# INTERNATIONAL SYMPOSIUM "INTERDISCIPLINY REGIONAL RESEARCH"

ISIRR 2009

ROMANIA - HUNGARY - SERBIA




## PROGRAM

Hunedoara, ROMANIA
23 - 24 April, 2009

***ORGANIZERS:***

***ASSOCIATION FOR MULTIDISCIPLINARY RESEARCH IN WEST ZONE OF ROMANIA (ACM-V) – TIMISOARA***

***UNIVERSITY POLITEHNICA – TIMISOARA, FACULTY OF ENGINEERING – HUNEDOARA***

***GENERAL ASSOCIATION OF THE ROMANIAN ENGINEERS (AGIR) – Branch of HUNEDOARA***

*in collaboration with our international traditional partners:*

***HUNGARIAN ACADEMY OF SCIENCE - branch of SZEGED, HUNGARY***

***UNIVERSITY OF NOVI SAD, NOVI SAD, SERBIA***

*with financial support of:*

***ROMANIAN MINISTRY OF EDUCATION, RESEARCH AND INNOVATION***

***NATIONAL AUTHORITY FOR SCIENTIFIC RESEARCH***

*with logistical support of:*

***RETEZAT NATIONAL PARK ROMANIA***

***ANNALS OF FACULTY ENGINEERING HUNEDOARA - JOURNAL OF ENGINEERING***


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## INTERNATIONAL ORGANIZING AND SCIENTIFIC COMMITTEE


**ROMANIA**

***Prof. dr. Nicolae FARBAŞ***
*– head of ASSOCIATION for MULTIDISCIPLINARY RESEARCH*
*of the WEST ZONE of ROMANIA (ACM-V) – TIMIŞOARA*


**ROMANIA**

***Prof. dr. eng. Teodor HEPUŢ***
*– dean of the FACULTY of ENGINEERING – HUNEDOARA*
***UNIVERSITY POLITEHNICA TIMISOARA***


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*and VETERINARY MEDICINE TIMISOARA*


**HUNGARY**

***Prof. dr. Imre DEKÁNY***
*– president of HUNGARIAN REGIONAL ACADEMY OF SCIENCES,*
*DEPARTMENT of COLLOID CHEMISTRY, UNIVERSITY of* ***SZEGED***


**HUNGARY**

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*– scientific secretary of HUNGARIAN REGIONAL ACADEMY OF SCIENCES,*
*GRADUATE SCHOOLS of the UNIVERSITY of* ***SZEGED***


**HUNGARY**

***Prof. dr. Cecilia HODUR***
*– member of HUNGARIAN REGIONAL ACADEMY OF SCIENCES,*
*FACULTY of FOOD ENGINEERING, UNIVERSITY of SZEGED*


**SERBIA**

***Prof. dr. Radmila MARINKOVIC-NEDUCIN***
*– rector of the UNIVERSITY of NOVI SAD,*
*FACULTY of TECHNOLOGY, NOVI SAD*


**SERBIA**

***Prof. dr. Mirjana VOJINOVIC-MILORADOV***
*– UNIVERSITY of NOVI SAD,*
*FACULTY of TECHNICAL SCIENCES, NOVI SAD*


**SERBIA**

***Prof. dr. Vladimir KATIC***
*– UNIVERSITY of NOVI SAD,*
*FACULTY of TECHNICAL SCIENCES, NOVI SAD*


**ROMANIA**

***Prof. dr. eng. Francisc WEBER***
*– head of GENERAL ASSOCIATION of the ROMANIAN ENGINEERS*
*(AGIR) – branch of HUNEDOARA*


**ROMANIA**

***Prof. dr. Aurel JECU AVRAM***
*– „VICTOR BABEŞ" UNIVERSITY of MEDICINE and FARMACY, TIMIŞOARA*
*member of ASSOCIATION for MULTIDISCIPLINARY RESEARCH*


**ROMANIA**

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**ROMANIA**

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*– scientific secretary of FACULTY of ENGINEERING – HUNEDOARA*
***UNIVERSITY POLITEHNICA TIMISOARA***

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## REGIONAL ORGANIZING COMMITTEE

**ROMANIA**

***Assoc. Prof. dr. eng. Ana Virginia SOCALICI***
*– vice-dean of* ***FACULTY of ENGINEERING – HUNEDOARA***
***UNIVERSITY POLITEHNICA TIMISOARA***

***Assoc. Prof. dr. eng. Imre KISS***
*– scientific secretary of the ISIRR 2009,*
***FACULTY of ENGINEERING – HUNEDOARA,***
***UNIVERSITY POLITEHNICA TIMISOARA***

***Assist. ec. dr. eng. Vasile ALEXA***
*– coordinator of organizing activities of the ISIRR 2009,*
***FACULTY of ENGINEERING – HUNEDOARA***
***UNIVERSITY POLITEHNICA TIMISOARA***

***Assist. dr. eng. Sorin RAȚIU***
*– coordinator of organizing activities of the ISIRR 2009,*
***FACULTY of ENGINEERING – HUNEDOARA***
***UNIVERSITY POLITEHNICA TIMISOARA***

***Assist. dr. eng. Vasile George CIOATĂ***
*– coordinator of organizing activities of the ISIRR 2009,*
***FACULTY of ENGINEERING – HUNEDOARA***
***UNIVERSITY POLITEHNICA TIMISOARA***

## SECRETARY OFFICE OF THE ORGANIZING COMMITTEE:

**ROMANIA**

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# SCHEDULE OF EVENTS

## *1ST DAY, Thursday, 23rd April, 2009*

*08.00 – 10.00* *Welcoming of guests and registration of participants – in the HALL of Faculty of Engineering – Hunedoara*

*10.00 – 10.20* *Opening Ceremony – in the AMPHITHEATRE of Faculty of Engineering*

*10.20 – 10.40* *Plenary Lecture # 1*
*FROM THE RETEZAT NATIONAL PARK TO EUROPE'S "YELLOWSTONE" - SEEDS FOR THOUGHTS FOR THE ESTABLISHMENT AND EFFICIENT MANAGEMENT OF EUROPE'S LARGEST PROTECTED AREA COVERING THE SOUTHERN AND WESTERN CARPATHIANS IN ROMANIA AND SERBIA*
*Dr. Erika STANCIU – WWF Danube Carpathian Programme, Carpathian, Forests and Protected Area Leader, Retezat National Park President*

*10.40 – 11.00* *Plenary Lecture # 2*
*SUSTAINABLE DEVELOPMENT AND THE ECONOMIC CRISIS*
*Dr. Carmen HĂRĂU – UNIVERSITY POLITEHNICA TIMIŞOARA*
*FACULTY OF ENGINEERING – HUNEDOARA*

*11.00 – 11.20* *Plenary Lecture # 3*
*SLAG – UTILIZATION IN ROAD CONSTRUCTION – EXPERIENCE AND SOLUTIONS*
*Eng. Rodica ISTRATE – Business Services Prest SRL Hunedoara*

*11.20 – 11.40* *Plenary Lecture # 4*
*ADVANCED TECHNIQUES IN ELECTRON SPECTROSCOPY FOR SURFACE AND INTERFACE STUDIES,*
*Prof. Dr. Bernard GRUZZA – Polytech'Clermont-Ferrand UFR Sciences, Université Blaise Pascal – Clermont II Clermont-Ferrand, Head of the research group "Surfaces and Interfaces", Laboratoire des Sciences des Matériaux pour l'Electronique et d'Automatique , LASMEA, France*

*11.40 – 12.00* *Coffee break – in the HALLS of Faculty of Engineering – Hunedoara*

*12.00 – 12.30* *Setting of posters by sections – in the HALLS of the Faculty of Engineering*

*12.30 – 14.00* *Presentations and debates by sections – in AMPHITHEATRES of the Faculty of Engineering*

*14.00 – 16.00* *Break for lunch – in STUDENT RESTAURANT of the Faculty of Engineering*

*16.00 – 19.00* *Debates by sections – in the Amphitheatres of Faculty of Engineering*

*19.00* *Festive dinner – in the HOTEL MAIER – HUNEDOARA ****

## 2ND DAY, Friday, 24th April, 2009

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| *08.00 – 10.00* | *Breakfast – in the STUDENT RESTAURANT of the Faculty* |
| *10.00 – 12.00* | *Presentations and debates by sections and posters – in HALLS and in AMPHITHEATRES of the Faculty* |
| *12.00 – 12.30* | *Coffee break* |
| *12.30 – 13.30* | *Informative Meeting – in the COUNCIL CHAMBER of the Faculty* |
| *13.30 – 14.00* | *Final debates and Closing Ceremony – in the AMPHITHEATRE of Faculty* |
| *14.00 – 15.00* | *Break for lunch – in STUDENT RESTAURANT of the Faculty* |
| *15.00* | *Visit to tourist sights (CORVIN CASTLE and surroundings)* |

# SYMPOSIUM TOPICS

***SECTION 1.***
***ECONOMICAL DEVELOPMENT AND STRATEGIES IN OUR REGIONS AND ABROAD***
***SECTION 2.***
***MEDICAL ISSUES, LABOR HEALTH AND VETERINARY MEDICINE***
***SECTION 3.***
***APPLIED ECOLOGY AND ENVIRONMENTAL PROTECTION IN THE REGION, INCLUDING BIOLOGY***
***SECTION 4.***
***USES OF NATURAL RESOURCES IN REGIONS, MINING, ENERGY CONSERVATION AND PLANNING, INCLUDING AGRICULTURE***
***SECTION 5.***
***APPLIED SCIENCES AND TECHNOLOGIES – MANUFACTURING AND RESEARCH IN ENGINEERING FIELDS***
***SUBSECTION 5a.***
***APPLIED SCIENCES AND TECHNOLOGIES – MANUFACTURING AND RESEARCH IN MECHANICAL ENGINEERING***
***SUBSECTION 5b.***
***APPLIED SCIENCES AND TECHNOLOGIES – MANUFACTURING AND RESEARCH IN INFORMATICS & ELECTRICAL ENGINEERING***
***SUBSECTION 5b.***
***APPLIED SCIENCES AND TECHNOLOGIES – MANUFACTURING AND RESEARCH IN MATERIAL SCIENCE ENGINEERING***
***SECTION 6.***
***METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES IN THE NATURAL SCIENCE FIELDS***
***SUBSECTION 6a.***
***METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES IN THE FIELDS OF CHEMISTRY AND PHYSICS***
***SUBSECTION 6b.***
***METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES IN THE FIELD OF MATHEMATICS***
***&***
***INFORMATIVE MEETING***


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# *SECTION 1.*
# *ECONOMICAL DEVELOPMENT AND STRATEGIES IN OUR REGIONS AND ABROAD*

*- focusing on problems concerning the general field of economics and management, the European Integration of our countries, the differences between the development of the regions from Eastern Europe and the management of diminishing unfavourable differences, including aspects regarding the globalization and economy of small and medium enterprises, human resources, management strategies and organization behaviour, provides a leading forum for interaction and research on the competitive strategies of managers and the organizational structure of firms;*

***MODERATORS:***



**ROMANIA**
***Marius Călin BENEA***
*UNIVERSITY POLITEHNICA TIMISOARA, FACULTY of ENGINEERING – HUNEDOARA*



**HUNGARY**
***Árpád FERENCZ***
*COLLEGE of KECSKEMET, ECONOMICS RURAL DEVELOPMENT*



**SERBIA**
***Vladimir KATIC***
*UNIVERSITY of NOVI SAD, FACULTY of TECHNICAL SCIENCES, NOVI SAD*

***PROGRAM SCHEDULE:***

*Faculty of Engineering – Hunedoara*
*Amphitheatre # 1 – Group C , Floor 1*
*Presentations and debates by sections*

***1ST DAY, Thursday, 23rd April, 2009***
*12.30 – 14.00 and 16.00 – 19.00*

***2ND DAY, Friday, 24th April, 2009***
*10.00 – 12.00*

*Faculty of Engineering – Hunedoara*
*Central Hall # 1 – Group C , Floor 1*
*Presentations and debates by posters*
***1ST DAY, Thursday, 23rd April, 2009***
*16.00 – 19.00*

***PROGRAM of PRESENTED PAPERS (oral presentations and posters):***

| ***No. crt.*** | ***Representing the Country:*** | ***TITLE OF PRESENTED PAPERS*** *Authors* |
|---|---|---|
| *S1-01.* | ***HUNGARY*** | ***THE ANALYSIS OF THE SALE PROMOTION-LIKING IN THE GROUP OF THE YOUNG*** *Edina VINCZE-LENDVAI* |

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|---|---|---|
| S1-02. | **HUNGARY** | ***MENTAL MAPPING IN GEOGRAPHICAL APPROACH AND REGIONAL ENVIRONMENTAL DISPARITIES AT FRONTIERS***<br>*Ildikó HORVÁTH GÁLNÉ, József GÁL* |
| S1-03. | **ROMANIA** | ***ONLINE TRANSMISSION OF TAX RETURNS – A STRATEGIC GOAL OF SERVICE E-GOVERNMENT IN ROMANIA***<br>*Alin ISAC, Claudia ISAC* |
| S1-04. | **SERBIA, GREECE, BULGARIA, GERMANY** | ***SOME RESULTS OF MAPPING OF MASS CUSTOMIZATION ACTIVITIES IN SOUTH-EAST OF EUROPE***<br>*Zoran ANISIC, Boris TUDJAROV, Alexander TSIGKAS, Christos CHATZOPOULOS, Robert FREUND* |
| S1-05. | **ROMANIA** | ***ECONOMIC AND SOCIAL IMPLICATIONS OF UNEMPLOYMENT AND OPPORTUNITIES OF DIMINISHING IT***<br>*Alina FLEŞER, Oana DOBRE-BARON* |
| S1-06. | **ROMANIA** | ***THE JIU VALLEY'S EXTRACTIVE INDUSTRY TRANSITION TO THE MARKET ECONOMY***<br>*Oana DOBRE-BARON, Alina FLEŞER* |
| S1-07. | **ROMANIA** | ***NEW DEVELOPMENTS IN THE RELATIONSHIP SELLING APPROCH***<br>*Marius Călin BENEA* |
| S1-08. | **ROMANIA** | ***INTERNAL MARKETING AND PERFORMANCE IN SERVICES ORGANIZATIONS***<br>*Marius Călin BENEA* |
| S1-09. | **ROMANIA** | ***MARKET BASED INSTRUMENTS – EFFECTIVE TOOLS FOR ENVIRONMENTAL STABILITY IN EUROPEAN UNION***<br>*Luminița VOCHIȚA, Ramona GRUESCU* |
| S1-10. | **HUNGARY** | ***SOME ASPECTS OF THE HUNGARIAN SPATIAL AND SETTLEMENT DEVELOPMENT***<br>*Tamás BESZE, Miklós LUKOVICS* |
| S1-11. | **HUNGARY** | ***THE STRENGTH OF INTELLECTUAL PROPERTY PROTECTION AND THE TRANSFER OF TECHNOLOGIES***<br>*Benedek NAGY* |
| S1-12. | **HUNGARY** | ***REGIONAL SUSTAINABILITY INDICATORS***<br>*Mónika TÓTH* |
| S1-13. | **HUNGARY** | ***ROLE OF PROXIMITY IN INFORMATION TECHNOLOGY CLUSTERS (IN SZEGED AND ITS SUBREGION)***<br>*Zsófia VAS* |
| S1-14. | **HUNGARY** | ***TECHNOLOGICAL CHANGE AND SUSTAINABILITY - PART OF THE PROBLEM OR THE SOLUTION?***<br>*Zoltán BAJMÓCY, György MÁLOVICS, Zsuzsanna TYETYÁK* |
| S1-15. | **HUNGARY** | ***INFLUENCE OF TRADITIONAL PRODUCTS TO THE REGION MANAGEMENT IN HUNGARY***<br>*Márta NÓTARI, Csaba BERDE, Árpád FERENCZ* |
| S1-16. | **ROMANIA** | ***SUSTAINABLE DEVELOPMENT AND THE ECONOMIC CRISIS***<br>*Carmen HĂRĂU* |


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*S1-17.* ***HUNGARY*** ***ECONOMIC AND MARKETING EXAMINATION OF TRADITIONAL HORTICULTURAL PRODUCTS AMONG THE COSTUMERS IN HUNGARY***
*Árpád FERENCZ, Márta NÓTARI*

*S1-18.* ***ROMANIA*** ***MANAGING PRODUCTION ACTIVITIES USING THE BALANCED SCORECARD STRATEGIC MANAGEMENT SYSTEM***
*Vasile ALEXA, Imre KISS, Sorin RAȚIU*

*S1-19.* ***HUNGARY*** ***SPATIAL DISTRIBUTION OF KNOWLEDGE INTENSIVE INDUSTRIAL SECTIONS IN HUNGARY***
*Izabella SZAKÁLNÉ KANÓ*

*S1-20.* ***HUNGARY*** ***ECONOMIC THEORIES, INSTITUTIONS AND REGIONAL COMPETITIVENESS***
*Zsolt FENYŐVÁRI*

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# SECTION 2.
# MEDICAL ISSUES, LABOR HEALTH AND VETERINARY MEDICINE

*- focusing on novelties in medical studies and veterinary medicine, medical advice, diagnoses and treatment, including new knowledge on pathogens, immunity to pathogenic micro-organisms, epidemiology related to infections, specific aspects of treatment of diseases, pathological and clinical studies (including case reports), diagnosis tests and technical reports, as well as labour related accidents and professional diseases;*

***MODERATORS:***



**ROMANIA**
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*„VICTOR BABEŞ" UNIVERSITY of MEDICINE and FARMACY, TIMIŞOARA*



**HUNGARY**
***András PAPP***
*UNIVERSITY of SZEGED, FACULTY of MEDICINE, DEPARTMENT of PUBLIC HEALTH*



**SERBIA**
***Slobodanca STANCOVIC***
*UNIVERSITY of NOVI SAD, FACULTY of TECHNICAL SCIENCES, NOVI SAD*

***PROGRAM SCHEDULE:***

*Faculty of Engineering – Hunedoara*
*Amphitheatre # 1 – Group B, Floor 2*
*Presentations and debates by sections*

***1ST DAY, Thursday, 23rd April, 2009***
*12.30 – 14.00 and 16.00 – 19.00*

***2ND DAY, Friday, 24th April, 2009***
*10.00 – 12.00*

*Faculty of Engineering – Hunedoara*
*Halls # 1-2 – Group B, Floor 2*
*Presentations and debates by posters*

***1ST DAY, Thursday, 23rd April, 2009***
*16.00 – 19.00*

***PROGRAM of PRESENTED PAPERS (oral presentations and posters):***

| ***No. crt.*** | ***Representing the Country:*** | ***TITLE OF PRESENTED PAPERS*** *Authors* |
|---|---|---|
| *S2-01.* | ***HUNGARY*** | ***REAL-TIME MULTIPLEX PCR ASSAY FOR INVESTIGATION OF THE KINESIN LIGHT-CHAIN 1 GENE A185C AND C406T MUTATIONS*** *Ferenc SOMOGYVÁRI, Zoltán SZOLNOKI, Lívia DÉZSI, Yvette MÁNDI* |
| *S2-02.* | ***HUNGARY*** | ***NEONATAL SURGERY IN SZEGED, HUNGARY*** *László JUHÁSZ, Szabolcs TORNYOS, Sándor TÚRI* |


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| *S2-03.* | ***HUNGARY*** | ***GENERAL AND NERVOUS SYSTEM EFFECTS OF LEAD APPLIED IN NANOPARTICULATE FORM INTO THE TRACHEA OF RATS***<br>*András PAPP, Leila SÁRKÖZI* |
| *S2-04.* | ***ROMANIA*** | ***THE HEAVY METALS MONITORING IN CANNED VEGETABLES MIX***<br>*I. DAVID, F. BERBENTEA, M. ŞTEFANUŢ, L. GEORGESCU, G. BUJANCĂ, T. TRAŞCĂ, M. DANCI, Oana DANCI* |
| *S2-05.* | ***HUNGARY INDIA JAPAN*** | ***EFFECTS OF SOME CALCIUM CHANNEL BLOCKER DERIVATIVES ON THE MULTIDRUG RESISTANCE OF CANCER CELLS***<br>*Julianna SERLY, Anamik SHAH, Noboru MOTOHASHI, Masami KAWASE, Joseph MOLNAR* |
| *S2-06.* | ***HUNGARY*** | ***DESIGN AND FABRICATION OF A TEST-BED AIMED FOR EXPERIMENT WITH PNEUMATIC ARTIFICAL MUSCLE***<br>*János GYEVIKI* |
| *S2-07.* | ***HUNGARY*** | ***INTERNATIONAL COMPARISON OF BLOOD PRESSURE AND BMI VALUES IN SCHOOLCHILDREN AGED 11-16 YEARS***<br>*Ákos BARÁTH, Krisztina BODA, Mária TICHY, Éva KÁROLY, Sándor TÚRI* |
| *S2-08.* | ***HUNGARY*** | ***MICROVASCULAR REACTIVITY IN JUVENILE ESSENTIAL HYPERTENSION***<br>*Péter MONOSTORI, Ákos BARÁTH, Ildikó FAZEKAS, Eszter HÓDI, Adrienn MÁTÉ, Zsuzsanna HRACSKÓ, Eszter KARG, Ilona VARGA, Viktória SÜMEGI, Balázs GELLÉN, Csaba BERECZKI, Sándor TÚRI* |
| *S2-09.* | ***HUNGARY*** | ***QUALITY CHANGES IN REGIONAL FOOD PRODUCTS AS A CONSEQUENCE OF CONSERVATION TREATMENT***<br>*Tibor PÁLI, J. KISPÉTER, M. FEKETE, L. FEHÉR, E. FODOR, L. KOVÁCS, ZS. LÁSZLÓ, K. BAJÚSZ-KABÓK, G. SZABÓ* |
| *S2-10.* | ***HUNGARY*** | ***EFFECT OF CHLOROPHYLL A AND B ON MULTIDRUG RESISTANCE OF CANCER CELLS***<br>*Margit SZABÓ, Lajos TANÁCS, József MOLNÁR, Imre OCSOVSZKI* |
| *S2-11.* | ***HUNGARY*** | ***IN VITRO SUSCEPTIBILITY OF DIFFERENT ZYGOMYCETES TO COMBINATIONS OF SURAMIN AND FLUVASTATIN***<br>*László GALGÓCZY, Máté VIRÁGH, Tamás PAPP, Csaba VÁGVÖLGYI* |
| *S2-12.* | ***HUNGARY*** | ***NEWBORN SCREENING FOR METABOLIC DISORDERS WITH TANDEM MASS SPECTROMETRY IN METABOLIC SCREENING CENTER OF SZEGED***<br>*F. PAPP, Gy. KARG, Gy. WITTMANN, M. TÖRÖK, Péter MONOSTORI, Ákos BARÁTH, Sándor TÚRI* |
| *S2-13.* | ***HUNGARY*** | ***MIGRAINE HEADACHE AND COMORBID CONDITIONS IN WOMEN: RETROSPECTIVE ANALYSIS***<br>*Délia SZOK, Éva PÁLINKÁS, Zsófia MAJLÁTH, Anita KISS, Aurélia UNGUREÁN, Árpád PÁRDUTZ, János TAJTI, László VÉCSEI* |
| *S2-14.* | ***ROMANIA*** | ***IMPLANT SUPPORTED OVERDENTURES***<br>*Cornel Radu CÂMPEANU* |
| *S2-15.* | ***ROMANIA*** | ***RETENTION FOR IMPLANT SUPPORTED OVERDENTURES***<br>*Cornel Radu CÂMPEANU* |
| *S2-16.* | ***ROMANIA*** | ***QUO VADIS, SEXUALITY?***<br>*Daniela BOTAŞ* |

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|---|---|---|
| S2-17. | ROMANIA | **SHORT-TERM URETERAL STENTING IN URETEROLITHOTRIPSY**<br>*Emil MITRANOVICI* |
| S2-18. | ROMANIA<br>HUNGARY | **STANDARDIZATION OF THE EXPERIMENTAL MODEL OF ISOLATED PERFUSED RAT HEART ACCORDING TO LANGENDORFF**<br>*Nicoleta MIRICĂ, Valentin ORDODI, Attila FARKAS, Andreea RADUCAN, Oana DUICU, Mircea HANCU, Norbert JOST, Andras TOTH, Alexandru CRISTESCU, Danina MUNTEAN, Andras VARRO* |
| S2-19. | ROMANIA<br>HUNGARY | **COMPARATIVE STUDY OF THE RAPID DELAYED RECTIFIER POTASSIUM CURRENT (IKR) IN DOG, RABBIT AND GUINEA PIG CARDIAC VENTRICULAR PREPARATIONS**<br>*Dimostenis TRAMBARIS, Cosmin NISTORAN, Norbert JOST, Laszlo VIRAG, Attila KRISTOF, Zsofia KOHAJDA, Mircea HANCU, Danina MUNTEAN, Andras VARRO, Al. CRISTESCU* |
| S2-20. | ROMANIA | **ACUTE APPENDICITIS - ALTERNATIVES AT THE CLASSICAL TREATMENT**<br>*Aurel Jecu AVRAM, Iulian AVRAM, Simona MANCIU, Mihaela PASZTORI, Mihaela AVRAM, Corina STĂNCIULESCU* |
| S2-21. | ROMANIA | **MINIMAL INVASION TECHNIQUES IN THE INGUINAL HERNIA TREATMENT**<br>*Aurel Jecu AVRAM, Iulian AVRAM, Simona MANCIU, Mihaela PASZTORI, Mihaela AVRAM, Corina STĂNCIULESCU* |
| S2-22. | ROMANIA | **THE IMPORTANCE OF VASCULAR DESEASES PRECOCIOUS HUNTING OUT THROUGHT THE ECHO DOPPLER VASCULAR EXAMINATION USE**<br>*Mihaela PASZTORI, Aurel Jecu AVRAM, Iulian AVRAM, Simona MANCIU, Mihaela AVRAM, Corina STĂNCIULESCU* |
| S2-23. | ROMANIA | **METHODOLOGICAL SUPERVISING OF THE MOTOR CAPACITY DEVELOPMENT**<br>*Constantin GRIGORE* |
| S2-24. | ROMANIA | **INFORMATICALLY SYSTEM FOR EVALUATION PROCESS OF THE SPORT TESTS**<br>*Constantin GRIGORE, Vasile ALEXA, Sorina ŞERBAN* |
| S2-25. | ROMANIA | **USING TAMSULOSIN FOR DISTAL URETERAL STONE CLEARANCE WITH OR WITHOUT SHOCK WAVE**<br>*Emil MITRANOVICI* |


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# *SECTION 3.*
# *APPLIED ECOLOGY AND ENVIRONMENTAL PROTECTION IN THE REGION, INCLUDING BIOLOGY*

*- focusing on the management of the city and on industrial waste materials, debating issues concerning the environmental engineering, the environmental impact analysis and assessment, the industrial and urban environmental management, the cleaning process, pollution agents and pollution sources, water – air – soil quality analysis, the reutilisation of industrial wastes and the diminishing of pollution and the environmental planning and environmental protection in the regions of the Eastern Europe area;*

***MODERATORS:***



**ROMANIA**
*Teodor HEPUT*
*UNIVERSITY POLITEHNICA TIMISOARA, FACULTY of ENGINEERING – HUNEDOARA*



**HUNGARY**
*Tamás ENDRŐDY*
*UNIVERSITY of SZEGED, FACULTY of ENGINEERING, SZEGED*



**SERBIA**
*Mirjana MILORADOV VOJINOVIC*
*UNIVERSITY of NOVI SAD, FACULTY of TECHNICAL SCIENCES, NOVI SAD*

***PROGRAM SCHEDULE:***

*Faculty of Engineering – Hunedoara*
*Amphitheatre # 4 – Group B , Floor 2*
*Presentations and debates by sections*

*1ST DAY, Thursday, 23rd April, 2009*
*12.30 – 14.00 and 16.00 – 19.00*

*2ND DAY, Friday, 24th April, 2009*
*10.00 – 12.00*

*Faculty of Engineering – Hunedoara*
*Halls # 3-4 – Group B , Floor 2*
*Presentations and debates by posters*
*1ST DAY, Thursday, 23rd April, 2009*
*16.00 – 19.00*

***PROGRAM of PRESENTED PAPERS (oral presentations and posters):***

| ***No. crt.*** | ***Representing the Country:*** | ***TITLE OF PRESENTED PAPERS*** *Authors* |
|---|---|---|
| *S3-01.* | ***HUNGARY*** | ***PRODUCTION OF CELLULOLYTIC ENZYMES ON AGRICULTURAL WASTE BY DIFFERENT ZYGOMYCETES*** *Miklós TAKÓ, Szabina LUNG, Judit KRISCH, Tamás PAPP, Csaba VÁGVÖLGYI* |

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| S3-02. | **HUNGARY** | ***BETA-CAROTENE PRODUCTION BY MUCORALEAN FUNGI***<br>*Tamás PAPP, Gábor NAGY, Árpád CSERNETICS, András SZEKERES, Csaba VÁGVÖLGYI* |
| S3-03. | **HUNGARY** | ***STRESS RESPONSES OF GENETICALLY MODIFIED MUCOR CIRCINELLOIDES STRAINS***<br>*Nikoletta KÁLMÁN, Ottó BENCSIK, Miklós PESTI, Tamás PAPP, Csaba VÁGVÖLGYI* |
| S3-04. | **ROMANIA** | ***ACOUSTICAL ARRANGEMENT OF THE URBAN ROADS***<br>*Vasile BACRIA, Nicolae HERIŞANU* |
| S3-05. | **HUNGARY** | ***HEAT TREATMENT OPTIMIZATION OF CANNED MEATS IN TERMS OF THE RESOURCE UTILIZATION AND THE QUALITY OF THE PRODUCTS***<br>*Zoltán FABULYA, György HAMPEL, Margaret NAGY* |
| S3-06. | **HUNGARY** | ***BLACK POPLAR (POPULUS NIGRA) GENE CONSERVATION IN THE SAND RIDGE REGION BETWEEN THE DANUBE AND THE TISZA***<br>*Gábor SZULCSÁN* |
| S3-07. | **SERBIA** | ***MORPHO-ANATOMICAL ANALYSIS OF SPIKE OF WHEAT GENOTYPES***<br>*J. LUKOVIĆ, L. ZORIĆ, Lj. MERKULOV, M. KODRANOV, B. KIPROVSKI* |
| S3-08. | **HUNGARY FINLAND** | ***STATISTICAL EXPERIMENTAL DESIGN OF THE REMOVAL OF DIFFERENT COMPOUNDS FROM SYNTHETIC WASTEWATER BY MICELLAR-ENHANCED ULTRAFILTRATION***<br>*Szabolcs KERTÉSZ, Junkal LANDABURU-AGUIRRE, Veronica GARCIA, Cecilia HODÚR, Eva PONGRÁCZ, Riitta L. KEISKI* |
| S3-09. | **SERBIA** | ***PLANT COVER OF THE SALINE GRASSLAND IN THE RIPARIAN ZONE OF THE OKANJ OXBOW LAKE (THE VOJVODINA PROVINCE, SERBIA)***<br>*A. KNEŽEVIĆ, P. BOŽA, M. STANKOV, LJ. NIKOLIĆ,S. STOJANOVIĆ, D. DŽIGURSKI, B. LJEVNAIĆ, D. POLIĆ* |
| S3-10. | **HUNGARY** | ***GREEN MOULD DISEASE OF OYSTER MUSHROOM IN HUNGARY AND ROMANIA: ECOPHYSIOLOGY OF THE CAUSATIVE AGENTS***<br>*László KREDICS, Péter KÖRMÖCZI, Tímea CSEH, Lóránt HATVANI, László MANCZINGER, Adrienn NAGY, Csaba VÁGVÖLGYI* |
| S3-11. | **SERBIA** | ***CHANGES OF FLORISTIC COMPOSITION IN THE GLOŽAN CONSTRUCTED WETLAND SYSTEM (THE VOJVODINA PROVINCE, SERBIA)***<br>*Ljiljana NIKOLIĆ, Slobodanka STOJANOVIĆ, Aleksa KNEŽEVIĆ, Dejana DŽIGURSKI, Branka LJEVNAIĆ* |
| S3-12. | **ROMANIA** | ***ECOLOGICAL RECONSTRUCTION IN THE BANAT BLACK PINE SITE FROM "DOMOGLED-VALEA CERNEI" NATIONAL PARK***<br>*Eugeniu-Corneliu FRĂTILĂ* |
| S3-13. | **HUNGARY** | ***MENTAL MAPPING IN GEOGRAPHICAL APPROACH AND REGIONAL ENVIRONMENTAL DISPARITIES AT FRONTIERS***<br>*Ildikó HORVÁTH GÁLNÉ, József GÁL* |
| S3-14. | **ROMANIA** | ***BIOSOLIDS AND VOLCANIC TUFF INFLUENCE OVER THE UPTAKE COEFFICIENT OF CADMIUM AND ZINC FROM POLLUTED SOILS IN MAIZE CULTIVATION***<br>*Smaranda MASU, Valeria RUS, N. DRAGOMIR, Stela URUIOC, Mariana ALBULESCU* |


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*S3-15.* ***SERBIA*** ***ANALYSIS OF PRECIPITATION QUANTITY IN VOJVODINA***
*Atila BEZDAN, Radovan SAVIC, Atila SALVAI*

*S3-16.* ***ROMANIA GERMANY*** ***ROMANIAN STEEL INDUSTRY IN THE THIRD YEAR OF EU INTEGRATION - ENVIRONMENTAL ISSUE TO COMPLY THE EU STANDARDS AND REGULATION – BADISCHE STAHL-ENGINEERING GERMANY "OFF GAS" CONCEPT***
*Rodica ISTRATE, Manfred SCHMITT*

*S3-17.* ***SERBIA*** ***CATEGORIZATION OF ALLUVIAL DEPOSITS FROM THE CONTENT OF IRON AND ALKALIZATION IN TOTAL SUSPENDED SOLIDS FROM HS DTD OF SOUTHERN BANAT REGION***
*K. NEMES, R. BUGARSKI, M. MATAVULJ, S. BELIĆ*

*S3-18.* ***SERBIA*** ***THE INFLUENCE OF TRIBUTARIES ON LOWER RIVER TISA BASIN WATER SUPPLY NETWORK***
*K. NEMES, R. BUGARSKI, Z. LOZANOV-CRVENKOVIĆ, S. BELIĆ.*

*S3-19.* ***SERBIA*** ***OBTAINING INFORMATION FOR RIVER DANUBE ECOLOGICAL STATUS FROM CITY OF NOVI SAD***
*Karolina NEMES, Milan MATAVULY*

*S3-20.* ***HUNGARY*** ***ENVIRONMENTAL IMPACTS OF NITRATE AND NITRITE***
*Gábor NAGY, Zoltán GALBÁCS*

*S3-21.* ***HUNGARY*** ***SUPPORTING THE REASONABLE AGRICULTURAL PRODUCTION WITH A NEWLY FOUNDED ENVIRONMENTAL LABORATORY IN THE SOUTH EASTERN REGION OF HUNGARY***
*Gábor NAGY, Tünde NYILAS, Szilvia ÖRDÖG, Anita VOLFORD*

*S3-22.* ***HUNGARY*** ***ARSENIC PROBLEM AND POSSIBLE SOLUTION FOR DRINKING WATER***
*Tamás BUJDOSÓ, Ágnes PATZKÓ, Zoltán GALBÁCS, István LICSKÓ, Imre DÉKÁNY*

*S3-23.* ***ROMANIA*** ***SLAG – UTILIZATION IN ROAD CONSTRUCTION – EXPERIENCE AND SOLUTIONS***
*Rodica ISTRATE, Adrian CALIMENTE*

*S3-24.* ***SERBIA*** ***PROBLEMS IN THE PROCESS OF WASTE WATER TREATMENT ON THE SUBOTICA WASTE WATER TREATMENT PLANT (WWTP)***
*Aleksandra KURTES, Bojana BURGER, Imre CSEKE,*
*Mirjana MILORADOV VOJINOVIC*

*S3-25.* ***SERBIA*** ***THE METHOD OF RISK ASSESSMENT AT WORKPLACE AND WORKING ENVIRONMENT IN AN EXAMPLE OF A METAL MECHANICAL PROCESSING SECTION OF A FACTORY***
*Bozo NIKOLIC, Biljana GEMOVIC*

*S3-26.* ***SERBIA*** ***METHODOLOGICAL FRAMEWORK FOR THE STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT (SEIA) OF SPATIAL PLANS IN AUTONOMOUS PROVINCE OF VOJVODINA***
*Dejan FILIPOVIĆ, Tamara ZELENOVIĆ VASILJEVIĆ, Mirjana VOJINOVIĆ MILORADOV, Maja ĐOGO, Ivana MIHAJLOVIĆ, Milena STOŠIĆ*

*S3-27.* ***SERBIA*** ***POLYCHLORINATED BIPHENYLS (PCBs), IN SOUTH BAČKA – FROM THE ENVIRONMENT TO HUMAN MILK***
*Mirjana VOJINOVIĆ MILORADOV, Tamara VUKAVIĆ, Jan SUĐI, Marija JEVTIĆ, Ivana MIHAJLOVIĆ*

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| S3-28. | SERBIA | ***VARIABILITY OF GAS-PARTICLE PARTITIONING OF POLYCYCLIC AROMATIC HYDROCARBONS IN A PILOT AREA OF VOJVODINA***<br>*Mirjana VOJINOVIC MILORADOV, Jelena RADONIC, Maja TURK SEKULIC, Jelena KIURSKI, Maja DJOGO* |
| S3-29. | ROMANIA | ***SNAIL MEAT, ROLE AND PLACE IN HUMANS DIET***<br>*Dana Carolina CRISAN, Ioan DANCIU* |
| S3-30. | SERBIA | ***ADVANTAGE OF THE SUBSTITUTION ETHYLMERCAPTAN, COMPOUND FOR ODORIZATION NATURAL GAS, WITH TETRAHYDROTHIOPHEN***<br>*Zoran ČEPIĆ, Jova JURIĆ, Mirjana VOJINOVIĆ MILORADOV* |
| S3-31. | SERBIA | ***QUANTITY AND RECYCLABILITY OF Fe - METALS AT THE END-OF-LIFE VEHICLES IN REPUBLIC OF SERBIA***<br>*Milan PAVLOVIĆ, Nikola KARANOVIĆ, Zoran ČEPIĆ, Aleksandar PAVLOVIĆ* |
| S3-32. | ROMANIA | ***IMPLEMENTATION VERIFICATION REQUIRED EQUIPMENT TO COMBAT PESTS AND DISEASES IN ROMANIA IN ORDER TO ELIMINATE ENVIRONMENTAL CONTAMINATION WITH TOXIC SUBSTANCES***<br>*S.T. BUNGESCU, W. STAHLI, V. VLADUT, S.S. BIRIS, M.E. NAGY, T. IANCU* |
| S3-33. | HUNGARY | ***EXAMINATION OF BLACK LOCUST (Robinia pseudoacacia L.) AFFORESTATIONS IN BÁCS-KISKUN COUNTY***<br>*Tamás BARNA, Gábor SZULCSÁN* |
| S3-34. | ROMANIA | ***FROM THE RETEZAT NATIONAL PARK TO EUROPE'S "YELLOWSTONE" - SEEDS FOR THOUGHTS FOR THE ESTABLISHMENT AND EFFICIENT MANAGEMENT OF EUROPE'S LARGEST PROTECTED AREA COVERING THE SOUTHERN AND WESTERN CARPATHIANS IN ROMANIA AND SERBIA***<br>*Erika STANCIU* |


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# *SECTION 4.*
# *USES OF NATURAL RESOURCES IN REGIONS, MINING, ENERGY CONSERVATION AND PLANNING, INCLUDING AGRICULTURE*

*- focusing on general fields of industry, mining, agriculture, forestry, botany and horticulture, hydrology, biotechnology, material and energetically resources, including energy conservation and planning and alternate energy development, in multidisciplinary studies;*

***MODERATORS:***



**ROMANIA**
***Gallia BUTNARU***
*"BANATUL" UNIVERSITY*
*TIMISOARA*



**HUNGARY**
***Tamás BARNA***
*KEFAG Zrt.*
*Kecskemét*



**SERBIA**
***Radovan SAVIĆ***
*UNIVERSITY of NOVI SAD, FACULTY of AGRICULTURE, NOVI SAD*

***PROGRAM SCHEDULE:***

*Faculty of Engineering – Hunedoara*
*Amphitheatre # 3 – Group B , Floor 2*
*Presentations and debates by sections*

*Faculty of Engineering – Hunedoara*
*Halls # 3-4 – Group B , Floor 2*
*Presentations and debates by posters*

***1ST DAY, Thursday, 23rd April, 2009***
*12.30 – 14.00 and 16.00 – 19.00*

***PROGRAM of PRESENTED PAPERS (oral presentations and posters):***

| ***No. crt.*** | ***Representing the Country:*** | ***TITLE OF PRESENTED PAPERS*** *Authors* |
|---|---|---|
| *S4-01.* | ***ROMANIA*** | ***BIOMASS A REGENERATING SOURCE OF THERMAL ENERGY FOR DRYING INSTALLATIONS*** *Murad EROL, Victor-Viorel SAFTA, Georgeta HARAGA* |
| *S4-02.* | ***HUNGARY*** | ***ANTIMICROBIAL AND ANTIOXIDANT POTENTIAL OF WASTE PRODUCTS REMAINING AFTER JUICE PRESSING*** *Judit KRISCH, László GALGÓCZY, Tamás PAPP, Csaba VÁGVÖLGYI* |
| *S4-03.* | ***SERBIA*** | ***MAPPING OF RISKS ON THE MAIN ROAD NETWORK OF SERBIA*** *Krsto LIPOVAC, Dragan JOVANOVIĆ, Svetlana BAŠIĆ* |
| *S4-04.* | ***SERBIA*** | ***UTLIZATION OF WASTE MATERIALS FROM BIOMASS AS ENERGY-GENERATED PRODUCT IN TECHNOLOGICAL PROCESS*** *Zoran ĐUKIĆ, Srđan KOVAČEVIĆ, Dragan ADAMOVIĆ, Nemanja STANISAVLJEVIĆ* |
| *S4-05.* | ***SERBIA*** | ***THREATS IN TRAFFIC FOR THE YOUNG PEOPLE IN THE TERRITORY OF SERBIA*** *Dragan JOVANOVIĆ, Svetlana BAŠIĆ* |

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| S4-06. | SERBIA | **DETERMINING THE FLOW OF GOODS WITH THE GOAL OF INCREASE OF EFFECTIVENESS IN CARGO TRANSPORTATION IN THE RIVER-SEA DIRECTION**<br>*Vladimir ŠKILJAICA, Todor BAČKALIĆ, Ivan ŠKILJAICA* |
| S4-07. | ROMANIA | **VACUUM IMPREGNATION PRETREATMENT OF FRESH CUT VEGETABLE**<br>*Claudiu URSACHI, Rodica SEGAL, Claudia MURESAN* |
| S4-08. | ROMANIA | **ENVIRONMENT ECOLOGICAL PROCESS IN HUNEDOARA AREA THROUGH REINSERTION IN ECONOMIC CIRCUIT OF SCRAP AND PULVEROUS WASTE**<br>*Teodor HEPUȚ, Ana SOCALICI, Erika ARDELEAN, Marius ARDELEAN* |
| S4-09. | ROMANIA | **POSIBILITY TO RECYCLING OF DEFERRIZED STEELSHOP SLAGS IN AGRICULTURE**<br>*Ana SOCALICI, Erika ARDELEAN, Marius ARDELEAN, Teodor HEPUȚ* |
| S4-10. | ROMANIA | **STUDIES REGARDING OF SIDERITIC RESIDUE UTILIZATION FOR CEMENT PRODUCTION**<br>*Marius ARDELEAN, Erika ARDELEAN, Teodor HEPUȚ, Ana SOCALICI, Laura BENEA* |
| S4-11. | ROMANIA | **RESEARCHES CONCERNING TO THE POSSIBILITY OF USE THE SIDERITIC RESIDUE FOR PRODUCTION OF CLINKER**<br>*Erika ARDELEAN, Marius ARDELEAN, Teodor HEPUȚ, Ana SOCALICI, Laura BENEA* |
| S4-12. | ROMANIA | **THE IMPORTANCE OF NON-CONVENTIONAL BIOFUEL UTILIZATION FOR POLLUANT EMISSIONS REDUCTION**<br>*Arina NEGOIȚESCU, Adriana TOKAR, Daniel OSTOIA* |
| S4-13. | ROMANIA | **RESEARCH ON THE RELIABILITY MODELING OF HYDRO MECHANICAL SYSTEMS**<br>*Cristina HORA, Simona DZIȚAC* |
| S4-14. | ROMANIA | **FUZZY SIMULATION IN RELIABILITY ANALYSIS**<br>*Simona DZIȚAC, Cristina HORA* |
| S4-15. | SERBIA | **VARIABILITY OF GAS-PARTICLE PARTITIONING OF POLYCYCLIC AROMATIC HYDROCARBONS IN A PILOT AREA OF VOJVODINA**<br>*Mirjana VOJINOVIC MILORADOV, Jelena RADONIC, Maja TURK SEKULIC, Jelena KIURSKI, Maja DJOGO* |
| S4-16. | SERBIA | **ADVANTAGE OF THE SUBSTITUTION ETHYLMERCAPTAN, COMPOUND FOR ODORIZATION NATURAL GAS, WITH TETRAHYDROTHIOPHEN**<br>*Zoran ČEPIĆ, Jova JURIĆ, Mirjana VOJINOVIĆ MILORADOV* |
| S4-17. | SERBIA | **QUANTITY AND RECYCLABILITY OF Fe - METALS AT THE END-OF-LIFE VEHICLES IN REPUBLIC OF SERBIA**<br>*Milan PAVLOVIĆ, Nikola KARANOVIĆ, Zoran ČEPIĆ, Aleksandar PAVLOVIĆ* |
| S4-18. | ROMANIA | **SLAG – UTILIZATION IN ROAD CONSTRUCTION – EXPERIENCE AND SOLUTIONS**<br>*Rodica ISTRATE, Adrian CALIMENTE* |
| S4-19. | SERBIA | **UTLIZATION OF WASTE MATERIALS FROM BIOMASS AS ENERGY-GENERATED PRODUCT IN TECHNOLOGICAL PROCESS**<br>*Zoran ĐUKIĆ, Srđan KOVAČEVIĆ, Dragan ADAMOVIĆ, Nemanja STANISAVLJEVIĆ* |
| S4-20. | HUNGARY | **ENERGY STORAGE IN SOLAR COLLECTOR SYSTEMS WITH PCM SOLAR TANK**<br>*István Péter SZABÓ* |


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# *SECTION 5.*
# *APPLIED SCIENCES AND TECHNOLOGIES – MANUFACTURING AND RESEARCH IN ENGINEERING FIELDS*

*- focusing on engineering science and practice, covering the full spectrum of engineering theory and practice, including studies involving the application of physical and mathematical techniques to fundamental investigations and emerging areas within the engineering fields, incoming with information from a wide variety of applied science specialties in multidisciplinary studies;*

**SUBSECTION 5a.**
**APPLIED SCIENCES AND TECHNOLOGIES –**
**MANUFACTURING AND RESEARCH IN MECHANICAL ENGINEERING**

***SUBSECTION 5b.***
***APPLIED SCIENCES AND TECHNOLOGIES –***
***MANUFACTURING AND RESEARCH IN INFORMATICS & ELECTRICAL ENGINEERING***

***SUBSECTION 5b.***
***APPLIED SCIENCES AND TECHNOLOGIES –***
***MANUFACTURING AND RESEARCH IN MATERIAL SCIENCE ENGINEERING***

**MODERATORS:**



**ROMANIA**
*Carmen Inge ALIC*
*UNIVERSITY POLITEHNICA TIMISOARA, FACULTY of ENGINEERING – HUNEDOARA*



**HUNGARY**
*Cecilia HODÚR*
*UNIVERSITY of SZEGED, FACULTY of ENGINEERING, SZEGED*



**SERBIA**
*Siniša KUZMANOVIĆ*
*UNIVERSITY of NOVI SAD, FACULTY of TECHNICAL SCIENCES, NOVI SAD*

**PROGRAM SCHEDULE:**

*Faculty of Engineering – Hunedoara*
*Amphitheatre # 1 – Group F*
*Presentations and debates by sections*

| *1ST DAY, Thursday, 23rd April, 2009* | *2ND DAY, Friday, 24th April, 2009* |
|---|---|
| *12.30 – 14.00 and 16.00 – 19.00* | *10.00 – 12.00* |

*Faculty of Engineering – Hunedoara*
*Central Hall of Faculty – Group F*
*Presentations and debates by posters*

| *1ST DAY, Thursday, 23rd April, 2009* | *2ND DAY, Friday, 24th April, 2009* |
|---|---|
| *12.30 – 14.00 and 16.00 – 19.00* | *10.00 – 12.00* |

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## PROGRAM of PRESENTED PAPERS (oral presentations and posters):

| No. crt. | Representing the Country: | TITLE OF PRESENTED PAPERS<br>Authors |
|---|---|---|
| S5-01. | MONTENEGRO | **CONTRIBUTION TO REDUCE DEFECTS IN PRODUCTION OF PLAIN BEARINGS**<br>Darko SKUPNJAK |
| S5-02. | HUNGARY | **SLIDING MODE CONTROL OF A ROBOT ARM DRIVEN BY PNEUMATIC MUSCLE ACTUATORS**<br>Péter TOMAN, János GYEVIKI, Tamás ENDRŐDY, József SÁROSI, Antal VÉHA, Zénó SZABÓ |
| S5-03. | HUNGARY | **DESIGN AND FABRICATION OF A TEST-BED AIMED FOR EXPERIMENT WITH PNEUMATIC ARTIFICIAL MUSCLE**<br>Péter TOMAN, János GYEVIKI, Tamás ENDRŐDY, József SÁROSI, Antal VÉHA |
| S5-04. | HUNGARY | **EXAMINATION OF THE EFFECT OF MICROWAVE HEATING ON THE BIODEGRADABLE AND SOLUBLE FRACTION OF ORGANIC MATTER OF SLUDGE**<br>Sándor BESZÉDES, Zsuzsanna LÁSZLÓ, Gábor SZABÓ, Cecilia HODÚR |
| S5-05. | HUNGARY | **THE EFFECT OF MICROPARTICLES FOR THE MEMBRANE RESISTANCE**<br>Angéla SZÉP, Szabolcs KERTÉSZ, Zsuzsanna LÁSZLÓ, Cecilia HODÚR |
| S5-06. | ROMANIA | **CALCULUS METHOD OF THE TECHNOLOGICAL LOADS TRANSMITTED TO THE EXTRACTING TOWERS WITH THE HOISTING INSTALLATIONS OF WINDING MACHINES WITH MULTICABLE DRIVING WHEELS ON**<br>Vilhelm ITU, Iosif DUMITRESCU, Bogdan-Zeno COZMA |
| S5-07. | ROMANIA | **ELEMENTS OF THE GEOMETRIC CALCULATION FOR STRAUGHT-TOOTHED CYLINDRICAL GEARS IN INCHES AND IN THE METRIC SYSTEM**<br>Vasile ZAMFIR, Gheorghe Bogdan URDEA |
| S5-08. | SERBIA | **MODIFIED DIAGRAM FOR STEAM-WATER INJECTOR MIXING CHAMBER**<br>Maša BUKUROV, Slobodan TAŠIN, Siniša BIKIĆ |
| S5-09. | SERBIA | **ANALYSIS OF THE MOST COMMON FAILURES OF GEARS IN UNIVERSAL GEAR REDUCERS**<br>Milan RACKOV, Siniša KUZMANOVIĆ |
| S5-10. | ROMANIA | **GENERAL CONCEPTS OF MAINTENANCE**<br>Natalia-Cernica BUZGĂU |
| S5-11. | ROMANIA | **A STUDY OF THE BOCKER'S OBSERVER IMPLEMENTATION TO ESTIMATE THE INDUCED POWER WITHIN A CAST-IRON CONVEYANCE AND DOSAGE ELECTROMAGNETIC PUMP**<br>Adrian DĂNILĂ |
| S5-12. | ROMANIA | **WORKING TECHNOLOGY FOR CNC MACHINES**<br>Doina MORTOIU, Lucian GAL |
| S5-13. | BOSNIA & HERZEGOVINA | **ADAPTIVE GENETIC FUZZY SYSTEMS IN INDUSTRY: CURRENT FRAMEWORK AND NEW TRENDS**<br>Tihomir LATINOVIC, Miroslav ROGIC, Milosav DJURDJEVIC |


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| *S5-14.* | ***SERBIA*** | ***POSSIBILITY OF APPLYING HYDRODYNAMIC COUPLERS FOR DRIVING BELT CONVEYORS***<br>*Svetislav Lj. MARKOVIĆ* |
| *S5-15.* | ***ROMANIA*** | ***WITH SPIDER8 ON RAILS***<br>*Tiberiu Ştefan MĂNESCU, Ion SIMION, Nicuşor Laurenţiu ZAHARIA* |
| *S5-16.* | ***HUNGARY*** | ***EXAMINATIN OF REFRIGERATOR ENGINES WITH THE METHOD OF VIBRATION DIAGNOSIS***<br>*Lajos TÓTH* |
| *S5-17.* | ***ROMANIA*** | ***ON THE ENERGETIC CHARACTERISTICS OF THE SHOCK INSULATORS OF RAILWAY VEHICLES***<br>*Ion COPACI* |
| *S5-18.* | ***ROMANIA*** | ***ON THE STATIC AND DYNAMIC CHARACTERISTICS OF THE SHOCK INSULATORS EQUIPPING RAILWAY VEHICLES***<br>*Aurelia TĂNĂSOIU, Ion COPACI* |
| *S5-19.* | ***ROMANIA*** | ***THE INFLUENCE OF ELASTIC SYSTEMS ON THE TRAVEL SAFETY OF RAILWAY VEHICLES***<br>*Aurelia TĂNĂSOIU* |
| *S5-20.* | ***ROMANIA*** | ***ON THE DYNAMIC CHARACTERISTICS OF THE DAMPENER WITH ELASTIC RUBBER ELEMENTS USED ON A SUBURBAN TRANSPORT VEHICLE (EGYPT)***<br>*Mihai SÂRB, Ion COPACI, Aurelia TĂNĂSOIU* |
| *S5-21.* | ***BOSNIA & HERZEGOVINA*** | ***A CONSTRUCTIVE SOLUTION FOR A SOLAR COLLECTOR WITH ALUMINUM ABSORBER***<br>*Mirko DOBRNJAC, Tihomir LATINOVIĆ* |
| *S5-22.* | ***ROMANIA*** | ***THE INFLUENCE OF LOW TEMPERATURES ONTHE MECHANICAL CHARACTERISTICS OF THE 34MoCrNi15X-RS STEEL UNDERGOING SHOCK-BENDING, DEPENDING ON THE SAMPLING POSITION***<br>*Francisc WEBER* |
| *S5-23.* | ***ROMANIA*** | ***THE TORSION MECHANICAL CHARACTERISTICS UNDER LOW TEMPERATURE OF 34MoCrNi16X STEEL***<br>*Francisc WEBER* |
| *S5-24.* | ***ROMANIA*** | ***DYNAMICS OF WORKING PROCESS OF FLAT SIEVES***<br>*Radu ILEA* |
| *S5-25.* | ***ROMANIA*** | ***THE ATTEMPT TO TRACTION OF THE INSULATION OF THE CABLE LAY-UPS FROM CARS***<br>*Teodor VASIU, Adina BUDIUL-BERGHIAN* |
| *S5-26.* | ***ROMANIA*** | ***SOLUTIONS FOR BREED THE AVAILABILITY OF THE PARALLEL GANG SHEARS ASSIGNED FOR CUTTING THE METALLURGICAL PRODUCTS***<br>*Adina BUDIUL BERGHIAN, Teodor VASIU* |
| *S5-27.* | ***ROMANIA*** | ***INTERNET USING FOR INTERACTIVE AND COLLABORATIVE LEARNING IN MECHANICAL ENGINEERING***<br>*Carmen Inge ALIC, Cristina MIKLOS, Imre Zsolt MIKLOS* |
| *S5-28.* | ***ROMANIA*** | ***INTEGRATION OF INTERACTIVE MULTIMEDIA LEARNING SOFTWARE INTO MECHANICAL ENGINEERING COURSE'S***<br>*Carmen Inge ALIC, Imre Zsolt MIKLOS, Cristina MIKLOS* |

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| S5-29. | ROMANIA | ***EVALUATION OF THE SMOKE DEGREE AND $CO_2$ EMISSION IN CORRELATION WITH THE DISTANCE COVERED BY ROAD VEHICLES***<br>*Gelu PĂDURE, Virgiliu Dan NEGREA* |
| S5-30. | ROMANIA | ***AN EXPERIMENTAL ANALYSIS ABOUT THE FRACTURE OF THE WHEELSET-AXLES OF THE 5100 KW ELECTRIC LOCOMOTIVE***<br>*Eugen GHITA, Lucia VILCEANU, Ramon BALOGH, Monica DOBRA* |
| S5-31. | ROMANIA | ***ASPECTS REGARDING THE LIFE-TIME OF WIRES BELONGING TO A STEEL WIRE ROPE***<br>*Lucia VILCEANU, Eugen GHITA, Vasile PUTAN* |
| S5-32. | ROMANIA | ***CONSIDERATIONS REGARDING THE TESTING OF ELECTRICAL APPARATUS WITH THE TYPE OF PROTECTION "INCREASED SAFETY"***<br>*Martin FRIEDMANN, Lucian MOLDOVAN* |
| S5-33. | ROMANIA | ***THEORETICAL AND EXPERIMENTAL ASPECTS REGARDING THE SEALED EFFICIENCY OF DIESEL ENGINES COMBUSTION CHAMBERS***<br>*Adriana TOKAR, Daniel OSTOIA, Arina NEGOIȚESCU* |
| S5-34. | ROMANIA | ***EXPERIMENTAL DETERMINATION OF THE MECHANICAL STRESSES ON THE WARM ROLLING CYLINDERS***<br>*Camelia PINCA BRETOTEAN, Gelu Ovidiu TIRIAN* |
| S5-35. | ROMANIA | ***THE USAGE OF TYPE SILIUMINIU ALLOYS WITH MAGNESIUM FOR CASTING A VERY LARGE USED PIECES***<br>*Remus BOBOESCU, Ion SPOREA, Ilarie BORDEAȘU, Adriana TOKAR, Victor BUJOR* |
| S5-36. | ROMANIA | ***STUDIES AND TESTS CONCERNING SMELTING CASTING ALLOY OF UNIVERSAL ALUMINIUM***<br>*Adriana TOKAR, Ion SPOREA, Arina NEGOIȚESCU* |
| S5-37. | ROMANIA | ***MEASURING THE PRESSION FIELD IN AN INVERTED AIR FILTER***<br>*Sorin RAȚIU, Corneliu BIRTOK-BĂNEASĂ, Liviu MIHON* |
| S5-38. | ROMANIA | ***LABORATORY MEASUREMENTS OF LIGHT-DUTY VEHICLE POLLUTION AND FUEL CONSUMPTION***<br>*Liviu MIHON, Daniel OSTOIA, Carmen Inge ALIC, Sorin RAȚIU* |
| S5-39. | ROMANIA | ***MODALITIES OF REDUCING THE LEAKAGE FLOW IN MECHANICAL SEALING***<br>*Veronica ARGESANU, Mihaela JULA, Ioan LAZA* |
| S5-40. | ROMANIA | ***THERMO ELASTIC INSTABILITY WITHIN A CLASS IV FRICITON JOINT***<br>*Veronica ARGESANU, Mihaela JULA, Ioan LAZA* |
| S5-S5-41. | ROMANIA | ***STUDY REGARDING MASS REPARTITION TO ROAD VEHICLE WITH MULTIPLE DESTINATIONS***<br>*Ioan LAZA, Daniel OSTOIA, Lucian MOLDOVAN* |
| S5-42. | ROMANIA | ***METALLOGRAFIC ASPECTS OF THE ELEMENTS MAKING UP A STEAM BOILER***<br>*Amalia Ana DASCĂL* |
| S5-43. | ROMANIA | ***REGISTRATION AND PROCESSING OF FUNCTIONAL PARAMETERS VALUES FOR INTERNAL COMBUSTION ENGINES***<br>*Sorin RAȚIU, Ștefan MAKSAY, Ana JOSAN* |
| S5-44. | ROMANIA | ***STUDY ON THE VARIATION OF CONVENTIONAL FLOW LIMIT DEPENDING ON THE MAIN ALLOY ELEMENTS FOR THERMORESISTANT STEEL***<br>*Amalia Ana DASCĂL* |


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| *S5-45.* | ***ROMANIA*** | ***APPLICATION OF THE SQUIRREL CAGE ASYNCHRONOUS MACHINE WORKING AS SINGLE PHASE GENERATOR IN MICROHYDRO POWER PLANTS***<br>*Sorin Ioan DEACONU, Marcel TOPOR, Gabriel Nicolae POPA, Diana BISTRIAN* |
| *S5-46.* | ***ROMANIA***<br>***GERMANY*** | ***YIELD FACTORS OF A PHOTOVOLTAIC PLANT***<br>*Cristian P. CHIONCEL, Dieter KOHAKE, Ladislau AUGUSTINOV, Petru CHIONCEL, Gelu Ovidiu TIRIAN* |
| *S5-47.* | ***ROMANIA*** | ***PERFORMANCE RATIO OF A PHOTOVOLTAIC PLANT***<br>*Cristian P. CHIONCEL, Ladislau AUGUSTINOV, Petru CHIONCEL, Nicoleta GILLICH, Gelu Ovidiu TIRIAN* |
| *S5-48.* | ***ROMANIA*** | ***PREDICTION OF THE SIGNALS USING THE NEURONAL NETWORKS***<br>*Gelu Ovidiu TIRIAN, Stela RUSU-ANGHEL, Camelia PINCA-BRETOTEAN* |
| *S5-49.* | ***GERMANY***<br>***ROMANIA*** | ***ERROR HANDLING AND MESSAGES WITH APPLICATION SERVER ABAP***<br>*Ana Daniela CRISTEA, Adela Diana BERDIE* |
| *S5-50.* | ***ROMANIA*** | ***CONTRIBUTIONS TO THE IMPLEMENTATION OF THE TELEMETRIC PROGRAMMABLE AUTOMATS BY RTU TYPE FOR AUTOMATION, MONITORING AND CONTROL INSTALLATIONS***<br>*Constantin OPREA, Cristian BÂRZ, Alexandru SEREGHI* |
| *S5-51.* | ***GERMANY***<br>***ROMANIA*** | ***WORKING WITH ABAP PERSISTENT DATA***<br>*Ana Daniela CRISTEA, Adela Diana BERDIE, Mihaela OSACI* |
| *S5-52.* | ***ROMANIA*** | ***CONSIDERATIONS ABOUT NEURO-FUZZY ADAPTIVE SYSTEMS***<br>*Gelu Ovidiu TIRIAN* |
| *S5-53.* | ***ROMANIA*** | ***A STUDY ABOUT A RESISTIVE STEPPED TRANSDUCER USED FOR WATER LEVEL MEASUREMENT***<br>*Gabriel Nicolae POPA, Iosif POPA, Sorin Ioan DEACONU, Corina Daniela CUNȚAN* |
| *S5-54.* | ***ROMANIA*** | ***DISCSP-NETLOGO-EDUCATIONAL SOFTWARE MEANT FOR THE IMPLEMENTATION AND EVALUATION OF THE ASYNCHRONOUS SEARCH TECHNIQUES IN NETLOGO***<br>*Ionel MUSCALAGIU, Diana MUSCALAGIU, Teodora PETRAS, Manuela PĂNOIU* |
| *S5-55.* | ***ROMANIA*** | ***EDUCATIONAL SOFTWARE FOR ANALYSIS OF PARALLEL ALGORITHMS USING PRAM MODEL***<br>*Alexandru-Ştefan OPREAN, Tatiana-Elena DUȚĂ, Manuela PĂNOIU* |
| *S5-56.* | ***ROMANIA*** | ***EDUCATIONAL SOFTWARE METHODS AND STRATEGIES FOR DESIGNING ALGORITHMS BACKTRACKING, GREEDY METHOD AND DYNAMIC PROGRAMMING***<br>*Tatiana-Elena DUȚĂ, Alexandru-Ştefan OPREAN, Manuela PĂNOIU* |
| *S5-57.* | ***ROMANIA*** | ***EDUCATIONAL SOFTWARE FOR THE PRESENTATION OF HYPERBOLOID***<br>*Anca IORDAN, Manuela PĂNOIU* |
| *S5-58.* | ***ROMANIA*** | ***DESIGN OF SEQUENCE DIAGRAMS FOR IMPLEMENTATION OF A DYNAMICAL SOFTWARE FOR DOING GEOMETRICAL CONSTRUCTIONS***<br>*Anca IORDAN, Manuela PĂNOIU* |
| *S5-59.* | ***ROMANIA*** | ***STUDY OF LOW-SIGNAL AMPLIFIERS WITH FIELD-EFFECT TRANSISTORS***<br>*Corina Maria DINIŞ, Corina Daniela CUNȚAN, Gabriel Nicolae POPA, Angela IAGĂR* |

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| S5-60. | ROMANIA | **SIMULATION OF SOME FAULTS IN THREE-PHASE ELECTRIC SYSTEMS USING THE PSCAD-EMTDC PROGRAM**<br>*Angela IAGĂR, Corina Maria DINIŞ, Gabriel Nicolae POPA, Ioan BACIU* |
| S5-61. | ROMANIA | **COMPUTER SIMULATION OF THE FUNCTIONING OF THE OPERATIONAL AMPLIFIER INVERSE TYPE**<br>*Cornelia ANGHEL* |
| S5-62. | ROMANIA | **EXPERMINETAL RESEARCH FOR IDENTIFYING INDUSTRIAL PROCESSES BY STATISTICAL METHODS**<br>*Stela RUSU-ANGHEL, Gelu Ovidiu TIRIAN* |
| S5-63. | ROMANIA | **AUTOMATIC DETERMINATION OF THE MINERAL COMPOSITION OF THE PORTLAND CEMENT CLINKER**<br>*Stela RUSU-ANGHEL* |
| S5-64. | ROMANIA | **MODELING OF THE ENERGY ENTITIES FUNCTIONING USING THE MARKOV CHAINS METHOD**<br>*Raluca ROB, Anca IORDAN, Caius PĂNOIU, Manuela PĂNOIU* |
| S5-65. | ROMANIA | **DETERMINATION OF THE CURRENT HARMONICS INTRODUCED IN THE GRID BY THE D.C.-SUPPLIED CONSUMERS**<br>*Ioan BACIU, Corina Daniela CUNȚAN, Angela IAGĂR* |
| S5-66. | ROMANIA | **ANALYSIS OF A DOUBLE-WAVE ACCURACY RECTIFIER'S OPERATION WITH OPERATIONAL AMPLIFIERS**<br>*Corina Daniela CUNȚAN, Ioan BACIU, Caius PĂNOIU, Corina DINIŞ* |
| S5-67. | ROMANIA | **VIBRATIONS INFLUENCE OVER THE METALLIC ALLOYS CRYSTALLIZATION**<br>*Crenguța Manuela PÎRVULESCU, Constantin BRATU, Ioan MĂRGINEAN, Bogdan Alexandru VERDEŞ, Adrian S. COCOLAŞ* |
| S5-68. | ROMANIA | **FEW TEORETIC ELEMENTARY NOTIONS REQUIRED FOR CHARACTERIZATION OF METAL MELT AND APRECIATION OF BEHAVIOR AT INTERFACE DURING CASTING**<br>*Ioan MĂRGINEAN, Bogdan Alexandru VERDEŞ, Adrian S. COCOLAŞ, Crenguța Manuela PÎRVULESCU, SUSU Cătălin* |
| S5-69. | HUNGARY FINLAND | **STATISTICAL EXPERIMENTAL DESIGN OF THE REMOVAL OF DIFFERENT COMPOUNDS FROM SYNTHETIC WASTEWATER BY MICELLAR-ENHANCED ULTRAFILTRATION**<br>*Szabolcs KERTÉSZ, Junkal LANDABURU-AGUIRRE, Veronica GARCIA, Cecilia HODÚR, Eva PONGRÁCZ, Riitta L. KEISKI* |
| S5-70. | ROMANIA | **FATIGUE TESTS AT HYBRYD ALUMINUM ALLOY JOINTS**<br>*Dinu DRĂGAN, Mircea Cristian ARNĂUTU, Ion SIMION, Nicuşor Laurențiu ZAHARIA* |
| S5-71. | ROMANIA | **ROTORS CASTING FOR AVIATION TURBOCOMPRESSORS**<br>*Ion CHIRA, Bogdan Alexandru VERDEŞ* |
| S5-72. | ROMANIA | **THE PROMOTING, THE PARTNERSHIP AND REGIONAL COLLABORATION OF FOUNDRIES**<br>*Ion CHIRA, Bogdan Alexandru VERDEŞ* |
| S5-73. | ROMANIA | **ANALYSIS OF THE TECHNOLOGY OF STEEL ELABORATION T 35 Mn 14 INTENDED FOR CASTING THE PIECES**<br>*Ana JOSAN, Vasile PUȚAN, Sorin RAȚIU* |


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| *S5-74.* | ***ROMANIA*** | ***MATHEMATICAL MODELLING OF THERMAL STRATIFICATION PHENOMENA IN STEEL LADLES***<br>*Vasile PUȚAN, Ana JOSAN, Lucia VÎLCEANU* |
| *S5-75.* | ***ROMANIA*** | ***DETERMINATION OF TEMPERATURE VARIATION IN THE METALLIC WALL FORMS AT THE STATIC CASTING OF BIMETALLIC MILLING ROLLS***<br>*Gabriela MIHUȚ, Erika POPA* |
| *S5-76.* | ***ROMANIA*** | ***SOLIDIFICATION AND COOLING PHENOMENON IN THE AREA OF STEEL CONTINUOUS CASTING***<br>*Erika Monika POPA, Imre KISS, Gabriela MIHUȚ* |
| *S5-77.* | ***ROMANIA*** | ***MULTIDISCIPLINARY APPROACHES IN THE FIELD OF THE CAST IRON ROLLING ROLLS MANUFACTURING***<br>*Imre KISS, Stefan MAKSAY, Vasile ALEXA* |
| *S5-78.* | ***ROMANIA*** | ***STUDY OF THE MACHINING ERROR DUE TO CONTACT DEFORMATION OF WORKPIECE-FIXTURE SYSTEM***<br>*Vasile George CIOATĂ, Imre KISS* |
| *S5-79.* | ***ROMANIA*** | ***MULTIDISCIPLINARY RESEARCH AREAS FOR INCREASING THE ROLLING-MILL ROLLS QUALITY***<br>*Imre KISS, Vasile George CIOATĂ* |
| *S5-80.* | ***FRANCE*** | ***ADVANCED TECHNIQUES IN ELECTRON SPECTROSCOPY FOR SURFACE AND INTERFACE STUDIES***<br>*Bernard GRUZZA* |
| *S5-81.* | ***ROMANIA*** | ***EXPERIMENTAL RESEARCH IN PILOT PHASES REGARDING THE SEMISOLID STATE PROCESSING OF STEEL***<br>*Daniela-Cătălina MILOSTEAN, Mihaela-Corina FLORI* |
| *S5-82.* | ***ROMANIA*** | ***VIEWING PERIODICAL SYSTEM WITH THE HELP OF MICROSOFT ACCESS DATA BASE***<br>*Sorina ȘERBAN* |
| *S5-83.* | ***ROMANIA*** | ***INFLUENCE OF THERMAL REGIME IN THE CALCULUS OF THE THERMAL STRESSES UPON WARM CYLINDERS***<br>*Camelia PINCA BRETOTEAN* |

# SECTION 6.
# METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES IN THE NATURAL SCIENCE FIELDS

*- focusing on the theory and practice of chemistry and physics, including mathematics, covering the full spectrum of natural sciences in multidisciplinary studies;*

***SUBSECTION 6a.***
***METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES IN THE FIELDS OF CHEMISTRY AND PHYSICS***

***SUBSECTION 6b.***
***METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES IN THE FIELD OF MATHEMATICS***

**MODERATORS:**

| ROMANIA | HUNGARY | SERBIA |
|---|---|---|
| *Georgeta Maria SIMU* | *András ERDŐHELYI* | *Radmila MARKOVIĆ* |
| *INSTITUTE of CHEMISTRY TIMIŞOARA* | *UNIVERSITY of SZEGED, INSTITUTE of SOLID STATE and RADIOCHEMISTRY* | *MINING and METALLURGY INSTITUTE, BOR* |

**PROGRAM SCHEDULE:**

*Faculty of Engineering – Hunedoara*
*Amphitheatre # 2 – Group B, Floor 2*
*Presentations and debates by sections*

| *1ST DAY, Thursday, 23rd April, 2009* | *2ND DAY, Friday, 24th April, 2009* |
|---|---|
| *12.30 – 14.00 and 16.00 – 19.00* | *10.00 – 12.00* |

*Faculty of Engineering – Hunedoara*
*Halls # 1- 2 – Group B, Floor 2*
*Presentations and debates by posters*

| *1ST DAY, Thursday, 23rd April, 2009* | *2ND DAY, Friday, 24th April, 2009* |
|---|---|
| *12.30 – 14.00 and 16.00 – 19.00* | *10.00 – 12.00* |


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## *PROGRAM of PRESENTED PAPERS (oral presentations and posters):*

| *No. crt.* | *Representing the Country:* | *TITLE OF PRESENTED PAPERS*<br>*Authors* |
|---|---|---|
| *S6-01.* | ***SERBIA*** | ***INFLUENCE OF SOME ELEMENTS FROM ANODE COPPER ON CATHODE COPPER QUALITY***<br>*Branislav ČADJENOVIĆ, Radmila MARKOVIĆ, Aleksandra MILOSAVLJEVIĆ* |
| *S6-02.* | ***SERBIA GERMANY*** | ***ELECTROCHEMICAL BEHAVIOR OF COPPER WITH NON-STANDARD IMPURITIES CONTENT***<br>*Radmila MARKOVIĆ, Bernd FRIEDRICH, Jasmina STEVANOVIĆ, Bore JEGDIĆ* |
| *S6-03.* | ***ROMANIA*** | ***SYNTHESIS AND CHARACTERIZATION OF A CATALYST FORMED BY DIRECT INCORPORATION OF SOME HETEROPOLYACIDS INTO MESOPOROUS MATERIALS***<br>*Alexandru POPA, Viorel SASCA, Cătălin IANASI, Orsina VERDES, Livia AVRAM* |
| *S6-04.* | ***ROMANIA*** | ***THE HEAVY METALS MONITORING IN CANNED VEGETABLES MIX***<br>*I. DAVID, F. BERBENTEA, M. ŞTEFANUŢ, L. GEORGESCU, G. BUJANCĂ, T. TRAŞCĂ, M. DANCI, Oana DANCI* |
| *S6-05.* | ***ROMANIA*** | ***BIOCOMPATIBLE MATERIALS REALIZED BY PLASMA THERMAL SPRAYING OF HYDROXYAPATITE ON METALLIC SUPPORTS***<br>*Radu ROŞU, Doru Romulus PASCU, Ioana SAVIN* |
| *S6-06.* | ***ROMANIA*** | ***THERMAL SHOCK BEHAVIOR OF THE COATS DEPOSITED BY PLASMA SPRAYING OF THE $TiO_2$***<br>*Maria Laura BENEA* |
| *S6-07.* | ***HUNGARY*** | ***PREPARATION AND CHARACTERIZATION OF GOLD NANOCLUSTERS WITH COADSORBED METALS***<br>*János KISS, András BERKÓ, László ÓVÁRI, László BUGYI, Zsolt MAJZIK, Nándor BALÁZS* |
| *S6-08.* | ***HUNGARY ROMANIA*** | ***POSSIBLE USE OF METAL COMPLEXES OF POLYAMINOPOLYPHOSPHONIC ACIDS***<br>*Imre LABÁDI, Károly MOGYORÓSI, Ecaterina PRINCZ* |
| *S6-09.* | ***HUNGARY*** | ***DEGRADATION OF PURE AND WASTE PVC AND PET IN THE PRESENCE OF MODIFIED POROUS CATALYSTS***<br>*János HALÁSZ, Kinga VŐNEKI, Judit KRAJKÓ* |
| *S6-10.* | ***HUNGARY*** | ***STEAM REFORMING OF ETHANOL ON ALUMINA SUPPORTED NOBLE METAL CATALYSTS***<br>*Márta DÖMÖK, Kornélia BAÁN, István SARUSI, Albert OSZKÓ, András ERDŐHELYI* |
| *S6-11.* | ***HUNGARY*** | ***DIODE LASER BASED PHOTOACOUSTIC INSTRUMENT FOR AMMONIA CONCENTRATION AND FLUX MONITORING***<br>*A. POGÁNY , Á. MOHÁCSI, Z. GALBÁCS, T. WEIDINGER, L. HORVÁTH, A. VARGA , Z. BOZÓKI, G. SZABÓ* |
| *S6-12.* | ***HUNGARY*** | ***DEMONSTRATION OF THE APPLICABILITY OF NOVEL PHOTOACOUSTIC AEROSOL MONITOR FOR OPTICAL ABSORPTION COEFFICIENT DETERMINATION – LABORATORY AND FIELD TEST***<br>*T. AJTAI, M. SCHNAITER, C. LINKE, M. VRAGEL, Ágnes FILEP, Lajos FÖDI, Gábor MOTIKA, Z. BOZÓKI, G. SZABÓ* |

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| S6-13. | **HUNGARY** | ***ENVIRONMENTAL IMPACTS OF NITRATE AND NITRITE***<br>*Gábor NAGY, Zoltán GALBÁCS* |
| S6-14. | **HUNGARY** | ***NITRATE IN TOBACCO - ANOTHER SOURCE OF DANGER OF SMOKING***<br>*Gábor NAGY, Zoltán GALBÁCS* |
| S6-15. | **HUNGARY** | ***ROCK EVAL PYROLYSIS AS A TOOL FOR CHARACTERIZATION OF ORGANIC MATTER IN SOIL SAMPLES***<br>*Tünde NYILAS, Marianna IMRE* |
| S6-16. | **HUNGARY** | ***SUPPORTING THE REASONABLE AGRICULTURAL PRODUCTION WITH A NEWLY FOUNDED ENVIRONMENTAL LABORATORY IN THE SOUTH EASTERN REGION OF HUNGARY***<br>*Gábor NAGY, Tünde NYILAS, Szilvia ÖRDÖG, Anita VOLFORD* |
| S6-17. | **HUNGARY** | ***ARSENIC PROBLEM AND POSSIBLE SOLUTION FOR DRINKING WATER***<br>*Tamás BUJDOSÓ, Ágnes PATZKÓ, Zoltán GALBÁCS, István LICSKÓ, Imre DÉKÁNY* |
| S6-18. | **HUNGARY** | ***OXIDATIVE TREATMENT OF PHENOLIC WASTEWATERS: DETEMINATION OF THE EFFICIENCY OF FE-CONTAINING CATALYST***<br>*Adrienn BANGÓ, János HALÁSZ* |
| S6-19. | **ROMANIA** | ***THERMODYNAMIC STUDY OF A SYMMETRICAL DISAZO DIRECT DYE DERIVED FROM 4,4'-DIAMINO-BENZANILIDE ON MERCERIZED COTTON***<br>*Georgeta Maria SIMU, Simona FUNAR-TIMOFEI, Gianina BALŞ* |
| S6-20. | **ROMANIA** | ***INCLUSION COMPLEXES WITH A SYMMETRICAL DISAZO DYE WITH α- AND β-CYCLODEXTRINS***<br>*Gianina BALŞ, Georgeta Maria SIMU* |
| S6-21. | **ROMANIA** | ***OPTICAL STUDY OF STEEL SURFACES AFTER THERMOCHEMICAL TREATMENT***<br>*Simion JITIAN* |
| S6-22. | **ROMANIA** | ***DETERMINATION OF THE ROUGHNESS LEVELLING DEPTH FOR METALLIC SURFACES BY OPTICAL MEASUREMENTS BASED ON THE LIGHT REFLEXION***<br>*Simion JITIAN* |
| S6-23. | **ROMANIA** | ***DETERMINATION OF OPTICAL CONSTANTS OF POLYMER FILMS THROUGH REFLECTION***<br>*Simion JITIAN* |
| S6-24. | **ROMANIA** | ***A THREE DIMENSIONAL AXI-SYMMETRIC MODEL FOR THE BLOOD FLOW IN THIN VESSELS***<br>*Sonia PETRILA, Balázs ALBERT* |
| S6-25. | **ROMANIA** | ***MATHEMATICAL MODEL FOR THE BLOOD FLOW IN CAPILLARY VESSELS***<br>*Sonia PETRILA, Balázs ALBERT* |
| S6-26. | **ROMANIA** | ***CONSIDERATIONS UPON THE $C_R^2$ TRUNCATED EXPONENTIAL DISTRIBUTION***<br>*Ştefan MAKSAY, Diana A. BISTRIAN* |
| S6-27. | **ROMANIA** | ***ON H-TRICHOTOMY IN BANACH SPACES***<br>*Codruța STOICA, Mihail MEGAN* |
| S6-28. | **ROMANIA** | ***ASYMPTOTIC BEHAVIORS OF STOCHASTIC EVOLUTION COCYCLE***<br>*Diana STOICA* |


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| *S6-29.* | ***SERBIA*** | ***SOME DISADVANTAGES OF STANDARD BUCKLING ANALYSIS COMPARING TO INCREMENTAL GEOMETRIC NONLINEAR ANALYSIS***<br>*Ivana MATIJEVIĆ, Dušan KOVAČEVIĆ* |
| *S6-30.* | ***ROMANIA*** | ***SOME GENERALISATION OF THE BARTLE, DUNFORD AND SCHWARTZ INTEGRABILITY MODEL***<br>*Octavian LIPOVAN* |
| *S6-31.* | ***ROMANIA*** | ***THE BENDING OF THE FINITE ELASTIC ROD ON ELASTIC FOUNDATION UNDER THE ACTION OF CONCENTRATED LOADS***<br>*Wilhelm W. KECS* |
| *S6-32.* | ***SWITZERLAND ROMANIA*** | ***FURTHER CONSIDERATIONS ON THE FORMAL VERIFICATION OF NUMBER THEORETICAL ALGORITHMS***<br>*Laura Ildikó KOVÁCS, Adalbert KOVÁCS* |
| *S6-33.* | ***ROMANIA AUSTRIA*** | ***CONSIDERATIONS ON THE CALCULUS ALGORITHM OF THE FLUID'S VELOCITY POTENTIAL THROUGH PROFILE GRIDS***<br>*Adalbert KOVÁCS, Laura Ildikó KOVÁCS* |
| *S6-34.* | ***ROMANIA*** | ***DENSITY OF POLYNOMIAL REPARTITIONS***<br>*Stefan MAKSAY, Diana STOICA* |
| *S6-35.* | ***ROMANIA*** | ***NUMERICAL METHOD FOR SPATIAL STABILITY ANALYSIS OF A VORTEX STRUCTURE AT HIGH REYNOLDS NUMBERS***<br>*Diana A. BISTRIAN, Ştefan MAKSAY* |
| *S6-36.* | ***ROMANIA*** | ***BOUNDARY ADAPTED SPECTRAL APPROXIMATION FOR SPATIAL STABILITY OF BATCHELOR VORTEX***<br>*Diana A. BISTRIAN, Ioana F. DRAGOMIRESCU* |

# INFORMATIVE MEETING

- *discussing the topics:*

- ***REGIONAL INTEGRATION**, concerning the expanding of the application area for the transferable credit system between the specialized faculties and universities from HUNGARY, SERBIA and ROMANIA, educational and pedagogical issues common for this countries, as well as problems regarding the extending of connections between the institutions on educational matters, teaching and specializing processes and co-operation between professors and students.*
- ***EXTEND AREA OF ISIRR**, discussing about the expanding possibilities of the ISIRR in BULGARIA and SLOVAKIA.*
- ***ISIRR FOR ISI PROCEEDINGS APPLICATION**, discussing about the possibilities to accede into international databases for recognize the ISIRR as important Symposium in this area.*
- ***THE 11th ISIRR**, organized in Szeged, HUNGARY, in preliminary discussions.*

***MODERATORS:***

**ROMANIA**
*Nicolae FARBAŞ*
*– head of ASSOCIATION for MULTIDISCIPLINARY RESEARCH of the WEST ZONE of ROMANIA (ACM-V) – TIMIŞOARA*

**HUNGARY**
*Imre DEKÁNY*
*– president of HUNGARIAN REGIONAL ACADEMY OF SCIENCES, DEPARTMENT of COLLOID CHEMISTRY, UNIVERSITY of SZEGED*

**SERBIA**
*Mirjana VOJINOVIC-MILORADOV*
*– UNIVERSITY of NOVI SAD, FACULTY of TECHNICAL SCIENCES, NOVI SAD*

***HOSTS:***

**ROMANIA**
*Teodor HEPUŢ*
*– dean of the FACULTY of ENGINEERING – HUNEDOARA UNIVERSITY POLITEHNICA TIMISOARA*

**ROMANIA**
*Imre KISS*
*– scientific secretary of the ISIRR 2009, FACULTY of ENGINEERING – HUNEDOARA, UNIVERSITY POLITEHNICA TIMISOARA*

***PROGRAM SCHEDULE:***

*Faculty of Engineering – Hunedoara*
*in the Council Chamber of the Faculty of Engineering*
***2ND DAY, Friday, 24th April, 2009***
*12.30 – 13.30*


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*Dear Participants,*

*We invite you cordially to participate at the* ***10th INTERNATIONAL SYMPOSIUM "INTERDISCIPLINARY REGIONAL RESEARCH" – ISIRR 2009 – ANNIVERSARY EDITION****, which will be held in* ***Hunedoara – ROMANIA****, in* ***April, 23rd – 24th, 2009****.*
*The previous Symposiums, held in HUNGARY, SERBIA and ROMANIA since 1996, proved to be an efficient, convenient and amicable way of exchanging ideas on relationships of multidisciplinary research areas, and will ensure an exchange of scientific information and didactical opinions in fields with an impressive dynamic considering the research and the technological progress.*
*The Symposium will also provide the opportunity for exchanging ideas and experience with our colleagues coming from* ***HUNGARY****,* ***SERBIA*** *and* ***ROMANIA*** *and for developing new scientific collaboration.*
*This time, the Symposium is again organized jointly by the* ***Association for Multidisciplinary Research of West Zone of Romania – Timișoara****, through the* ***Faculty of Engineering – Hunedoara****. The Symposium will be held in the* ***FACULTY OF ENGINEERING – HUNEDOARA,*** *at* ***Revolutiei Street 5, Hunedoara, ROMANIA****.*
*The Symposium is an open invitation for all specialists, professors, researchers and experts in all scientific fields, who can produce a free presentation of the results in their activities. There will be oral and poster presentations.*
*The Symposium includes* ***plenary sessions****,* ***work-shops****,* ***poster presentations****,* ***informative and agreement actions****. The papers of a high scientific level will be presented during the Symposium, while the rest of the papers will have a poster-form presentation.*
***Oral presentation****: Invited speakers will have* ***20 min****, and other participants* ***10 min*** *(****+ 5 min*** *for discussion).*
***Poster presentation****: The maximal width of posters is* ***90 cm****, and the length,* ***140 cm****.*
*Date: Thursday,* ***23rd*** *– Friday,* ***24th*** *of* ***April, 2009****.*
*The official language at the Symposium is* ***English.***
*The organizers look forward to your participation and presentations, and hope that the Symposium will further promote regional cooperation on relationships of multidisciplinary research areas.*

*Regional Organizing Committee*





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## ***SYMPOSIUM TOPICS***

### ***SECTION 1.***
### ***ECONOMICAL DEVELOPMENT AND STRATEGIES IN OUR REGIONS AND ABROAD***

*- focusing on problems concerning the general field of economics and management, the European Integration of our countries, the differences between the development of the regions from Eastern Europe and the management of diminishing unfavourable differences, including aspects regarding the globalization and economy of small and medium enterprises, human resources, management strategies and organization behaviour, provides a leading forum for interaction and research on the competitive strategies of managers and the organizational structure of firms;*

### ***SECTION 2.***
### ***MEDICAL ISSUES, LABOR HEALTH AND VETERINARY MEDICINE***

*- focusing on novelties in medical studies and veterinary medicine, medical advice, diagnoses and treatment, including new knowledge on pathogens, immunity to pathogenic micro-organisms, epidemiology related to infections, specific aspects of treatment of diseases, pathological and clinical studies (including case reports), diagnosis tests and technical reports, as well as labour related accidents and professional diseases;*

### ***SECTION 3.***
### ***APPLIED ECOLOGY AND ENVIRONMENTAL PROTECTION IN THE REGION, INCLUDING BIOLOGY***

*- focusing on the management of the city and on industrial waste materials, debating issues concerning the environmental engineering, the environmental impact analysis and assessment, the industrial and urban environmental management, the cleaning process, pollution agents and pollution sources, water – air – soil quality analysis, the reutilisation of industrial wastes and the diminishing of pollution and the environmental planning and environmental protection in the regions of the Eastern Europe area;*

### ***SECTION 4.***
### ***USES OF NATURAL RESOURCES IN REGIONS, MINING, ENERGY CONSERVATION AND PLANNING, INCLUDING AGRICULTURE***

*- focusing on general fields of industry, mining, agriculture, forestry, botany and horticulture, hydrology, biotechnology, material and energetically resources, including energy conservation and planning and alternate energy development, in multidisciplinary studies;*




## ***SECTION 5.***
## *APPLIED SCIENCES AND TECHNOLOGIES –*
## *MANUFACTURING AND RESEARCH IN ENGINEERING FIELDS*

### ***SUBSECTION 5a.***
### *APPLIED SCIENCES AND TECHNOLOGIES –*
### *MANUFACTURING AND RESEARCH IN MECHANICAL ENGINEERING*

### ***SUBSECTION 5b.***
### *APPLIED SCIENCES AND TECHNOLOGIES –*
### *MANUFACTURING AND RESEARCH IN INFORMATICS & ELECTRICAL ENGINEERING*

### ***SUBSECTION 5b.***
### *APPLIED SCIENCES AND TECHNOLOGIES –*
### *MANUFACTURING AND RESEARCH IN MATERIAL SCIENCE ENGINEERING*

*- focusing on engineering science and practice, covering the full spectrum of engineering theory and practice, including studies involving the application of physical and mathematical techniques to fundamental investigations and emerging areas within the engineering fields, incoming with information from a wide variety of applied science specialties in multidisciplinary studies;*




## ***SECTION 6.***
## *METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES*
## *IN THE NATURAL SCIENCE FIELDS*

*- focusing on the theory and practice of chemistry and physics, including mathematics, covering the full spectrum of natural sciences in multidisciplinary studies;*

### ***SUBSECTION 6a.***
### *METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES*
### *IN THE FIELDS OF CHEMISTRY AND PHYSICS*

### ***SUBSECTION 6b.***
### *METHODS AND TECHNIQUES, INSTRUMENTS AND SUPPLIES*
### *IN THE FIELD OF MATHEMATICS*

***&***

## ***INFORMATIVE MEETING***



ISIRR 2009 ROMANIA - HUNGARY - SERBIA

# THE ANALYSIS OF THE SALE PROMOTION-LIKING IN THE GROUP OF THE YOUNG

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**Abstract**

Nowadays the market is saturated. All enterprises want to sale more and more themselves products. Because of it, they have to use elements of marketing mix; for example: the sweepstakes. In my work I examined, is this means really effective, and do the people like it. To the reach my aim I made a questioner, and filled it with students at age of 14 - 22. The number of filled questioner is 200. I analysed the opinions only in food-sweepstakes, because this products are bought by everyone in everyday. The main resources are: The 77% of the answerers have heard about this means. The most of them have got their information in TV. However the most of young think the food-sweepstakes is senseless, they said, it is good thing, because everybody have to purchase food, and also if you can win something it is nice. Students like send to answers or the codes by email and sms, but the most likely possibility is the honouring the coupons in shops. The prize is important for the questioned. The 45 % of the answerers won some presents under the 1000 Ft-price, for example: chocolate, drink, sweet.

**Keywords**

Sale promotion, sweepstake, questioner

## 1. INTRODUCTION

Nowadays people can choose from a really lot of food in the shops. The factories have to use a many kinds of sale promotion. The one of these manners is the sweepstake.

The sale promotion is a marketing-method, which inspires directly the consumer, it offer the special value with the purchasing. The advertisement gives the cause; the sale promotion gives inducement for the shopping (Hoffmann, 2004.).

The advantages of the sale promotion are:

It is a popular manner from both side – producer and buyer too. It may be quickly put on the market and quickly stop. It can be successful in short time, but in long time it affect to the image of the company. It help to build connect between the producers, the commerce and the consumers. It helps to difference between the similar products. The disadvantages are: the sale of concrete product has grown, but the other – substituting - product has diminished. The cost of sale promotion can be more than its profit. The consumer has tired, has not carried an article (Bérczi, 2003.).

The main territories of the sale promotion are: the consumer, the trader and the seller. In the first case the main aim is the calling the attention, for example with presents, or tasting. The other aim is the additional promotion, which means: competitive, drawing, bonus points or sweepstakes. In the second case (commercial) the main aim is the conviction of the trader with keeping a connection, studying or the product-preview. In the third case the main means are: study or support (Kotler, 2006.)

## 2. MEANS AND METHODS

The sweepstakes is a game and a joy and a fortune. It is near to the young people. So I have chosen this age-group for analysing their habits. I made a questioner and had filled in with students' age of 14-22. They study in secondary school and at the university. The most

important themes are: if they like the sweepstakes or not, what kind of sweepstakes they like, where they have listened about it, how often they buy such food, have an influence on their shopping, have they ever won wit h this game.

I have got 200 filled questioners, and I analysed them with STATISTICA 8 programme.

## 3. RESULTS

At first I present the demographic characters: The asked' sexes are: 37% women, 63 % man. The 50% is from secondary school, the 50% study at the university. The 60% of the filler live in county town, 21% in a city and 19% in a village. The87 of them usually make their shopping in county town, 9% in a city and only 4% in the village.

In the first diagram we can see the division of the opinion about the usefulness of the food-sweepstakes. The 30% of the asked think, that it is a pointless thing, but the other said it is a good idea for promotion (19%), for win (18%) or for funny (14%). 8% -8 % told that it is a swindle, because have decided who will win or they are indifferent. And only 3% (6 students) thing, that it is only a mood of a prise-rising.

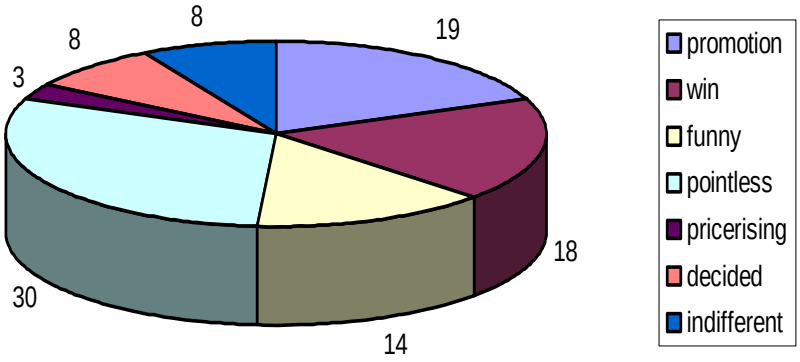



Fig. 1. The division of the opinions about the sweepstakes

The most of students (77%) have heard about the food-sweepstakes, they gathered their information from the TV (25%), Internet (12%), radio (7%), newspaper (10%), ad paper (10%), shops (11%), leaflet (10%), poster (8%) and friends (7%).

In the next question I asked young people, that is it good idea or not if a food is in this game. 35% think "yes", because people must buy food, so it is a specially occasion to win something. The other 35% told, it is indifferent, because they have to buy food. The 16% of the think it is promote for purchasing, but 14% are pessimist: they said for the winning people buy more and more food, but they can not to eat them, so the foods go bad.

The one of the different opinions is that the sweepstakes increases the price. In the next question I asked about it the answerers. The most of them (69%) said, it does not add to the price. The 25% told me, that food will be more expensive, if they are in this game, and the others (6%) thought foods will be cheaper.

In the sweepstakes people can do changeable mood of the games. I wondered what kind of methods like young (figure 2.). The most popular in the group of students (47%) is the shop-exchangeable thing (points, coupons, etc). The second beloved deal (35%) is to send an answer by e-mail (because of it is free and comfortable). The 25-25% like the coupons and the answer send by sms. Student do not like too much the sending by post office - it is too "complicate" for them.

And the last question in this theme was about the motivation. I asked young people, if it was important or not, what was the prize. 83 % of them is motivated by the prize.. the other does not matter with it.

The next theme of the questioner is the buyer-habits. At first I would like to know, if the asked were looking for food in sweepstakes or not. The half part of them has never sought this food. The 46% of this people hunt them, if it is interesting, and only 2% said, that they always buy these articles.

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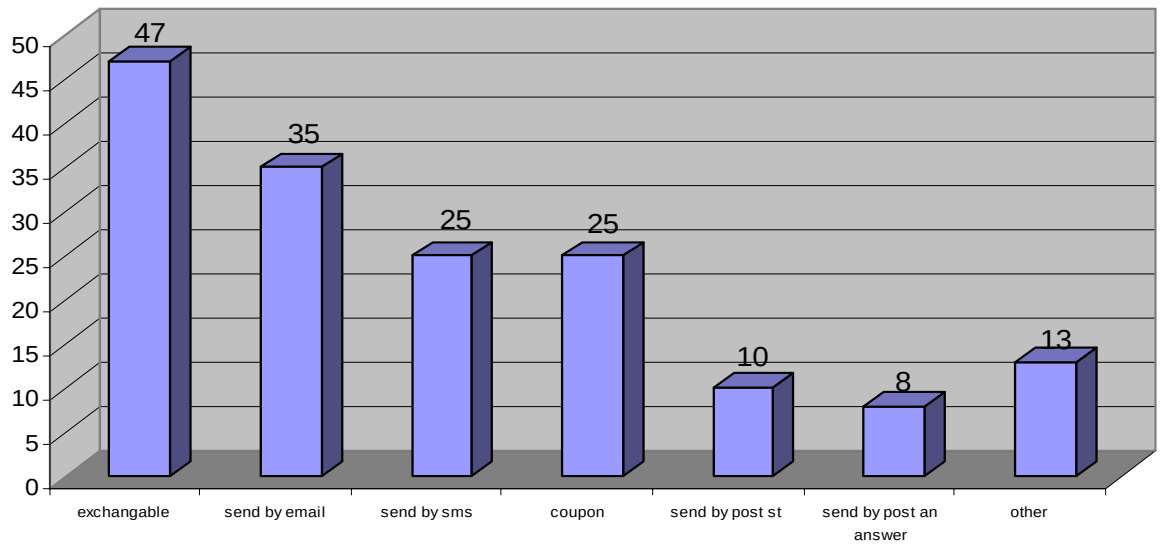



Figure 2. The division of the students about the mood-liking

On the 3rd figure we can see, how often buy the sweepstakes foods the young people. The part of them rarely does it, 17% of them monthly, and only 4 % weekly or daily. The 13% of them have never bought this kind of food. The 1/10 part of students chose the "other" opportunity, for example, if they hear about a good sweepstakes, buy more often than generally.

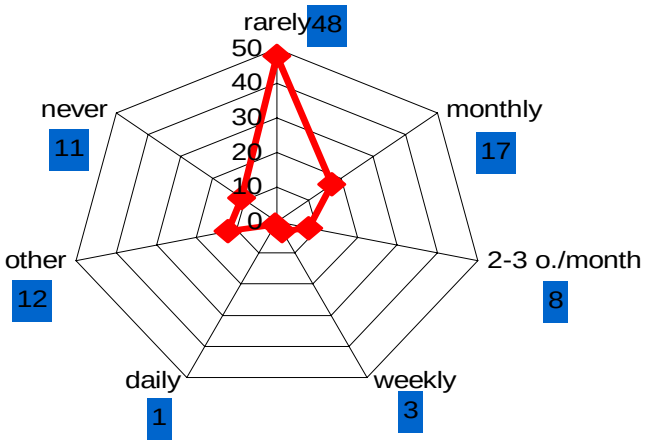



Fig. 3. The division of the answerers about the frequency of the shopping

I asked students if they bought a food only because of the sweepstakes. The 12,5% do it, 87,5% do not. The most part (88%) of these 25 students buy only 1-2 pieces, and 12% buy a lot, they really want to win.

The next situation is: there are 2 similar articles, one of them is in sweepstakes, and the other is not (fig. 4.). The 46% of the students choose the beloved article, irrespectively of the sweepstakes. If the price is same, the 25% buy the winner. If the price is different, only 1% shops the goods in game, 6% told me, they choose the winner, only if its price is not too high and 6% will cull the cheaper. 12% of them will take the better quality, and 4% said it is depend on the prize.

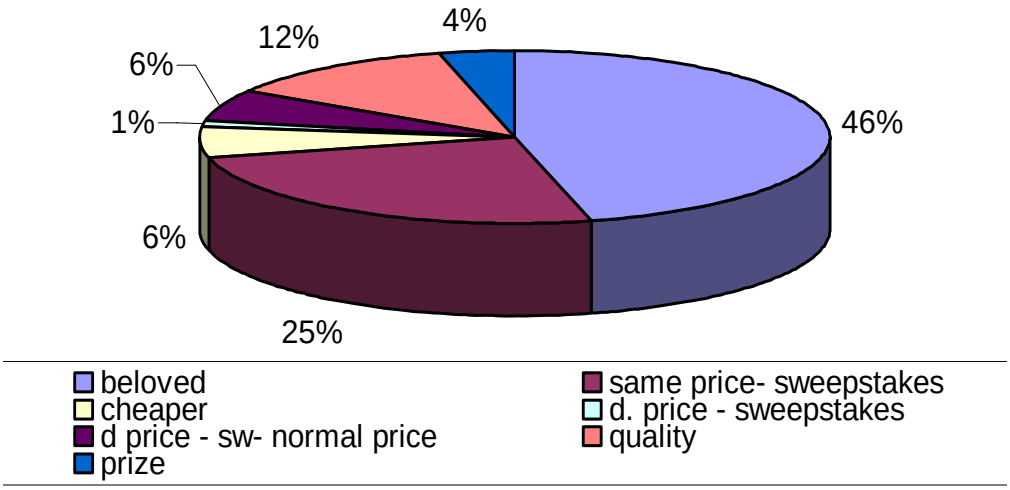



Figure 4. The division of the students about their choice from two articles

At last I wondered about the prizes, have the students ever won something. The bigger part (58%) of them has won, a lot of them (45%) something less then 1000 HUF, for example chocolate, chips, pen, cap, cup, etc. The 9% won more expensive things: CD, perfume, cinema tickets, book, t-shirt, etc. 10 student won really value things: DVD player, camera, bicycle, VIP concert tickets. Some of them (18%) have changed their habits; often buy food if it is in sweepstakes.

## 4. SUMMARY

Everybody must to eat, so everybody must to buy food, so everybody. In my work I made an analysis about a young people's habits. 200 people - 14 – 22 years old students - filled in my questioner. The main results are the followed:

The half part of them thing it is a good thing, 30% said it was pointless;

- 77% of them have ever heard about this game, most of them from the television;
- 69% of the filler thing the sweepstakes was not effect to the price;
- Them most of student favourite to collect something (points, pieces, etc) and after it they can to exchange them for the prize;
- The win inspires 83 % of young people for the shopping.

By the analysing I have found out, that the students had have heard about the sweepstakes, they liked it, but their consumer shopping habits had has not change because of it.

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# MENTAL MAPPING IN GEOGRAPHICAL APPROACH AND REGIONAL ENVIRONMENTAL DISPARITIES AT FRONTIERS

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**ABSTRACT**

Literature follows with attention the process of globalization and inter-regionalisation of environmental market. It offers and requests new possibilities and demands in agriculture too. Using of new, modern technologies in developed countries and conserve outmoded ones take difference among different less-developed and developed countries of the world. Well-known, environmental pollution does not know frontiers, so the gap between countries can be huge. What is the situation and what we can do in this area? Where to invest to win the best output?

Speaking about values we can find different measures in different countries. It takes many difficulties against how to solve problems. One is the most important factor is the disparity of short-term and long-term interests.

It has subjective and objective ways to transform and understand. People often create preconception by their mental map and connect territories and problems. It is not so simple.

We can assert reduction of over mentioned situation can be stimulated. Discrepancy and discrepancy along areas of frontiers cannot sustainable, mainly not in Central and Eastern Europe.

## 1. INTRODUCTION

The process of internationalization can be observed in the case of environmental programs, as well. The importance of financial funds that stimulates new technologies is increasing. This way the emphasis has been put on prevention from cleaning and controlling. It is realized differently in the case of countries on different levels, as the change to a reasonably modern technology from an undeveloped one is a significant leap forward in Eastern Europe. The problem is that the developed world appreciates only „future technologies". The structure of environmental market in Eastern and in certain Central European countries will be similar to the earlier structure of EU, whereas a certain change in structure is proceeding towards integrated, intensive solutions in developed world. At the boundaries of regions we can often find different indexes, different measuring technologies, and significant differences in attitude (e.g. Finland and Russia) but – mainly in the case of smaller countries – the only solution is reduction of these differences and elaboration of common, harmonized solutions. The members of EU question the unification of problem management in big regions because of their disparity in measurement. Only a unified measuring technology and index system can be regarded as the basis of objective judgment of processes. An essay from Brussels confirms it. (Communication from the Commission 2003) This question is particularly problematic in the successor states of the Soviet Union, as they consider certain cases as successful ones but according to other methods these cases can be valued very modest. Placing the capital outside EU appears in this field, too, so its specific efficiency can be multiplied. Nevertheless, the process (stimulation) of abandonment of conflict between the long-term interests of environment, and the short-term interest of economy has begun in the Central and Eastern European countries-with different intensity and methods.

A kind of idea about the future is required in which different regions can develop in intensive division of labour and not in subordination to each other. The territorial inequality is lessening, the main centers of development are regions and counties, and their cooperation with other regions along the borders creates the opportunity to join the European integrating processes (Gal, J. – Valko, L. 1998). Discrepancies where countries in different state of development can be found will get more important role.

The environmental responsiveness of governments in these countries is very different. A number of enterprises deal with production, development of environmental technology and with environment protection. The role the government takes has an impact of crucial importance on them. Deriving from the nature of the market, only smaller amounts are typical that are rarely supplemented by a bigger order. This situation requires flexibility, significant capital from the enterprises; therefore a lot of them cannot survive in the rapidly changing market. From the prospect of demand the legal regulation, the lawful behavior of enterprises ensure motivation, and the pulling-impeding-moving unity of market mechanism, too, which is able to move the situation from its deadlock. The condition of its function is that it affects the whole economy including the society. In this terminology „impediment" means that we have to prevent materials, energy, products from leaving the process of production and consumption too soon. It should be realized within national frames. Regulation supporting the pull factor removes by-products from the system and it does not let it accumulate to harm the environment. Recycling, collection and managing of waste materials play important roles in this process. Most processes have regional impacts, so the role of cooperation is appraised. Only a small part of these activities can be done on purely market base, in most cases the token of effective solution is in the hand of the state. We can find both good and unacceptable examples for it in Central and Eastern Europe. For instance, Austria's efforts prove that results can be reached in the fields of collection of paper refuse and its use as a second raw material etc.-, which projects have failed in other, mainly Eastern European, countries.

The judgment of environmental market is changing into a favorable direction in Central and Eastern Europe because of the accepted positive externalities of the environment protection. Its effect can be observed in the legal phase, in regional development, in manpower market and in other innovative processes, as well.

## 2. DISCUSION

The above mentioned facts are supported by a study from Tubingen (Valko L. 1998), according to which 45% of the Western European environment technical enterprises can survive the first 5 years, and only 35% of them the first 10 years. It is mentioned that the condition of survival is that the given enterprise can comprehend the whole market scale from planning through analysis, consultation, execution, operation, and service to the after-care. An enterprise with only one of these activities financially runs a grave risk. Long-term situation of services with oversupply in environmental market is getting more risky comparing to firms presenting intensive environmental technique, technology. The condition of survival is adjustment to the regional and local conditions, this way the role of eco-marketing is going to be appraised. In this context the state's role can be mentioned again, and the dynamic effect of steps that increase demand. There are regional programs not only in EU but in discrepancies, as well. Regional approach is supported by the fact that Eastern European countries that were excluded from joining in 2004 should change their environmental policy and their environment economical programs rapidly, since their backwardness is significant.

Chart no 1
National Environment Protection Program II Hungary
Source: NKP-II

| TAP megnevezése | A 2003-2008 közötti időszak teljes költsége (mFt) | kp-i költségvetésből (mFt) | % |
|---|---|---|---|
| 1. Quality of urban environment | 1.626.561 | 900.647 | 29,3% |
| 2. Water protection and sustainable use | 1.095.875 | 680.100 | 19,7% |
| 3. Change of climate | 961..273 | 262.575 | 17,3% |
| 4. Health and safety | 682.273 | 386.757 | 12,3% |
| 5. Use of fields | 541.752 | 245.046 | 9,7% |
| 6. Waste management | 363.000 | 94.817 | 6,5% |
| 7. Biodiversity and ecological protection | 181.166 | 106.706 | 3,3% |
| 8. Safety of environment | 64.527 | 61.677 | 1,2% |
| 9. Development of environmental awareness | 40.577 | 32.612 | 0,7% |
| Together: | 5.556.820 | 2.770.937 | 100,0% |

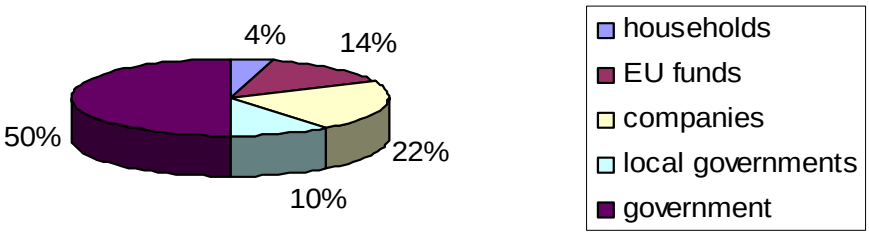
In the National Environment Protection Program II Hungary (chart no 1) has formulated a thematic action program and has planned expenses which show that harmful effects of urbanization and water protection claim the highest expense. These two problematic fields are typical of the Central and Eastern European countries. Technical-technological side of solution is ensured in these countries; the problem is the lack of financial sources. It is worth examining what distribution of sources Hungary planned in order to realize her planned obligation. I suppose that the proportions are similar in other joining countries, as well. The situation is entirely different in the case of other

countries as the rate of EU-funds is essentially smaller. The source-proportion (diagram no 1) coming from the central and municipal budgets exceeds 60%, EU makes a contribution of 13,9 % to it, and finally, there is a problematic self-share, as well.

In the early 60's American psychologists and geographers modeled a special method of cartography, which is surveying the familiarity with a place by means of the mental map. With the mental map we analyze the map formed in people's brain about their immediate environment.

Diagram no 1
Distribution of financial means in Hungary 2003-2008
(planned)

Source: NKP-II




This method helps us to see which places, flows approaching solutions are known for the inhabitants of a settlement; according to the data we can get a picture about the question that which the most interesting and the less interesting environmental impacts are, where the cardinal points of a region or a town can be found. It is worth comparing these notes with the mental maps of those who are interested in the environmental flows.

The answers to these questions help us to examine which are the questions about the areas that have aroused the people's attention and which are we have to highlight.

To serve this purpose we have to introduce the following terms: region, factors that form the region, regional development, environmental conditions. Then we show the development of the region and the immediate environment, together with the advantages and disadvantages that follow the development of the given area. If a really consistent and environmentally friendly transformation is expected, it is worth calling the attention to it.

For the sake of the efficient teaching-learning form the students should be able:

- to analyze the typical region according to different points of view,
- to recognize the typical region with the help of pictures and descriptions,
- to recognize and to name its most important features,
- to make a drawing about the region, to make a description of it,
- to try to imagine and to draw the possible future changes of the typical region,
- to inform about the rehabilitation of an environmentally destroyed region from different sources of information.

The question of the method of the process is very important here. It is the most obvious to make a task sheet where the following methodological possibilities can be exploited well:

- to draw a region on the basis of their knowledge and experience,
- to make a description of a region on the basis of lesson experiences, visual or map information,
- to analyze a region according to some given points of view,
- to make students recognize the process of a regional development with ordering pictures and drawings,
- comparative regional analysis on the basis of a written text (for example the same region in different times or different regions in the same time).

The analysis was about a region at border of Romania, Serbia and Hungary by means of which it was possible to show the connection between man and his environment, and it pointed out how the natural region became economic region.

Global problems of our environment has been revealed during decades, and at the same time the favorable counter moves have been formulated more accurately. Content of these frameworks (international organizations, contracts, financial funds etc.) depends on the responsibility taken by the region and nation. The level of environmental knowledge of nations and the available system of means move on a very wide scale. Therefore, the different short-term interests of developed and undeveloped countries have a significant impact on the international cooperation of environment protection. It

seems that the most effective way of managing global problems is the cooperation between small regions. This solution is able to handle regional disparities and discrepancies above all. In the Central and Eastern European countries the regional cooperation has been getting stronger in most regions since the 90's –after the former political alliance system had collapsed. „Visegrád countries", Carpathian-Europe-Region, Alps-Adria or the league of Vajdasag, Transylvania and South-Eastern Hungary are good examples for it. In the field of environmental protection these cooperation could not have results that would take their environmental status closer to the Western European level. The main reason for it is the lack of financial sources.

## 3. CONCLUSIONS

As a result of a new attitude on both sides of discrepancies the more developed country stimulates the environmental problems, rehabilitation of the less developed one with her increased role. In the case of Austria and her Eastern neighbours the regional environmental investments can bring bigger benefit for the less developed countries but at the same time they have a positive effect on the whole region, as well. According to a certain research the economical and ecological profit of Austria's foreign environmental investments can be the triple of the same investment inside the borders of Austria.

This change means that environment political principles have new definitions, so does the principle of prevention which emphasizes the efficiency of prevention as opposed to rehabilitation of damages. The principle of the individual, who caused damage which says, that this individual has to bear the costs of rehabilitation. The principle of subsidiary, which says that adequate steps have to be taken on the most efficient institutional level. The principle of cooperation and harmonization which attempts to synchronize the environment protection policy of different countries in the interest of the most favorable output. According to the principle of compatibility the environment policy should be integrated into the work of other fields, so it has to be in harmony with the social and economical policy.

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# ONLINE TRANSMISSION OF TAX RETURNS – A STRATEGIC GOAL OF SERVICE E-GOVERNMENT IN ROMANIA

ISAC Alin, ISAC Claudia

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**Abstract:**

Implementation of e-government in Romania is a complex process related to the development of this system at European and international, the legal framework is the national strategy for promoting the new economy and implementing the information society and Government strategy computerization of public administration. In the paper after a brief overview of the strategic objectives of widespread on-line transmission of all the tax returns of the economic and a brief analysis of the current provision of these services, we reveal the types of relations existing in the information carried by e-government in Romania.

**Keywords:**

e-government, information society, on-line transmission, G2B, B2G

## A. STRATEGIC GOAL OF SERVICE E-GOVERNMENT IN ROMANIA

In order to understand the role and the place held by e-Government processes in implementing modern public strategies, it is important that these processes, which in Romania [1], started in an empiric form together with the development of technologies based on the Internet, be approached step by step.

The implementation of e-Government in Romania is a complex process correlated with the development of this system on European and on international level, while the legal framework is represented by the National strategy for promoting new economies and implementing computer systems, as well as the Government Strategy regarding the information technology of public administration. In this respect, a series of Government specialists, specialists from the Group for Promoting Information Technology, from the Ministry of Communication and Information Technology, from research institutes, from universities or other public institutions and non-governmental organizations aim at coordinating on strategic level and integrating information systems on national level so that they could provide natural persons and legal entities with a set of public information and services which are in fact the quintessence of e-Government.

During the first decade of the 21st century, from informational point of view, the Romanian public administration underwent a full process of e-Government implementation based on a modern computer infrastructure and a coherent set of applications, data bases and services which provide access to information and information management.

## B. E-GOVERNMENT CONCEPT

According to Wikipedia [8], e-Government refers to the use of internet technology as a platform for exchanging information, providing services and transacting with citizens, businesses and other arms of government. Romanian specialists, without issuing a complex definition of this concept, are trying to determine it from the point of view regarding the effects of its implementation. Thus, Colesca E. [1] acknowledges that e-Government is a more efficient and cheaper alternative for providing public services 'which may enable the Government to be closer to the citizens and to adapt its services according their demands.'

E-Government is defined [7] as: "the use of ICT in public administrations combined with organizational change and new skills in order to improve public services and democratic processes, and strengthen support to public".

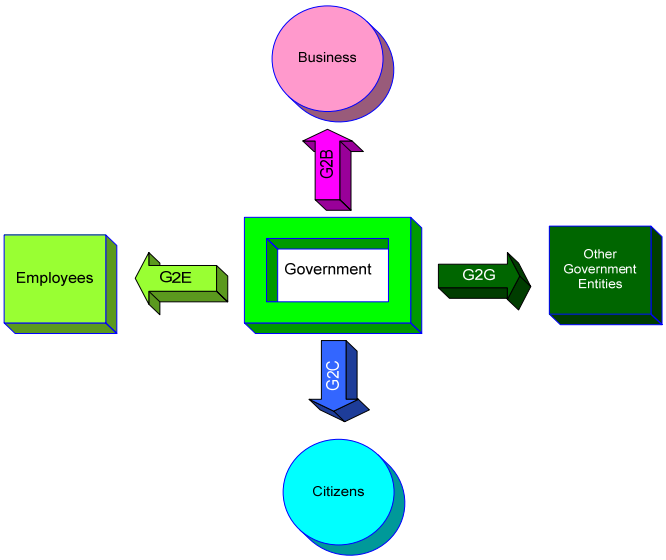



Figure 1. The actual Romanian e-Government relationships model

## C. E-GOVERNMENT MODELS

The efforts to determine precisely the existing relations within the informational process conducted by e-Government in Romania enable us to identify four types of delivery models:

- ***relations between government and citizens – G2C*** (Government to Citizen). This component of e-Government includes, beside *public relations* regarding information about everyday life, necessary to separate certain public information and to read certain political and legislative documents, *interactive communication* which provides communication services such as e-mails, blogs/portals and *transactional services* which send certain forms to citizens and stock them over the internet;
- ***relations between Government and the business environment – G2B*** (Government to Business) represent the most important component of e-Government due to the fact that their efficiency has significant implications in the high costs of traditional data and document transmissions. Thus, G2B includes beside *public acquisition and auction systems* over the internet, *services offered to legal entities regarding the transmission of data and documents* or the registration of companies;
- ***relations between Government institutions – G2G*** (Government to Government) can be maintained through information changes on various security levels between the computers of the institutions which interact. This interaction is necessary among public institutions because in order to solve some complex situations it is necessary to process some of the information held by various institutions;
- ***relations between Government and employees – G2E*** (Government to Employees) and their interaction based on computer systems represents the essence of public management improvement and it is going to determine in a very short period of time the forming of an organizational culture characteristic for e-Government. The applications used by G2E are represented mainly by *internal data bases* which make it easier and faster to carry out tasks and responsibilities and *specific applications for employees*.

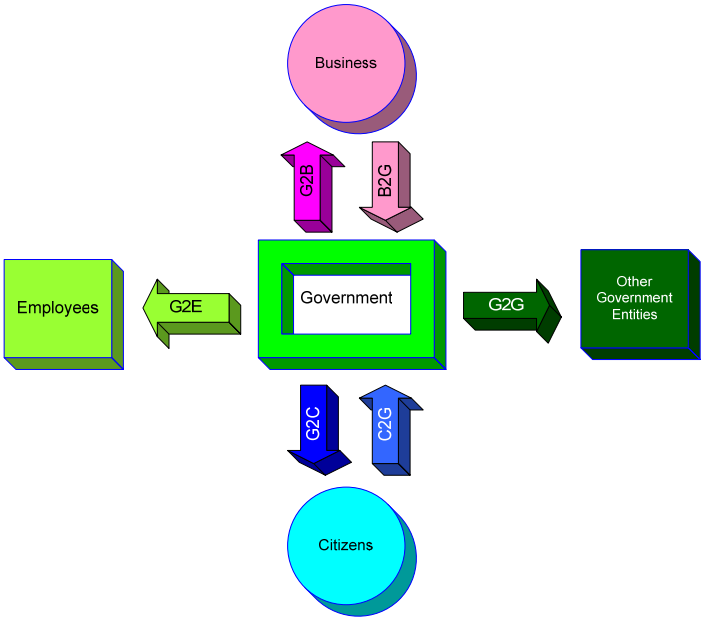



Figure 2. The E-Government Model tendencies

The increasing complexity of activities from public administration, the implementation of high performance informational infrastructure and the training of employees from public institutions show that the new instruments used by e-Government must obey three fundamental dimensions:

- cutting through informational frontiers;
- the transparency of governmental actions;
- developing the knowledge management.

These dimensions are possible through an interaction of the four types of relations created by e-Government (G2C, G2B, G2G, G2E) and through creating new and distributed forms of information management based on modern activity management systems (G2G, B2G) [2].

## D. ONLINE TRANSMISSION OF TAX RETURNS

The purpose of accounting operations materializes in summarizing the data in reports, such as annual financial reports which include, basically the balance sheet, the profit and loss account and other annexes, and it can be obtained from the general ledger, from the trial analytical and synthetic balances and registers.

These financial reports must be drawn up by economic units and sent to local financial administrations annually and bi-annually, together with the declarations regarding payments towards the state budget, the social insurance budget and the unemployment budget. In this respect, in order to eliminate the route between economic units and these institutions it is important to create Internet connections which are able to collect all this data [4].

Initially, e-Government may seem like another option for communication with citizens. But in the face of rising demands from demographic, economic, social, and global trends, e-Government no longer appears to be a matter of choice, but a necessity for any country wishing to enter the 21st century as a competitive nation in the world arena [9].

In this context, it shows the need to develop relationship B2G (Business to Government) as an important component of the nature of IT relationships that characterize the e-government system in Romania. This relationship allows increased flexibility in IT solutions used in the economic agents' level and especially in financial accounting. Brief, the online transmission stages of the annual financial statements are:

1. Create a "DecF" folder on the computer of the economic agent
2. Download, fill out and send the company's identifying form from the E-Government portal.
3. Generating the fiscal declaration forms and the annual financial reports with the help of the application used by the company; saving the data in the subfolders created in the first step.
4. Converting the saved data in the previous stage.
5. Connecting to E-Government portal and sending the files.
6. Checking the information received/reply and confirming the submission of online declarations.
7. Corroborating the data with the report of payments made by the company and generating demands for payment which will be communicated online to both the company and the fiscal unit where it is registered.
8. Centralizing the information with a view to draw up national statistic reports.

## E. THE IT SUPPORT OF B2G RELATIONSHIPS DEVELOPMENT

The first compulsory condition for sending these financial declarations on-line is the Internet connection through one of these variants: dial-up connection – it implies the existence of a modem installed on the computer and of a telephone line for connecting the computer to an Internet provider; ISDN connection (*Integrated Services Digital Network)* and ASDL connection (*Asymmetric Subscriber Digital Line)* which provide high speed internet connections, better than common telephone connections; cable TV and DSS connections (*Digital Satellite Systems*) supplied by companies which offer beside cable TV services, access to the Internet using the same cable and special modem.

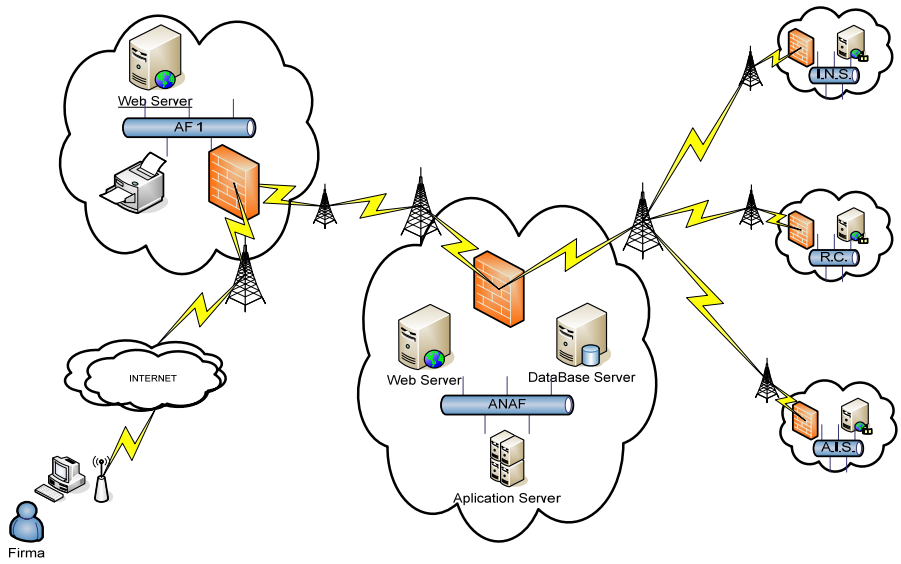



Figure 3. Fiscal information online sending systems

Thus, with the help of the Internet the data should be electronically transferred from an application that runs on a computer to the application that runs on another computer, located at a certain distance, without being printed out or manually stored on a magnetic support.

After the electronic processing of the accounting information in summarizing reports such as the trial balance, the ledger or other financial books, the information is uploaded in the fiscal declarations found on the site of the National Agency of Fiscal Administration; then they are sent to the E-Government portal.

## CONCLUSIONS

Online taking tax returns and annual financial statements is an important step for streamlining the relationship between state institutions and economic agents and to eliminate bureaucracy from the system.

On the other hand the generalization of information systems for collecting, processing and tracking of various information about the economic agent and the creation of interrelations databases is an easy tool for obtaining information and interaction with government services.

Thus, trends that are evident for the time period immediately following have the jump from static web to a dynamic and interactive web development methodologies to target and streamline internal processes to determine efficiency and shared services, standards for consistent use of information technologies and communication services transform classical oriented program in e-Government services integrated and not least the education and training of citizens of a culture based information [2], [3].

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# SOME RESULTS OF MAPPING OF MASS CUSTOMIZATION ACTIVITIES IN SE EUROPE

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**Abstract**

The paper presents results of mapping different activities and subjects in the field of mass customization and personalization (MCP) in Central and Southeast Europe. The results of mapping are presented in Google Maps, devided into four main groups: research institutions, companies, national websites and dedicated conferences. The map is open to everyone, accessible through the Internet, displaying information about the relevant people and institutions. It can be concluded that mass customization business model was first adapted by national universities and then successfully transferred to SME`s and entrepreneurs. The aim is to set up a network of knowledge to help researchers and companies to implement their ideas smoothly.

**Keywords**

Mass Customization and Personalization, Central and Southeast Europe, Google Maps, Mapping, Network of Knowledge

## 1. Introduction

The idea of mass customization is based on the observation that there is a customer interest in products that are adapted to his/her individual needs and preferences, since the adaptation will increase perceived performance. As the standard of living has increased in the last 50 years, individualization has received increased focus, since customization has come within reach of the average consumer. At the same time there has been a massive development of technologies [1].

The concept of mass customization was first identified in “Future shock” by Toffler [2] and was later described in “Future perfect” by Davis [3].

Stan Davis, who coined the term in 1987, refers to mass customization when “the same large number of customers can be reached as in mass markets of the industrial economy, and simultaneously they can be treated individually as in the customized markets of pre-industrial economies“ [3]. In order to address the implementation issues of mass customization, Tseng and Jiao [4] provide a working definition of mass customization that is very useful. The objective of mass customization is “to deliver goods and services that meet individual customers´ needs with near mass production efficiency**”** [5].

Doing so, mass customization is performed on four levels. While the differentiation level of mass customization is based on the additional utility (value) customers gain from a product or service that corresponds better to their needs, the cost level demands that this can be done at total costs that will not lead to such a price increase that the customization process implies a switch of market segments. The information collected in the course of individualization serves to build up a lasting individual relationship with each customer and, thus, to increase customer loyalty (relationship level). While the first three levels have a customer centric perspective, a fourth level takes an internal view and relates to the fulfillment system of a mass customizing firm: Mass customization operations are performed in a fixed solution space that represents [5] “the pre-existing capability and degrees of freedom built into a given manufacturer’s production system” [6].

Personalization should therefore be clearly distinguished from customization. Both customization and personalization are based on the assumption that a homogeneous offering is not

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sufficient in meeting the customers needs (...). As defined by the Webster dictionary [7], personalize means "to make something personal or individual; specifically: to mark as the property of a particular person" [8]. The definitions of mass customization and of personalization implies that the goal is to detect customers needs and then to fulfill these needs with an efficiency that almost equals that of mass production.

For more than two decades, mass customization has been the future of manufacturing – and for some manufacturers it will probably always be. On the face of it, mass customization is remarkably attractive proposition for customers and producers alike. Consumers get reasonably priced tailor-made product reflecting their personal selection of colors, features, functions and styles. Producers for their part get to reduce their inventories and manufacturing overhead costs, to eliminate waste in their supply chains, and to obtain more accurate information about demand. In short, a win-win position. Today's manufacturing systems have the potential to build a large variety of end products at costs comparable to mass-produced items. However, this potential is just the beginning to be realized based on the complexity of the product, manufacturing, and supply chain. Therefore, different manufacturing sectors have different business drivers and are at varying degrees of readiness to adopt MC methodologies.

Two relatively recent developments have given the prospects for mass customization a boost: first success enjoyed by Dell Computers and other high-tech companies that build products to order, and second the emergence of the Internet, giving the manufactures a platform for taking orders from mass audience for customized products, such as bicycles, clothes, cosmetics, shoes and vitamins, at almost no cost. In the past, customization of this kind was handled by skilled but expensive salespeople closely interacting with customers. With these trends, many issues arise in the product development and production cycle.

These issues are being addressed by capabilities in computational, communicational, and informational areas creating innovations in flexible automation, networks, and electronic product design. An increasing number of companies are adopting mass customization strategies at different levels in their product development cycles (Figure.1).

Having in mind the aim of the research, it was very interesting to find out what kind of Mass Customization and Personalization is present in the region of Central and Southeast Europe, in which economy sectors, what is the depth of involving customers into the process and finally how can companies from the region benefit from implementation of the named strategy. After three successfully organized MCP Conferences (Poland 2004, Poland 2006 and Serbia 2008), Mass Customization and Open Innovation (MC-OI) Network was established from researchers and institutions that initiated and organized previous conferences.

The joint research work through the network started with mapping of MCP subjects in to Google Maps and the obtained results are given bellow.

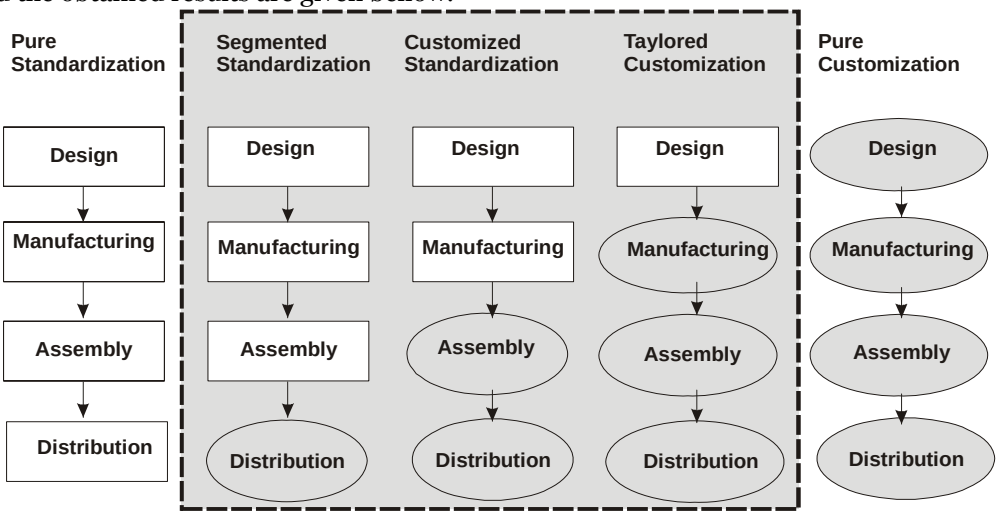



Figure 1 Level and depth of involving customers

## 2. Implementation of MCP Strategy in the Region – Results of Mapping presented in Google Maps

The future of mass customization seems to depend highly on the interest of customers in buying customized products. In the last decades that's just the customers forced manufacturers to increase constantly the quality of products and to offer more and more diverse range of products. In developed societies, like in Western European countries and in the US a pressure is put on manufacturers to offer

products better matching individual and diverse customers' preferences and expectations. Introduction of mass customization seems to be the best solution to changes happening on markets" [9].

Identifying present subjects in the field of MCP as a part of the larger research activities was carried out for the following countries of Central and Southeast Europe: Poland, Czech Republic, Slovakia, Austria, Hungary, Croatia, Bosnia & Herzegovina, Serbia, Montenegro, Romania, Moldova, Albania, FYR of Macedonia, Bulgaria and Hellenic Republic (Greece). For the referent sources are used proceedings from MCP Conferences, as well as other dedicated conferences like, IMCM - International Mass Customization Meetings, MCPC - World Congresses, academic or education websites and different company websites.

All subjects: researchers, institutes, professors, doctors, experts, companies, etc. are divided into four groups of tags:

- Blue: Universities/Researchers (42 items),
- Green: Companies (14 items),
- Red: national websites (1 items),
- Yellow: Conferences (3 items).

Table 1 Results of Mapping MCP Activities in Central and Southeast Europe

| Mass Customization & Open Innovation in Central Europe | Universities/ Researchers Blue colour | Companies Green colour | Conferences Yellow colour | National Websites Red colour |
|---|---|---|---|---|
| Austria | 5 / 17 | 4 | - | - |
| Albania | - | - | - | - |
| Bosnia & Herzegovina | - | - | - | - |
| Bulgaria | 1 / 8 | - | - | - |
| Chech Republic | - | - | - | - |
| Croatia | 1 / 1 | - | - | - |
| FYROM | 1 / 3 | 1 | - | - |
| Hellenic Republic (Greece) | 6 / 10 | 1 | - | - |
| Hungary | 1 / 1 | - | - | - |
| Lithuania | - | 1 | - | - |
| Moldova | - | - | - | - |
| Poland | 15 / 30 | 3 | 2 | 1 |
| Romania, | 2 / 2 | 3 | - | - |
| Serbia | 6 / 17 | 1 | 1 | - |
| Slovenia | 2 / 4 | - | - | - |
| Slovakia | - | - | - | - |
| Ukraine | 2 / 3 | - | - | - |
| **Total** | **42 / 87** | **14** | **3** | **1** |

Figure 2 presents results of mapping visible in the Google maps at the link given below:
http://maps.google.com/maps/ms?ie=UTF8&hl=en&msa=0&msid=115394000225018160781.00045faaf54d785f4ec64&ll=47.872144,23.203125&spn=28.231113,79.101563&t=h&z=4

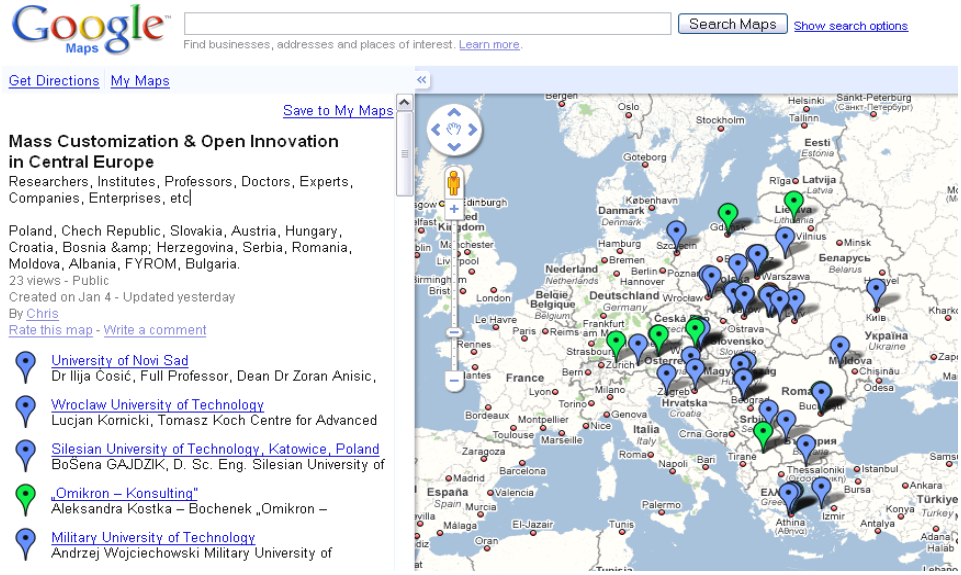



Figure 2 Mapping of the Mass Customization and Open Innovation activities in Central Europe

The sources of data are proceedings of conferences and a research process through the internet. The uploading process of the data imposes the user to create an account in Google's services (like the Gmail account). After that, the user should click on the option of the Google's Site named Google Maps. He has a plenty of choices to do "things", such as zooming in any region all over the world, accessing in geographical and political data, accessing also in data that other users before uploaded. Also there are options of viewing the map in Google Earth, printing user's map, send the map via an email and gain the specific internet link of the map to use it for websites, Blogs or other activities. There is also the capability of uploading photos, videos, Wikipedia options, traffic labels, and different options screen, like Map, Satellite and Terrain. The use of that kind of tool is mostly exchanging information in an open environment through the Internet for the continuous improvement of researches, projects, innovation and knowledge. Any researcher or company that want to participate in this network can create an account in Google and then they are free to open that map of Mass Customization & Open Innovation in Central and Southeast Europe and put information in their territory.

## 3. MCP as a possibility to increase competitiveness of the companies in the region

### 3.1 Customization of Produtcs

We focus on discussing Web – based product configurators, because they are very important means for the practical implementation of MCP. Online product configuration tools allow web users to personalize their products over the internet. Depending on the type of product, the configuration services can simplify the selection of product options, help enterprises in capturing customers' needs and bridge the gap between customers' desire and firms' competencies. On Fig.3 are given some examples of configurators for different products:

a) 3D cars demonstrators to display cars of different models and colors (example get from http://www.mercedes-benz.de);
b) Displaying of 3D virtual mobile phones of different models and colors (http://www.nokia.co.uk);
c) Configurator focused on furniture products (http://www.fwc3d.com);
d) A software tool for customization of computers, software, mobile accessories, etc. (http://demo.x-cart.com);
e) Configurator for clothes, gifts and etc. (http://www.earlyimpact.com);
f) Experimental 3D Web configurator [11] - it supports and maintains the development and marketing of modular positioning and handling systems called "DriveSets".

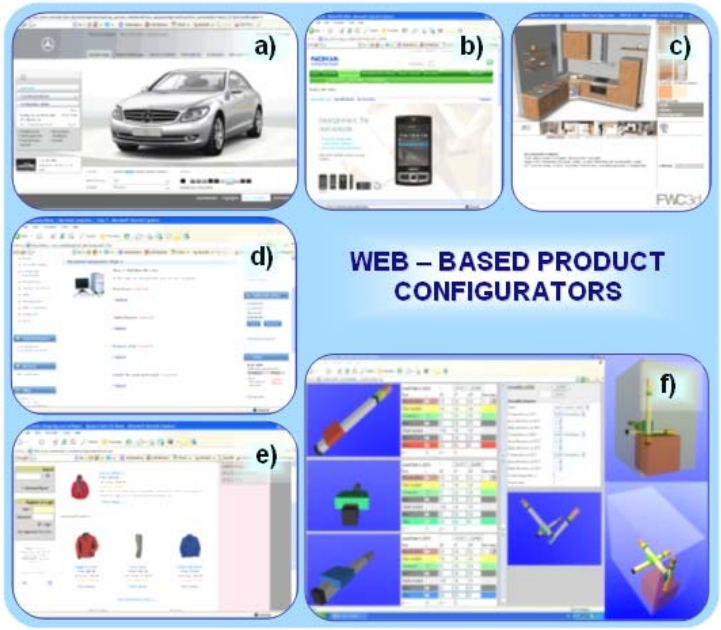



Figure 3 Web – based product configurators

It can be given many examples of products configurators but here our goal is to analyze their repeatable elements and represent their possibilities and functions in common. The features of the products configurators are very well summarized on the site http://www.technicon.com. These features include:

- Providing appropriate queries and generating of order-ready quotes, including by accessing the latest product and pricing information.
- Flagging incompatible options and highlighting prior options that are incompatible with the current option.
- Supporting the import of external and legacy configuration data and rules into Custom Commerce configuration models.
- Supporting complex pricing models that allow multiple price lists to be associated with any product option.
- Providing context-appropriate help messages and selling suggestions.
- Providing graphics and animations to aid in the configuration process, including 2D drawings and 3D models.
- Supporting the use of spatial relationships and rules for configurations, allowing layout and assembly of multiple products to arrive at integrated solutions.

We pay attention to the functionality, because the quality of the reconciling customers' interests and features of products depends on technical functionality of the configurators. So it is very important to implement new ideas and technologies for their development. For example for the assurance of the appropriate to the design by the customer process functionality, the experimental 3D Web configurator given on Fig.3 f) was developed by the use of the relatively new X3D (eXtensible 3D) language for the description of product (we have used virtual product model of the DriveSets-family brought to the market by Systec E+S GmbH, Germany - http://www.drivesets.de). The 3D Web configurator provides as feedback in the web-browser of the customer not only the appropriate graphical representation of the newly developed system, but the model of the systems installation and operational area, animation of the systems action and dynamical change of the model parameters such as dimensions of form, dimensions of dispositions and etc.

By using of Web configurators it become possible users to customize (even in some cases to design) their products over the internet. The direct customer participation in the personalization of product or in the design of it saves time and money, reduces the engineering efforts in respect to the solving of the design problem, improves the quality, changes the attitude of the customers towards the product and on this way facilitates the product market realization.

### 3.2 Customization of Services

The "decades of the middle", with a more educated and discerning population, have led to a higher level of expectation for personalized services. Allied to that, service providers themselves need to differentiate their offering in some way to sustain market share and profitability. An increasingly common method of service differentiation these days is to introduce options and choices (often associated with premium charges) that give the customer some customization and control over service content and availability. Increasingly, an extremely cost-efficient way of deploying a service to many customers is transforming it into software, that is, automating it and bundling it in some way within the product package. The customer must still be the focus, whether the service is manual or automated; therefore, the product package and the service parts of the package have to treat different customers differently. We're not putting service automation in question; rather, we're stressing that any new or enhanced service must be at least as customized as the previous one – manual or semi-manual – to make sense in the context of Mass Customization, for both simple and complex services.

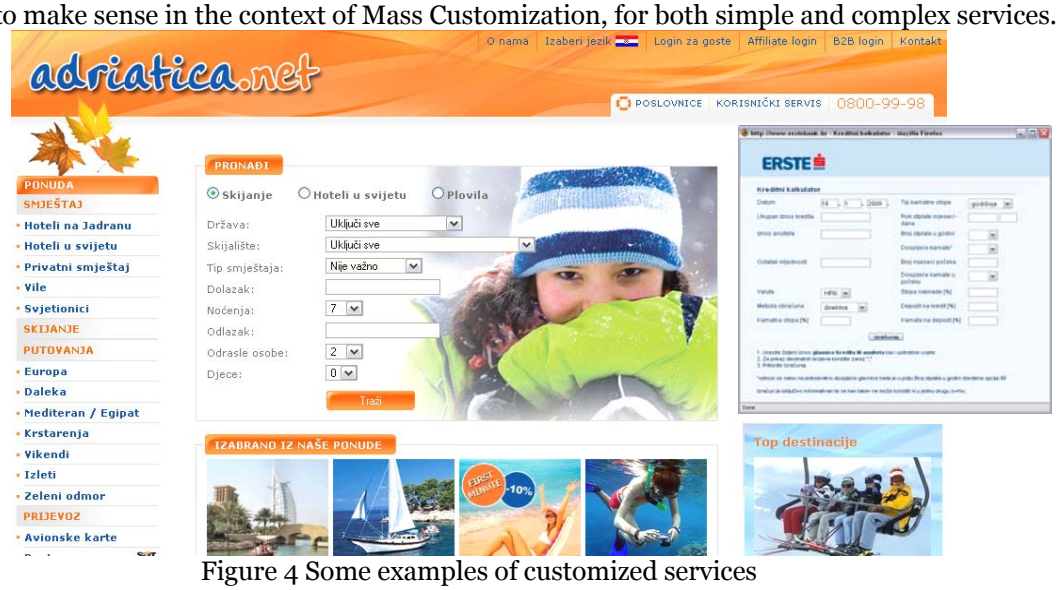



Figure 4 Some examples of customized services

Customization of services, according to the conducted research follows the situation in Western Europe or North America. Possibilities of customization were expanded from typical e-commerce applications in the following areas [12, 13]:

- Transportation services (tickets),
- Financial services (assurance, leasing, etc.),
- Tourism (accommodation, restaurants, etc.)
- Other (arranging celebrations, education, etc.).

Customization of services offers much potentials of implementing MCP concept (quicker and easier building of business model) instead of customization of products, due to the technological level, strength of companies and economies of the stated countries. On the other hand there are many possibilities to develop services, especially in tourism, culture or education in order to integrate, present and promote values of the specific regions to world market through the global net.

## 4. Conclusions

The economies of the Central and Southeast European countries currently move through very different developmental stages, ranging from the highly industrialized economies of the EU full member states to those transitional and economically unstable systems.

Bearing in mind such a complex state of affairs, the introduction of the Mass Customization and Personalization concept has a very special value and represents a unique challenge.

The results of mapping showed, that there are many mass customization activities in south east European region. Starting at Universities as knowledge transfer centers, more and more companies/entrepreneurs realize, that mass customization business model can help to strengthen their competitiveness. Keeping in mind special cultural aspects of southeast European region, universities should include mass customization business model in their curriculum, build transfer centers for sme and build up stronger networks.

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# ECONOMIC AND SOCIAL IMPLICATIONS OF UNEMPLOYMENT AND OPPORTUNITIES OF DIMINISHING IT

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**ABSTRACT:**

Economy does not constantly develop. A period of economic expansion and prosperity is followed by recession or even economic crises. At present, one of the worst consequences of economic recession is unemployment increase. Accordingly, under such circumstances, the paper tries to focus on the consequences of unemployment increase upon economic and social life and to identify a series of goals and measures capable to diminish it.

**KEYWORDS:**

economic recession, unemployment, social life

Economic development is fundamental for human beings' existence. At the same time, human beings detain the leading position in economic development; they are, together with nature, "primary" production factors. The mutual connections between population and economy occur within certain more or less varied processes and under various time and space historical circumstances.

Society's existence and progress is provided when both the evolution of the two terms – population and economy – and their interaction meet certain quality and size characteristics. Their absence or sizing might determine negative effects such as: economic underdevelopment, unemployment, decrease of the living standard which are quite often considered to be lacks of balance of the population – economy correlation.

History shows that a country's economy has a cyclical evolution. A few years of economic expansion and prosperity are followed by recession and even economic crises; one of the most negative consequences is unemployment increase. As production decreases, companies need less labor; they do not hire anymore new employees; those who still work are fired. Such circumstances manifest more and more obviously in our country too, especially within the present-day circumstances of world financial crisis.

In Romania, the first affected fields have been those connected with exports, especially those towards the European Union that represent about 70% of the whole amount of exports. Although at present statistics barely show the diminishing of industrial production and exports, the effects of the disturbances on international financial markets also affect Romania.

Romania's motor cars industry has already been affected by the effects of the economic crisis; problem are encountered by Dacia and Ford companies as well as by those companies that produce car spare parts. As regards metallurgy, Arcelor Mittal Galati has decided to decrease laminates production and to close certain production capacities. Romania's building field is also affected by present-day circumstances and the increase of crediting costs that negatively influences the demand development of residential segment.

Generally, the hardening of circumstances and the increase of crediting costs, as well as the relative lack of liquidities affect companies belonging to all the branches of Romania's activity. The whole range of economic activity manifests a restraint in expanding and deploying new investments; certain companies decreased production rhythm as a result of a lower demand, especially for exports goods. Companies do not register profits anymore; they postpone investments or, at worst, they suspend their activity, implicitly diminishing the

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number of employees. If, until now, Romania has had to face, in certain fields, a lack of labor, at present, in certain areas, unemployment affects even communities.

We have already stressed the fact that the periods of economic recession determine an important increase of unemployment rate. Generally, the characteristics of such a period are *cyclic unemployment and structural unemployment* [7].

*Cyclic unemployment* – sometimes also called *conjuncture*, is determined by the economic crises that occur, by partial crises or by other crises characteristic of certain circumstances. This type of unemployment can be the result of the defective administration of the correlation between the salaries level, on the one hand, and the level of prices and labor productivity, on the other one. Generally, cyclic unemployment can be totally or partly eliminated during the periods of economic growth.

*Structural unemployment* is determined by the economic, geographic, social, etc. restructuring tendencies that occur in various countries, especially due to technical progress. It is mainly the result of the lack of balance between labor offer and demand. The system reintegration of such labor can only be done according to a long and difficult process as it implies investments' increase and re-qualification of the affected persons.

At the same time, the appearance and expansion of certain non-typical forms of employment - such as occasional jobs, determined period jobs or seasonal jobs – have determined *intermittent unemployment* and *seasoning unemployment*.

As regards *technological unemployment*, as in Romania new technologies' implementation processes witness a slower rhythm, it is not so evident and ample. We do not support the idea that an ampler technological unemployment could be positive; nevertheless we should notice that the delay of the new technologies implementation process according to an optimum level is going to determine, on a long term, efficiency decrease; labor productivity diminishes as well and the companies' competition capacity also decreases.

Another main form of unemployment is *exclusion unemployment* [2]; it represents the active population including most aged persons, less qualified ones, and those unemployed for a long period of time.

The manifesting of the various forms of unemployment makes its diminishing extremely difficult and, at the same time, delicate.

During the present stage, the main causes that determined unemployment increase have been:

- massive employees dismissals that have occurred within all economic fields that undergo restructuring;
- insignificant increase of the number of jobs due to the lack of diversity of economic activities and to the slow development of the private field;
- a professional and educational qualification level that quite often does not match the demands of the labor market;
- a relatively low investment capacity in economic branches having real development opportunities;
- underdevelopment of medium and small size companies due to a relatively low level of investments;
- the acute effects of the international financial crisis in various fields.

Under such circumstances we support the idea according to which a high unemployment represents an economic problem as well as a social one. From an economic perspective, unemployment is a waste of precious resources. From a social point of view, it is the cause of deep sufferance as unemployed persons have to struggle living with low incomes. During high unemployment periods material problems increase deteriorating people's feelings and family life.[8]

Unemployment cost at the level of the economy and society is extremely complex and all-inclusive. The aspects taken into consideration include:

- waste of an important amount of labor resources as unemployment decreases labor's determining part as a production factor;
- diminution of the economic development as labor's under-use is a factor that determines the tremendous decrease of production amount under the potential one;

- - such facts determine losses of salaries and profits which, at their turn, determine consumption minimizing having negative effects upon the development economy; poverty increase and generalization, especially in mono-industrial areas strongly affected by the economic restructuring of that industry;
- decrease of the State budget's incomes and expenditures due to the spread effect of unemployment;
- increase of the State expenditures in order to maintain and make function public institutions in the field of registering and surveying unemployment, to pay unemployment aids and other social expenditures regarding labor reconversion;
- appearance of social discrimination, of the phenomenon of marginalization of certain persons or less favored groups.

During the last decades, the struggle against unemployment has been a basic element of defining the social policies implemented in all the member states of the European Union. In Romania which is a member of the European Union an important reform process occurs at present influencing all the fields of the economic and social life; its key elements are *unemployment and unemployed persons'* issues.

**Unemployment diminishing policies** (policies fighting against unemployment [3]) can be grouped in two large categories: the first category directly targets unemployed persons; the second one refers to the measures regarding the employees.

The first category includes: organizing measures of preparing and training those persons who look for a job in order to face the new techniques and technologies; the facilities given by the State in order to create new companies capable of offering new jobs and to create new jobs in public activities. Resorting to new forms of employment has become quite familiar during the last years: reduced program or atypical program jobs; determined period employments.

The policy of unemployment decrease stipulates, accordingly, selective measures in order to train and employ long term unemployed persons.

The measures that regard employed population have as a goal, on the one hand, the prevention of unemployment increase through a needs adequate qualification, and, on the other one, they tend to decrease unemployment through creating new additional opportunities of employment.

The experience of the countries having a „tradition" in the field of unemployment and its settling has proved that the rapid progress and the well functioning of the labor market are influenced by two equally important elements: the first one is the *providing of basic social services for less favored categories* – that resides in social protection as a fundamental goal of social policy, and the second one is the *use of the most important treasure of the poor – namely, labor*.

**Social protection** represents a group of policies, measures, institutions, and organisms that provide a certain level of welfare and social security for the whole population and, especially, for certain social groups and persons that are nor able to reach owing to their own effort a normal, minimal life standard. Owing to juridical stipulations, social protection implements national and regional programs with a view of providing aids, allowances, allocations, and social services for less favored persons.

Two categories of labor social protection measures are stipulated:

- *passive measures* (targeting money aids such as: unemployment support, professional integration support, support allocation, and money compensations given to the persons that have been collectively dismissed);
- *active measures* (targeting the stimulation of natural and juridical persons that employ graduates of higher education institutions, the giving of advantageous credits in order to found small and medium size companies, qualification, re-qualification, and professional improvement of those who look for a job, organizing job promotions, other special active measures in order to employ dismissed labor).

Such protection measures are meant to stimulate the (re)turning to economic activity and the development of entrepreneurial spirit, to encourage the persons belonging to less favored categories, to increase the incomes of those having low incomes.

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The restructuring of the Romanian social and economic system according to the demands of the market economy determined deep and important changes at the level of the labor market that also include unemployment as a mass phenomenon. Under such circumstances, one of the essential goals of Romania's social and economic policies is the guarantee of a job and providing of a decent living standard, either determined by a person's direct work or provided by social protection and assistance (which have an important part in diminishing unemployment's effects among the less favored population).

At present, Romania's labor market displays a series of services as follows:

1. *Financial services* – that include the payment of certain money aids (unemployment support, professional integration support, support allocation, social support), advantageous credits given to the small and medium size companies or subsidies granted to those companies that hire graduates;
2. *Labor intermediation services* – that include activities of labor intermediation, counseling services regarding professional career and business counseling services;
3. *Information services* – for those who demand or offer jobs;
4. *Training services* – that include activities of professional preparation in specialized units (schools, colleges, universities, requalification and professional improvement centers).

Out of the services existing on labor market we are going to focus upon labor intermediation services that we consider as quite important in the process of labor integration/reintegration of unemployed persons.

We consider that, on the one hand, the labor intermediation service can support unemployed persons and those who can be threatened in the future by unemployment owing to the services at their disposal, and, on the other hand, business counseling offers mainly to the private field companies ideas and support regarding their development opportunities as well as counseling and support services for those interested in starting their own business; they consequently contribute to the development of the private field and the foundation of new jobs.

Labor mediation includes a series of activities owing to which they try to correlate demand and offer on labor market; it has as a final goal the employment of available persons and the occupation of vacant jobs. The matching between labor demand and offer should occur under circumstances capable of meeting both parts and of determining a long lasting professional relationship. [4]

Mediation centers offer to those who demand jobs complex information regarding:vacant jobs and the terms to be carried out in order to get them; services offered by mediation centers; statistics regarding labor market; employment programs started at a local level offering jobs prospects; qualification/professional training opportunities and terms to be carried out in order to take part in the courses.

In Romania, labor mediation centers have had to face a series of difficulties regarding: the activity's new characteristics, both for mediators and for their clients; lack of personnel properly trained for such an activity; improper material resources, especially adequate environments for the mediation activity; the increasing number of unemployed persons and the numberless problems to be settled; the timid relationships with companies and jobs suppliers; clients' reticence to resort to the services offered by mediation centers.

Due to the part played by this service with a view of matching labor demand and offer, we consider it necessary that decisional factors should pay the proper attention in order to develop such centers in the future.

Counseling, in general, is known as a wide spread and varied *professional service* in developed countries having a market economy and targeting a large category of persons or organizations belonging to various economic fields: public institutions, private or State small, medium or large companies, non-governmental organizations.

The Association of Companies Management Counseling in the U.S.A. (ACME) defines management counseling as a "service performed in exchange of a fee by independent and objective specialists that support the management of the companies and institutions with a view of attaining their goals and rationally and properly developing their activities." Business counseling as a professional service has the following essential goals: improvement of entrepreneurial spirit; entrepreneurial training addressing to a large number of persons apt

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or wanting to start their own company; stimulation of the creativity, flexibility, and work capacity of private business men/women.

We consider that the initiation of business counseling centers with a view of implementing active measures capable of fighting against unemployment is a logical and welcome measure especially under our country's present-day circumstances. The better organized and managed such a center the most the positive effects of its activity are going to be felt in the area it is active. Permanent results may consist in:

- a larger number of new private companies successfully operating and determining the development of the private field;
- development of the amount of the economic activity of the existent private companies (an increased financial result, more profits, etc.) and an increase of their quality indices (increase of productivity, profitableness, of quality and competition level of their products and services);
- a larger number of persons who gained or improved their management skills;
- and, as a corollary of such results, an increased number of jobs that are more stable, and a decrease of unemployment rate.

In essence, in our opinion, the main goals that should be noticed with a view of decreasing unemployment are the following ones:

- Determining opportunities for long-lasting employment; with this in view, regional development programs play an important part;
- Training and re-qualifying not only unemployed persons but also those who work in State companies which are to be restructured;
- Shifting the part played by unemployed persons protection policies from passive measures towards active measures;
- Giving facilities to those unemployed persons who get a job through their own efforts; we consider this could be a quite inciting measure with positive results;
- Increasing the degree of implication of local communities in the issue of diminishing unemployment rate ( e.g. limited period facilities – regarding taxes, fees, services, etc. - given by local town halls to the companies that hire unemployed persons);
- Giving the required attention to the notion of "permanent education" throughout one's whole life and even to the notion of "e-learning".

Taking into account the above facts we sustain that:

- Labor employment cannot be done by market games as it is known that labor market is the most imperfect of all markets;
- Employment issue cannot be superficially treated only according to the elaboration of theoretical programs as the degradation of the quality of human resources due to unemployment and lack of use determines chain budget constraints, weakens individual social security, and, under the circumstances of the accumulation of a critical mass, it determines ample social movements;
- A close connection should exist between the need of competent human resources and the proper financing of creating and developing human resources as otherwise e-capitalization effects of human capital are going to come out;
- At the same time, a proper correlation should exist between legislation in force regarding employment and unemployment and the management of the policies resulting out of that legislation;
- Last but not least, employment, unemployment prevention and struggle against it demand a balanced relationship between the active and passive policies of labor market, abandoning certain mechanisms (important compensatory payments) having minor positive effects or short term effects; investment and fiscal policies are to be conceives together with policies of supporting labor employment of generating stable jobs.

In our opinion, with a view of decreasing unemployment and increasing the degree of labor employment, they should search for a manner of matching and combining economic mechanisms, means, measures, and policies that owing to their common action are able to provide the carrying out of the envisaged goal with lower economic and especially social costs.

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# THE JIU VALLEY'S EXTRACTIVE INDUSTRY TRANSITION TO THE MARKET ECONOMY

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**ABSTRACT:**
1997 represented the beginning of the Jiu Valley's decline. Although it was clear that transition to the market economy would also imply, sooner or later, the re-structuring of the mining field, this process, done in a hurry and with no short or long term economic strategy, only determined the closing of a part of the mining units, unemployment, poverty, and despair. We consider that, according to the opinion of those times authorities, the mining field had to disappear as Romanian economy did no longer need coal. At present, opinions are different due to internal and international circumstances; solutions are looked for in order to improve this important field of the national economy.
**KEYWORDS:**
transition, reform, re-structuring, improvement, mining field, coal

**The reform of the mining field** is one of the most important components of Romania's transition process. Besides its positive effects upon the efficiency increase of the mining units and the losses decrease at the level of the national economy, the reform process has various negative consequences upon the miners and their families, upon the communities whose life is largely structured by mining activities, upon the persons who work within other fields (metallurgy or public services) depending or not on the mining industry, and, last but not least, upon local infrastructures. The most important **obstacles and difficulties** are the following ones:

- The increase of unemployment and the impossibility of finding an alternative job;
- The dramatic decline of life standards;
- The deterioration of local infrastructures and public services.

In 1990, with the changes that took place in the whole economy, the restructuring of the mining field started. Accordingly, the first legal act that determined changes of the mining units' organization was Law no. 15/07.08.1990, according to which State economic units were re-organized as autonomous administrations and companies. Autonomous administrations were founded in the strategic branches of the national economy: armament industry, energetic industry, mines and natural gas exploitation, post and railroad transports. At the same time, there were other fields that witnessed the foundation of autonomous administrations, decided by the government. Autonomous administrations have been settled through government decisions – in case of those having a national importance – and through decisions of district or local councils – in case of those having a local importance. Autonomous administrations are juridical persons and have their own economic administration and financial autonomy.

Besides these a series of strategic concepts have been formulated and implemented; they concern the basic restructuring of the mining industry and included:

1. Technical and production restructuring;
2. Organization and management restructuring;
3. Staff restructuring;
4. Restraining or stopping productive activity.

As an effect of the geological and mining characteristics of the exploited deposits and of ores' low content of metals, namely of coal's high content of ashes, as well as due to the poor efficiency of technological equipments in use, the costs of most mining products were, after 1989, and still are higher than the selling prices on external market; accordingly, the State had to support, through subsidies, the pit coal, lignite, and brown coal production extracted owing to underground methods as well as the production of ores containing non-ferrous and precious metals.

During the period 1990-2005 the Government support for the mining industry represented about 6,000 million U.S. dollars, representing production subsidies, budget allocations for capital expenditures, and social transfers (Table no.1). It is true that the subsidies decreased year by year so that in 2000 the whole subsidies for the Romanian mining system represented about 100 million dollars.

TABLE No. 1. Budget allocations for the mining industry during the period 1990-2000 (Million U.S. dollars)

| | |
|---|---|
| Subsidies | 3966.4 |
| Social transfers | 308.9 |
| Capital allocations | 1675.4 |
| Total | 5950.7 |

*Source*: The Ministry of Economy and Finance, *The strategy of the mining industry during the period 2007-2020*, p. 1

To this total amount, one should also add, during that period, an exploitation loss of 1547.3 million U.S. dollars. Accordingly, the State's effort for the mining field that also included budget expenditures determined by exploitation loss during the period 1990-2005 represented 6,519.7 U.S. dollars.

One should not overlook the fact that out of the total budget allocations social transfers represent 5.19%; in case one also calculates the amount of exploitation losses, a percent of only 4.73 is reached.

As regards the Jiu Valley, during the last 50 years, the importance of extracting and processing pit coal for the national economy determined a significant increase of production which, in 1988, attained 11.2 million tons; such a fact determined a rapid development of the region, but people dealt with a mono-factorial type of economy. The present mining development strategy estimates that in the future the Jiu Valley should attain an annual production of about 2.7 million tons of pit coal (Table no. 2).

TABLE No. 2. Estimation of the evolution of physical production of the units in the mining field (Thousand tons)

| | 2007 | 2008 | 2009 | 2010 | Total |
|---|---|---|---|---|---|
| Total coal | 34776.2 | 35667.1 | 37125.0 | 37964.4 | 145532.7 |
| Pit coal field | 2701.2 | 2709.1 | 2790.0 | 2879.4 | 11079.7 |
| Lignite field | 32075 | 32958 | 34335 | 35085 | 134453.0 |

*Source:* The Ministry of Economy and Finance, *The strategy of the mining industry during the period 2007-2020*, p. 71

TABLE No. 3. Evolution of coal production during the period 1989-2007 within CNH Petrosani (tons)

| Years | Extracted coal | Processed coal |
|---|---|---|
| 1989 | 10 919 534 | 8 586 644 |
| 1990 | 5 898 594 | 4 627 167 |
| 1991 | 5 275 716 | 4 018 282 |
| 1992 | 5 798 901 | 4 267 951 |
| 1993 | 5 939 287 | 4 405 722 |
| 1994 | 6 502 136 | 4 992 069 |
| 1995 | 6 546 121 | 5 087 295 |
| 1996 | 7 169 429 | 5 536 737 |
| 1997 | 5 759 511 | 4 403 159 |
| 1998 | 4 401 695 | 3 247 764 |
| 1999 | 3 821 070 | 2 805 343 |
| 2000 | 3 767 031 | 2 994 711 |
| 2001 | 4 098 549 | 3 210 089 |
| 2002 | 4 023 285 | 2 989 432 |
| 2003 | 3 346 613 | 2 626 490 |
| 2004 | 3 059 385 | 2 562 292 |
| 2005 | 3 002 434 | 2 613 676 |
| 2006 | 2 591 024 | 2 339 648 |
| 2007 | 2 637 484 | 2 452 959 |

*Source:* CNH Petrosani, *Production Department*

Due to the restructuring of Romanian metallurgy that has partly given up the use of the Jiu Valley coal in favor of imports, pit coal demand dropped from 10.9 million tons in 1989 to 5.7 million tons in 1997 (Table no. 3). At present, pit coal production is limited to 2.5 – 2.6 million tons and has two main beneficiaries, namely Paroseni and Mintia power-stations. On the other hand, the 2000 production of extracted pit coal represented one third of the 1989 production (10.9 million tons) and 52.5% of 1996 production, the year before effective restructuring. In 2007, due to the restructuring of extractive industry, to the diminishing of the number of employees, and also due to total or partial closing of several of the Jiu Valley mines, extracted production represented 2.63 million tons, that is 75.8% less than in 1989 and 63.2% less than in 1996.

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The continual decrease of coal production had, until 1997, two main causes:

- The decrease of the demand on internal market;
- The lack of investments for opening mining fields, acquiring new technology and modernizing.

As in the case of the other components of the transition process, the restructuring of this important field represents a national priority. Although all autonomous administrations in the mining field have to face relatively similar difficulties, the condition of the administrations in the coal industry seems to be most alarming as they have accumulated huge debts of thousand of billion lei, heavily affecting the State's budget. According to the calculations made by the experts of the former Ministry of Industries and Trade, "during the period 1991 – 1998, 4 billion dollars were lost by coal and ores extractive industry", when "economic activity mixed with social protection". Such a huge sum, out of which various small and medium size companies in the mining regions could have been financed, is the equivalent of about 47% of Romania's external debt at the end of September 1998. The losses registered by the Autonomous Administration of Pit Coal (the present National Pit Coal Company) of Petrosani represented, during the period 1990 – 1998 1,842.5 million U.S. dollars (representing total losses and subsidies) out of which exploitation losses of 445.8 million dollars, namely exploitation losses besides subsidies of 67.6 million dollars (Table no. 4). The same Administration has never paid its debts to the social insurances fund; its debts to the social insurances budget represent about 1,990 billion lei at the level of 1998 which are equivalent with 535 million dollars.

TABLE No. 4. Yearly losses registered by the Autonomous Administration of Pit Coal (the present National Pit Coal Company) of Petrosani (million U.S. dollars)

| Years | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Total losses, out of which: | 26.7 | 9.4 | 0 | 5.9 | 108.6 | 113.0 | 116.1 | 168.4 | 286.2 | 834.3 |
| Exploitation losses | - | - | - | 4.8 | 101.1 | 107.5 | 99.0 | 66.5 | 64.0 | 442.9 |
| Subsidies | 180.0 | 162.4 | 99.5 | 130.6 | 129.7 | 128.3 | 112.9 | 33.8 | 29.1 | 1007.2 |
| Exploitation losses besides subsidies | - | - | - | - | - | - | - | 32.7 | 34.9 | 67.6 |

*Source*: Larionescu Maria, Rughiniş Cosima, Rădulescu Sorin, *Cu ochii minerului. reforma mineritului în România*, Gnosis Publishing House, Bucharest, 1999, p. xxii

During the last years, the quality of extracted coal decreased while production costs significantly overpass coal's real cost. Poor administration of the mining units, their use of excessive labor, and, especially, the lack of efficiency of the activity in the mining industry have characterized, almost continually, this field, determining huge losses at the level of the national economy.

Nevertheless, despite such losses, mining has continued to be one of the most subsidized fields in Romania; more than 50% of the total State subsidies are directed towards the autonomous administrations in the mining industry. Instead of using such subsidies to equip or technologically modernize the units, they have been spent in order to periodically increase salaries and other incomes or bonuses for miners or their leaders.

Under such circumstances mining restructuring, and especially that of coal mining, has become a national necessity. The increased number of employees in the mining field and the accumulated coal stock determined Ciorbea Government to resort to the "solution" of dismissals owing to two orders: 9/1997, addressing to the employees dismissed from State Autonomous Administrations and State Companies, irrespective of their type of activity, and 22/1997 that gave special benefits to the miners dismissed "on demand". According to the stipulations of the last order, the fired miners were given "compensating payments" that represented between 12 and 20 average salaries of the branch.

Although the labor dismissal program in the mining field stipulated that, according to the implementation of Order no. 22/1997, only about 15% of the employees would leave the field, the number of those who voluntarily agreed to be dismissed over-passed all expectations due to the promised compensatory payments; accordingly, the employees of the administrations decreased with about 40%. Such circumstances determined a series of

immediate negative consequences upon the activity of certain mining units that had to face the lack of specialized employees and the prospect of future closing.

This whole massive restructuring process in the mining industry, conceived almost entirely from the point of view of decreasing the number of employees has had as a basic principle the improvement and increase of labor productivity in the field which has always been considered as non-profitable due to the high production cots, huge subsidies it has benefitted from, and massive debts it has accumulated during the years.

Accordingly, one would wonder whether restructuring has or has not as an effect the improvement of extractive activity. In order to answer this we have displayed the evolution of the average number of employees and of the coal production extracted during the period 1989-2007; we have paid attention only to those data belonging to the Jiu Valley's mining units excluding those from Tebea and Anina (that have also belonged to CNH Petrosani, although they do not belong to the coal basin of the Jiu Valley anymore) as well as the company's auxiliary units (Table no. 5).

One can notice that the number of employees decreased during the period 1997-2002 with 49.1%, production diminished with 19.3%, while labor's physical productivity of 266.9 tons/employee/year registered in 2002 was the biggest during the interval 1989-2007. Nevertheless, one cannot speak about a direct relation of cause between the decrease of the number of employees and the increase of productivity as long as in the mining field the plan figures depend on a lot of factors; among the most important factors one can cite technical equipments and the works of opening and preparing the mining fields. Yet, a visible increase of the productivity per employee can be noticed, a fact that is quite normal under the circumstances of severely diminishing the number of employees.

As compared with 1996, in 2007 the number of employees decreased with 69.29%, production with 55.83%, while labor's physical productivity increased with 43.88% tons/employee/year.

TABLE No. 5. Evolution of the average number of employees, of extracted production, and of labor's physical productivity during the period 1989-2007 in the Jiu Valley's mining units

| Year | Extracted coal production (tons) | Average number of employees (persons) | Labor's physical productivity (tons/average number of employees) |
|---|---|---|---|
| 1989 | 9,751,214 | 39894 | 244.4 |
| 1990 | 4,997,785 | 34614 | 144.4 |
| 1991 | 4,526,420 | 33751 | 134.1 |
| 1992 | 4,920,851 | 34281 | 143.5 |
| 1993 | 5,055,340 | 35365 | 142.9 |
| 1994 | 5,457,948 | 35822 | 152.4 |
| 1995 | 5,367,752 | 35505 | 151.2 |
| 1996 | 5,971,571 | 34796 | 171.6 |
| 1997 | 4,927,139 | 29306 | 168.1 |
| 1998 | 3,961,691 | 18179 | 217.9 |
| 1999 | 3,512,071 | 15843 | 221.7 |
| 2000 | 3,701,140 | 15402 | 240.3 |
| 2001 | 4,032,829 | 15281 | 263.9 |
| 2002 | 3,976,795 | 14902 | 266.9 |
| 2003 | 3,308,583 | 14382 | 230.1 |
| 2004 | 3,016,335 | 13228 | 228.0 |
| 2005 | 2,981,734 | 12011 | 248.3 |
| 2006 | 2,587,424 | 10909 | 237.2 |
| 2007 | 2,637,484 | 10683 | 246.9 |

*Source*: CNH Petrosani, *Production Department* and *Human Resources Department*

It is obvious that the Government which has started the restructuring process has not paid attention at all to the social costs of this approach nor to the economic ones. The Jiu Valley mining industry continued to benefit from massive State subsidies after 1997 too, while CNH's debts continued to grow. In 2007, the Company was, according to the data provided by the National Agency of Fiscal Administration (ANAF), Romania's biggest debtor; the debts to the general consolidated budget represented 2.83 billion RON. Accordingly, on

December 31st 2007, CNH owed 1.1 billion RON to the State budget, 1.5 billion RON to the State social insurances budget, 178.39 million RON to unemployment insurances budget, and 56.9 million RON to the health budget.

TABLE No. 6. State support for CNH Petrosani during the period 2007-2010 (thousand RON)

| Specification | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|
| State support out of which: | 401.440 | 338.940 | 293.160 | 256.022 |
| Subsidies | 384,962 | 324,818 | 281,057 | 245,649 |
| Transfers | 16,847 | 14,122 | 12,103 | 10,373 |

*Source*: The Ministry of Economy and Finance, *The strategy of the mining industry during the period 2007-2020*, p. 61

Under such circumstances, the State's support for CNH Petrosani during the period 2007-2010, given with the agreement of the European Board is going to increase to 1.28 billion RON (Table no. 6).

One can subsequently conclude that the restructuring process of the mining industry has taken place in a hurry with no concern for people's interests or for those of the mining units and areas. The government's program has been conceived and implemented over night and has not relied upon a fundamental and systematic conception capable of anticipating the medium and long term effects of restructuring. It has come out as a roller that swept away people without any alternative and without a concern for the future of the mining industry or of the strategic interests of Romania. Restructuring has not been a gradual process, developed according to certain stages, but more a rash political decision. In case the programs belonging to the restructuring process would have been implemented during several years, as the administrations initially conceived them, the former miners and the persons living in the mining areas had not have to face the extremely difficult conditions determined by unemployment.

As regards the economic and social decline of the Jiu Valley's population, one can say that almost all approaches and researches accomplished during the period 1997-1999 confirmed the fact that the conditions are going to continually aggravate not only for those who look for a job but for those who are employed too; they are going to be affected by the area's poverty and the increasing social tensions. Beginning with January 1999 when most of the "first wave" dismissed persons legally ceased to benefit from financial support (unemployment indemnifications and support allocations), central and local authorities had to face the numberless protests of those who demanded jobs.

The solution of these problems has, from the beginning, been perceived as unattainable from the point of view of its economic alternatives; the State's reaction has ultimately been determined by the serious forms the unemployed persons' protests took (from strikes and moving to Bucharest to hunger strikes, self-firings and even suicides). The solution has also been taken in a hurry, namely the short term financial support of unemployed persons (especially emergency support approved according to Government decisions).

Today, when one talks no more about closing all the Jiu Valley's mines and about renouncing for good to the pit coal extraction in the area (the European Union has re-considered its position and they have ultimately returned to the old advice "give the country as much coal as you can"), the authorities try to find out solutions to really improve the field; among them the giving of investment subsidies with a view of acquiring new technology or the settling of an energetic complex that would include both the mining units and the power stations of Mintia and Paroseni.

Yet, a last specification should be made, namely that after more than 10 years from the first Jiu Valley dismissals, at the end of 2007, CNH Petrosani hired personnel. It means that beginning with January the 3rd 2008, a number of 60 unskilled workers began their activity; they were distributed to all 7 mining units which are nowadays active.

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# NEW DEVELOPMENTS IN THE RELATIONSHIP SELLING APPROCH

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**Abstract:**
The traditional selling approach has suffered tremendous changes lately related to a major shift in the way the sales force is approaching the existent and potential customers. The new developments can be classified into many categories, but we would like it concentrate on few major developments that would dramatically impact the way sales force is evaluating the sales approach. We can classify these developments into 2 major categories: technology and conceptual. In the current context, we would like to analyze the specific changes in each category and a better understanding of the specific characteristics related to each category.

**Keywords:**
Relationship, selling approach, customer, buyer

## DEMANDING CUSTOMERS – FIERCE COMPETITION – BREATHTAKING TECHNOLOGICAL INNOVATION...

These are the realities of today's global marketplace... realities that have changed forever the way we do business, especially the way we sell. Gone are the days when salespeople could rely on charming small-talk and aggressive closing techniques alone to generate business.

Many traditional selling approaches regard selling as something the seller does to the buyer. They sell them something. The result of this attitude to sales is that many salespeople adapt a manipulative, almost coercive style of selling. Some salespeople think of selling as pushing a customer into buying, and success as a victory. Often, people fear salespeople and distrust them. They think of salespeople as fast talking and slick. They are wary of being sold something they really don't need or want.

The traditional customer call once seemed indispensable to the selling process; the time and expense involved were just a basic cost of doing business. In recent years, however, the business community has come to regard the sales call as an expenditure for which there are substitutes. For many companies telemarketing and direct mail have made the sales call a choice not inevitability. This is not surprising when various studies suggest that getting one sales person in front of one customer now costs triple since 1983. As a consequence professional salespeople have to be more effective than ever to justify the investment in a face to face effort.

In essence, we can draw a number of primary conclusions and taken together, these findings paint a picture of the current state of the sales environment.

**Customer Focus Creates Competitive Advantage:**

- The one term that sets top performers apart - customer focus
- Outstanding sales results depend on:

- The ability to think from the customer's point of view
- Understanding the customer's agenda, buying cycle and best interests

- Beyond a superficial reading of immediate customer needs, salespeople must gain a deeper understanding of both the buyer's long-term goals and the overall business climate
- At the heart of customer focus is the art of listening constructively - the best salespeople are masters at capturing information
- Customer focus means taking the customer seriously - to-day the salesperson who clings to the product orientation of a decade ago is losing ground
- As client companies branch into new markets and unfamiliar territories, they are demanding unique, flexible solutions from their vendors - customized to support specific goals

Another myth which can be exploded is that whilst customers value flexibility, being too flexible can undermine the sales relationship. On the whole salespeople imagine that customers value a vendor's responsiveness above all. However recent research shows that their primary concern is reliability.

In summary, in order to maintain customer focus the best salespeople become facilitators, creating a partnership that extends the selling relationship within the customer's company. The motivation to achieve this should be strong - it costs five times as much to attract and sell to a new customer as it does to an existing one!

**The right to do business has to be earned and *never* assumed:**

Rather than doggedly asking for the business, the very best sales people work to keep the relationship moving towards a sale. They realize the need to identify how to turn their company's products into real solutions, which must meet specific needs.

Unfortunately, our surveys confirm that the average salesperson drags the customer over old ground as much as 52% of the time - they are unable to provide continuous stimulation and never know when to treat an existing customer like a new one.

Conversely, exceptional salespeople only make such 'return' calls for 10% of the time. Above all, earning the right to proceed requires gaining the customer's trust and top salespeople work diligently to establish a climate in which the customer is willing to share information and feels comfortable doing so. The key here is integrity.

**Customers are persuaded when they are part of the process and not part of the audience:**

Sales success to-day demands a radical shift from the 'peddler' mentality of merely demonstrating products and expanding on their features. It requires treating the customer as a participant. More often than not, a 'flashy' sales presentation alone alienates rather than persuades

The best salespeople regard the sales call as a two-way conversation - not a one sided pitch. They have developed active listening skills. Average salespeople score fairly well in their ability to provide customers with facts and figures, but top performers dramatically outscore the rest when it comes to gathering information. In addition, how a salesperson collects information still distinguishes exceptional achievers from the rest of the pack. I.e. top performers ask better questions and as a result gain much better information. Essentially, they aim to engage customers in the buying process with questions that require thoughtful answers, that stimulate curiosity and that reveal the customers underlying needs.

**Businesses need to re-define selling and what constitutes basic selling skills:**

In to-day's world of selling, there is less and less room for apprenticeship. Selling has become an exclusive club of highly skilled professionals where product knowledge and time management skills, for instance, are the cost of membership not leadership.

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Ongoing research demonstrates that to-day's 'average' salesperson is just as effective as the high performer in explaining features and benefits effectively, relating a service or product to customer needs and closing a sale. But, above this Level 1 plateau of competence, the exceptional salesperson is busy defining the "basic skills of tomorrow".

Building an up-to-date foundation in sales competence does mean sacrificing some old notions of what it takes to succeed in a competitive marketplace. For example, a salesperson can no longer just "win by knowing". Every company needs to test their assumptions about what skills really contribute to sales success. Too often operating on old sales theories means training and rewarding people to do the wrong things.

**When the buyer and seller act as partners, they are building a bridge to profitability:**

Successful selling is definitely not about the "hit and run" sale. Sales achievers regard their relationships with key customers as a partnership and cultivate it as such. When customers face tough business challenges and complex technological choice, they rely on sales people who can assist them in making the right decisions.

The primary objective of a sales partnership has to be, to create and sustain a mutually productive relationship, which serves the needs of both parties, now and in the future. The key word here is symbiotic. Partnership does not mean eliminating the tension between buyer and seller; it means that top-performing salespeople know how to strike a balance between achieving immediate results and developing the relationship fully.

**In Summary: Why Do We Need A Fresh Approach To Selling?**

Many organisations have developed without objective analysis of their purpose and structure. The buying power in many industries is no longer evenly distributed - in a large number of markets a few big firms control the majority of purchases.

The development of new marketing techniques has meant that some tasks traditionally performed by the sales team can be more effectively handled by other methods. The prime objective of all sales staff is to gain business. From an organisational point of view, however, how they all achieve their goals must be defined in order to identify what kind and the quality of skills that are required.

Develop a long term relationship by attaining customer satisfaction Truly effective salespeople succeed because they are genuinely curious and concerned about people in general - and customers in particular. Their desire to understand the customer takes priority over their desire to sell their products and services. The delightful irony, of course, is that the very reason they are successful at selling is because they have made their desire to sell a secondary issue. The primary issue is the relationship they have with their customer.

The surest way to cement a long term business relationship with your customer is to remember that no sale is completed until the customers expectations have been met or, preferably, exceeded. There are many salespeople who take customers for granted. The excitement of new sales often leads to ignoring existing customers. The result is constant pressure to create new business from scratch. Meanwhile, some of your best prospects are right there under your nose, in your own customer base.

The "traditional", fast-talking slick sales person is no longer effective in today's global marketplace. Dynamic and highly competitive, our market consists of well educated, savvy consumers looking to the modern salesperson for guidance in making well-informed buying decisions. Those unwilling or unable to adapt not only experience declining sales, but also risk severing long-term customer relationships. The challenge is enormous and the stakes are high.

Customers buy for their reasons, not ours. When we strive to form a partnership with our customers, providing them with valuable help and advice as well as supplying vital products and services, we virtually ensure sales success.

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# INTERNAL MARKETING AND PERFORMANCE IN SERVICES ORGANIZATIONS

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**Abstract:**

The paper tries to reveal the critical importance of service employees and human resource in delivery of quality services and creating customer satisfaction. We consider that the employees' abilities (attitudes and behavior) can improve - or reduce- the reputation of services organization (employees are responsible for the organizational performance). Internal marketing is the vision of a services organization that wants to transform its employees in loyal customers. By satisfying „internal customers", the organization improves its ability of satisfying the „external customers" successfully. This paper focuses on the fact that the services organization's performance is fundamentally based on the way managers lead – using their creativity, imagination, competence – the employees.

**Keywords:**

Internal marketing, customer satisfaction, performance, employees

## 1. INTRODUCTION TO INTERNAL MARKETING

Internal marketing was first proposed within the services literature in the 1970's as a solution to the problem of delivering high quality service (Vary and Lewis, 1998). Internal marketing is a concept aimed at developing customer conscious employees that will consistently deliver superior quality service to the external marketplace (Papasolomou-Doukais, 2003). Internal marketing depends on a variety of individual activities throughout the organizations and it attempts to inform and educate the employee regarding the organizations mission the benefits of the product or service being sold, and the expectations of the organizations customers (Vary and Lewis, 1998). Such a programme aimed at generating employee commitment is not new as it is inherent in total quality management literature.

According to Ahmed and Rafiq (2002, p.1) internal marketing requires:

- The acceptance of marketing techniques and philosophy within an organization
- Customer orientation and a market orientation
- A participative approach to management
- A strategic approach to human resources management
- The coordination of all management activity to achieve customer or market orientation or customer focused management.

Definition of internal marketing

Internal marketing is an ambiguous concept (Flipo, 2000). The term internal marketing is used widely as a means of highlighting commitment to improving the effectiveness of the services offered by an organizations' resources (Gilmore, 2000). Internal marketing is not a departmental function rather an organizational activity as the entire resources within the organization must be coordinated (Hogg and Carter, 2000).

The definitions reviewed within the literature highlight the ability possessed by internal marketing to improve service quality through an organizational effort. The definitions encountered within the literature can be categorized according to three perspectives, the internal customer, the development of a customer orientation and the theory of internal marketing as an implementation mechanism. For the purpose of this paper the group will focus on the customer orientation perspective as it is relevant in the context of high contact service employees.

Customer Orientation

Internal marketing has been defined as the approach employed by the organization to advocate the philosophies of customer and service orientation throughout the organization through the motivation of employees (Varey, 1994). In this context the organization attempts to install a set of values related to achieving a superior service climate within the employees belief systems (Varey, 1994).

Barnes (1998) approaches internal marketing in a similar manner by defining it as actions taken by the organization to ensure that customers receive the highest standard of service due to the

employees' commitment to service quality. The organisation cultivates employee commitment by encouraging the use of customer focused quality techniques (Ballantyne, 1991).

In the context of customer orientation internal marketing considers the attraction, retention and motivation of service-minded employees. The motivation of employees is not enough in itself, as the customer orientation, must be communicated into the external marketplace through employee action (Rafiq and Ahmed, 2000). George (1990) illustrated that relational exchanges between employees within an organization should be considered a prerequisite for successful exchanges with external markets. The satisfaction of the internal customer is of critical importance as; satisfaction will ultimately effect the satisfaction of the external market (Ballantyne, 1997). Internal marketing is a technique implemented by the organization in an attempt to ensure the provision of excellent service.

The Models of Internal Marketing

Gronroos (****) believes Internal marketing is concerned with ensuring employees are consistently conscious of delivering service quality. The model highlights how internal marketing should be supported by management with information exchange, recruitment and training and employee decision making (Rafiq and Ahmed, 2002). Employees realize the importance of their position within the organization and develop into satisfied individuals. The model stresses the importance of interactive marketing in conjunction with internal marketing. Interactive marketing is a proposed with how customer contact employees take care of customers during service encounters (Bitner and Evans, 1993). By improving the service encounter through internal marketing customer satisfaction and employee motivation can be increased.

However, Gronroos (****) does not encapsulate all the elements of internal marketing (Rafiq and Ahmed 2000). The elements of internal marketing identified by Rafiq and Ahmed (2000) include:

- Employee motivation and satisfaction
- Customer orientation and customer satisfaction
- Interventional co-ordination and integration
- Marketing like approach to the above
- Implementation of specific corporate and functional strategies

Rafiq and Ahmed developed a comprehensive model of internal marketing based on these elements. According to the model the use of a marketing like approach is fundamental in internal marketing, as it incites the employee to become customer orientated through motivation and coordination of functional departments (Rafiq and Ahmed, 2002). Job satisfaction is incorporated due to the belief that if the internal customer is satisfied in the service position this satisfaction will be transferred to the external customer (Rafiq and Ahmed 2000). Empowerment is integrated into the model to highlight the importance of allowing the employee flexibility in terms of decision-making during the service encounter (Rafiq and Ahmed, 2000).

This model focuses on the area of service quality so it is largely applicable in the service industry.

The objectives of internal marketing

Internal marketing aims to improve customer consciousness by changing the beliefs of the front line employees (Ahmed, Rafiq and Saad, 2003). Helman and Payne (1992) believe the objectives of marketing depend on the reason it is being implemented. Internal marketing may be concerned with improving employee routines through internal motivation. Internal marketing may be concerned with ensuring the entire organization understands each department's function within the organization. The internal marketing function may be aimed at marketing the organizations product or services to customers.

Internal marketing aims to improve the overall business process within an organization to ensure that resources to progress the organizations aspiration are made available to the internal customer (Joesph, 1996).

## 2. MOTIVATING SERVICE EMPLOYEES

Why Motivate Employees:

As previously discussed, the service encounter and internal marketing include the use of motivation, as a perquisite for their success in the marketing of services. Management need to be aware of motivations exact connotation to comprehend its use to their business. Motivation can be defined as "the development of a desire within an employee to perform a task to his/her greatest ability based on that individual's own initiative" (Rudolf and Kleiner, 1989, p. 1). By analyzing the definition, one can ascertain, motivation to be the level at which an employee will perform a specified activity for the company, an imperative function for success.

Motivation can also mean employees "…strive to reach peak performance every day, … enjoy the continual challenge of improving results, genuinely care about their peers and their company, and will maintain positive results" (Evenson, 2003, p.21), or as "the willingness to exert high levels of effort

toward organizational goals, conditioned by the person's ability to satisfy some individual need" (Robbins, 1993 as cited in Lu, 1999, p. 63).

The definitions of motivation, lead an organization to believe their employees will perform their specified tasks better than the norm and will genuinely wish to do so, while this is important for the business, motivation can also have other benefits. Carlsen (2003) believes a motivated workforce is essential, as the complete participation of employees will inevitably drive the profitability of the organization. Another paramount concern for management is, motivating their employees relates directly to the perceived increase in performance the employees with deliver from managements' participation in the exercising of motivation techniques, therefore, there is a direct result between the levels of motivation and management's participation. (Tyagi, 1982).

Certain academics have linked motivation as being a key determinant of job performance and how a poorly motivated force will be costly in terms of excessive staff turnover, higher expenses, negative morale and increased use of managements' time (Jobber, 1994). Therefore, management need to know what exactly motivates their staff so resources are not misallocated and dissatisfaction develops among employees (Jobber, 1994). While motivation is a key determinant of performance, management must not neglect how motivation is the also concerned with the educating of employees. Darmon (1974) believe motivation is the educating of employees to channel their efforts towards organizational activities and thus increasing the performance of the said boundary spanning roles.

If management neglect to educate and motivate their employees, they will inevitable become dissatisfied or disenchanted with their job. Disenchantment in the workplace leads to absenteeism, turnover, sick leave, strikes, grievances and even accidents. Denton (1991) believes a motivated workforce would alleviate disenchantment felt by employees and improve these factors. Denton (1991) also believes a motivated workforce will lead to greater understanding, acceptance, commitment to implementation, understanding of objectives and decision making between management and employees.

Finally, motivation can also be used as a tool to develop further, the high performers and ensure they are satisfied with their work activities. Green (2000) envisages motivation to be proactive in the sense of; in dealing with employees who are high performers, motivation is essential, otherwise their performance will decline or they will simply leave the job. In the area of dealing with low performers, motivation is a prerequisite, otherwise these employees will drag results down, lower productivity and certainly won't leave the organization, as they will have nowhere else to go.

How management can motivate their employees?

Rewards: "Good manager helps sub-ordinates feel strong and responsible, who rewards them properly for good performance and who sees that things are organized in such a way that subordinates feel they know what they should be doing" (McClelland and Burnham, 1997, p.30). As McClelland and Burnham (1997) outline, management should reward their employees for their performance and loyalty. Rewards can take two forms; extrinsic rewards or intrinsic rewards.

Extrinsic Rewards: Extrinsic rewards as outlined by Rudolph and Kleiner (1989) and Sujan (1986) as those basic material requirements which management must meet for the employee. Examples include; salary, fringe benefits, promotions and so on. The extrinsic rewards are usually viewed by employees as a given and a must. Extrinsic rewards are usually thought of in terms of money.

Darmon (1974) believes money or financial incentives are motivators of employees' behavior and they can be used to influence their behavior; this can be used in a variety of circumstances, which may arise within the organization.

Dauten (1998) outlines how employees are best motivated, by having them bet on their own success. Therefore, management should tie their performance in with their bonuses; this will act as a motivator, as a challenge has been presented to them. Employees will want to achieve managements' goals as the greater their performance the greater the financial reward received.

Intrinsic Rewards: Rudolph and Kleiner (1989) outline intrinsic rewards as psychological incentives, for example, input, thanks, job rotation, job enlargement and so on. The importance of intrinsic rewards is how they build a climate and environment of trust and co-operation among employees. Or as Sujan (1986) outlines, employees who are motivated intrinsically "enjoy performing job-related tasks, such as influencing customers and learning about the company" (p.42).

Nelson (2003) contends, while money is a motivator, it is not as powerful as the following:

Feeling of contribution to the job, having management tell us we are doing a good job, having the respect of our peers and colleagues, being involved and informed of developments and having meaningful and interesting work. While, Nelson (2003) finds these methods as good motivating tools, he outlines how the use of recognition is the ultimate motivator. The importance being, "recognition is not just for the person who performed well – it also sends a message to other employees as it communicates the standard of the company" (Nelson, 2003, p.8). Nelson (2003) implores to

management, recognition will improve the level of performance by employees, which inevitably improves the financial performance of the organization. Nelson (2003) believes the uses of monetary rewards are becoming "viewed as a right as opposed to reward and therefore the ability for money to serve as incentive is diminished" (p.8). Money also distracts team members as their concentration is now focused on individual cash gains. Therefore, Nelson (2003) has developed a number of ways in which an organization can motivate their employees without incurring great financial costs.

Ways in which an organization can install recognition as low-cost (Nelson, 2003, p.9):

- Call employees into office and say "thanks"
- Acknowledge individual achievements
- Create employee "hall of fame"
- Photo collage of successful project and those who worked on it
- Place to display memos/posters as recognition of employees work in their help in achieving goals
- Behind – the – scenes awards for those out of limelight
- Certificate program
- Most importantly, be timely, sincere and specific.

## 3. CONCLUSION:

Many organizations testify that their employees are their most valuable resource. This is especially relevant in the service organization. Customers often base their perceptions of the service on the quality of the interaction with service personnel. For this reason it is essential that the employee is motivated to consistently deliver a high quality service experience to the customer. Motivation is especially important when employees operate in a boundary spanning position, as this involves high levels of stress and burn out.

We propose internal marketing as a mechanism for ensuring the motivation of service employees. The implementation of an internal marketing program ensures that motivation is at the forefront of managements' priorities. This realization implores management to consider that motivation is not solely the responsibility of human resources but must be adopted by all managers throughout the organization regardless of their functional department. In summary, the importance of motivated high contact employees is fully realized through the adoption of internal marketing.

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# MARKET BASED INSTRUMENTS – EFFECTIVE TOOLS FOR ENVIRONMENTAL STABILITY IN EUROPEAN UNION

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**Abstract**:
Market-based instruments (MBIs) can be particularly effective tools for dealing with the four major areas of action of the European Union 6th environmental action programme, namely: tackling climate change, preserving nature and biodiversity, protecting environment and human health, and through the sustainable use of resources and management of wastes. They do so by addressing the sources of environmental pollution most relevant to these areas such as: emissions from power stations, industry, cars and aircraft (tradable emission permits, fuel taxes); increasing waste generation by households and other actors (waste disposal taxes, taxes on packaging, incentives for recycling); emissions resulting from houses and offices (incentives for improved insulation and energy efficient heating systems); emissions resulting from agricultural activities (fertiliser and pesticide taxes).

**Keywords:**
MBIs, tradable permits, subsidies, environmental taxes, efficiency, polluter-pays principle

## 1. INTRODUCTION

### 1.1. Conceptual delimitations and classification of MBIs

There are a lot of definitions of economic instruments. The OECD labels instruments economic "when they affect estimates of the costs and benefits of alternative actions open to economic agents". This definition focuses on the mechanics of the measure and points to the existence of financial incentives and freedom of response, thus creating a distinction with direct regulatory or administrative measures. Hahn points to the outcome and calls an instrument economic when it improves efficiency compared with a situation where another instrument would have been in use, or none at all. A carefully-designed administrative measure can be an economic instrument in his view. James observes: "In reality, the distinction between direct regulations and economic instruments is often blurred as any system of economic instruments usually requires appropriate legislative or regulatory backing. Wherever economic instruments have been used, ... supporting regulations have been applied". His opinion represents a practical view, and points to the importance of policy mixes. Rather than defining market-based instruments, this paper lists the following environmental instruments as "economic": emissions trading, environmental taxes and charges, deposit-refund systems, subsidies (including the removal of environmentally-harmful subsidies), green purchasing, and liability and compensation. In dealing with these instruments, policy mixes will not be lost from view. An important policy mix that has emerged recently is environmental tax or fiscal reform, which combines market-based environmental measures with measures in the fiscal and economic sphere.

MBIs are classified into five main categories:

1. *tradable permits* that have been designed to achieve reductions in pollution (such as emissions of CO2) or use of resources (such as fish quotas) in the most effective way through the provision of market incentives to trade;
2. environmental taxes that have been designed to change prices and thus the behaviour of producers and consumers, as well as raise revenues;
3. environmental charges that have been designed to cover (in part or in full) the costs of environmental services and abatement measures such as waste water treatment and waste disposal;
4. environmental subsidies and incentives that have been designed to stimulate development of new technologies, to help create new markets for environmental goods and services including technologies, to encourage changes in consumer behaviour through green purchasing schemes, and to temporarily support achieving higher levels of environmental protection by companies;

5. liability and compensation schemes that aim at ensuring adequate compensation for damage resulting from activities dangerous to the environment and provide for means of prevention and reinstatement.

Experience in recent years shows that the question of 'which instrument is best' has changed to 'which mix of instruments is best', both in terms of using MBIs alongside other environmental measures such as regulations and in terms of using MBIs to meet environmental objectives in combination with economic and social objectives e.g. environmental tax reform and subsidy reform.

### 1.2. Guiding principles that govern MBIs

The potential qualities of market-based instruments were recognised early in the evolution of environmental policy. Following academic debate and incidental application, market-based instruments were widely recommended at the European and global level in the last two decades of the 20th century. The 5th environmental action programme (CEC, 1993) mentions market-based instruments as important tools "towards sustainability" as they "... encourage the production and use of environmentally-friendly products and processes". Agenda 21 states "Environmental law and regulation are important but cannot alone be expected to deal with the problems of environment and development. Prices, markets and governmental fiscal and economic policies also play a complementary role in shaping attitudes and behaviour towards the environment". The polluter-pays principle is a main guiding principle in environmental policy and is frequently invoked as the legislative justification for the broader use of market-based instruments. However, as originally formulated by OECD and adopted by the member countries, this principle only requests that "...the polluter should bear the expenses of carrying out the measures ... to ensure that the environment is in an acceptable state". This is a narrow definition as it leaves out any damage that may remain after the necessary measures have been taken. Many use a wider interpretation, wherein the polluter should bear "the cost of pollution abatement, the costs of environment recovery and the compensation costs for victims of damages if any, due to pollution". The EU has followed this interpretation with the recent adoption of the environmental liability directive, which has been based explicitly on the polluter-pays principle. Also in its wider interpretation, the polluter-pays principle does not request the polluter to pay for the use of the environment per se. The main guiding principle for the application of market-based instruments is the *economic principle of efficiency*. The costless use of objects that have a value for society is amarket imperfection that reduces efficiency and can be corrected by "getting the prices right". This is captured by the user-pays principle that complements the polluter-pays principle.

## 2. THE STUDY

### 2.1. Reasons for using MBIs as policy tools

The economic rationale for using market-based instruments lies in their ability to correct market-failures in a cost-effective way. Market failure refers to a situation in which markets are either entirely lacking (e.g. environmental assets having the nature of public goods) or do not sufficiently account for the "true" or social cost of economic activity. Public intervention is then justified to correct these failures and, unlike regulatory or administrative approaches, MBIs have the advantage of using market signals to address the market failures.

Whether by influencing prices (through taxation or incentives), or setting absolute quantities (emission trading), or quantities per unit of output, MBI implicitly acknowledge that firms differ from each other and therefore provide flexibility that can substantially reduce the costs of environmental improvements. MBIs are not a panacea for all problems. They need a clear regulatory framework in which to operate and will often be used in a policy mix with other instruments. But if the right instrument is chosen and appropriately designed, MBI carry certain advantages over regulatory instruments:

1. They improve price signals, by giving a value to the external costs and benefits of economic activities, so that economic actors take them into account and change their behaviour to reduce negative – and increase positive - environmental and other impacts.
2. They allow industry greater flexibility in meeting objectives and thus lower overall compliance costs.
3. They give firms an incentive, in the longer term, to pursue technological innovation to further reduce adverse impacts on the environment ("dynamic efficiency").
4. They support employment when used in the context of environmental tax or fiscal reform.

### 2.2. MBIs in the EU context

The European Union is a leading force in the world in taking action on environmental sustainability and, in particular, on climate change. This has been confirmed through the adoption of the energy and climate policy package in which the EU repeated its commitment to addressing climate change internally and on an international scale, to promoting environmental sustainability, to

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reducing dependence on external resources and to ensuring the competitiveness of European economies. In addition, halting loss of biodiversity, preserving natural resources that are under pressure and protecting public health also require urgent action. Without public intervention and the strong commitment of all actors, these ambitious objectives cannot be reached. The EU has increasingly favoured economic or market-based instruments ("MBI") – such as indirect taxation, targeted subsidies or tradable emission rights – for such policy purposes because they provide a flexible and cost-effective means for reaching given policy objectives. The more intensive use of MBI has also been advocated in the EU´s 6th Environment Action Programme (6th EAP) and the renewed EU Sustainable Development Strategy as well as the renewed Lisbon Strategy for Growth and Jobs. This paper launches a discussion on advancing the use of market-based instruments in the Community. In this sense the paper fits into the framework set by the new integrated energy and climate change agenda where market-based instruments and fiscal policies in general will play a decisive role in delivering the EU's policy objectives. The paper also explores options for a more intensive use of market-based instruments in different areas of environmental policy at both Community and national levels.

Besides their merits in helping achieving specific policy goals, the EU has used market-based instruments to avoid distortions within the internal market caused by differing approaches in individual Member States, to ensure that a similar burden falls on the same sector across the EU and to overcome potential adverse competitiveness effects within the EU. Common action also makes the EU stronger when confronting external competition from its trading partners. At the EU level, the most commonly used market-based instruments are taxes, charges and tradable permit systems. In economic terms these instruments work in similar ways. However, they also differ in notable aspects.

Firstly, quantitative systems, such as tradable permit schemes, provide more certainty as regards reaching specific policy objectives, e.g. emission limits, (subject to effective monitoring and compliance) compared to purely price-based instruments, such as taxes. Price-based instruments, in turn, provide security regarding the cost or the price of policy objective and tend to be easier to administer. Secondly, they differ when it comes to the aspect of revenue generation. Taxes (and in a more limited way charges) have increasingly been used to influence behaviour, but they also generate revenue. Tradable permit systems can generate revenue if the allowances are auctioned by public authorities. Tradable permit systems using auctioned allowances have therefore similar features to a tax (the regulatory and compliance aspects differ). Charges, on the contrary, are usually a payment in return for a clearly identified service or cost, and therefore lack the flexibility for the public budget to use such revenue.

The above features have, to an important extent, influenced the ways and areas that the EU currently uses market-based instruments at Community level, thus leading to the introduction of instruments such as the EU Emission Trading Scheme ("the EU ETS"), the Energy Taxation Directive, and, in the field of transport, the Eurovignette directive. These aspects have to be taken into account should the EU consider using market-based instruments further at EU level, in such a way as to make the best use of each of them in the most appropriate field and avoid overlaps. In principle, Community decision-making rules should not have an influential role to play in this context. Nevertheless the unanimity requirement in the tax area means that the possibility of using taxation as an instrument differs from other instruments in some respects.

## 3. ANALISES, DISCUSIONS, APPROACHES AND INTERPRETATIONS

The EU is strongly committed towards ensuring environmentally sustainable development as well as promoting the Growth and Jobs agenda. An environmental tax reform (ETR) shifting the tax burden from welfare-negative taxes, (e.g. on labour), to welfare-positive taxes, (e.g. on environmentally damaging activities, such as resource use or pollution) can be a win-win option to address both environmental and employment issues. At the same time, a long term tax shift will require relatively stable revenues from the environment related tax base. ETR can also help to alleviate the possible adverse competitiveness effects of environmental taxes on specific sectors. If the action is closely co-ordinated at the Community level, these impacts can be further reduced compared to unilateral actions by Member States. Reductions in labour taxation or social-security contributions which tend to benefit lower-income households, can counterbalance any possible regressive effect from environmental taxes.

Finally, with an ageing population, which increases pressure on public expenditure, and globalisation that makes taxation of capital and labour less viable, the shift of tax burden from direct taxation towards consumption and, in particular, environmentally damaging consumption, may provide considerable benefits from a fiscal perspective. As well as discouraging environmentally damaging behaviour through taxation, Member States may also use fiscal incentives such as subsidies

to encourage green behaviour, facilitate innovation, research and development, provided that public resources are first generated in some other way (e.g. by taxing environmentally damaging behaviour) or that spending is reduced (e.g. by removing environmentally harmful subsidies). This approach is particularly relevant in the context of the ambitious objectives of the climate and energy agenda of the EU, notably to achieve the reduction of greenhouse gas emissions by at least 20% by 2020, the binding target of 20% renewables of energy production by 2020, and the target of 10% biofuels.

At the EU level it is considered that it is for Member States to find the right balance between incentives and disincentives in their tax systems, while respecting overall fiscal constraints and fiscal neutrality. The Commission would like, however, Community tax policy to facilitate this balance. There may be scope to improve the structured exchange of information between Member States on their best practices in the area of MBI in general and environmental tax reform in particular. While specialised structures exist in some areas there is no horizontal forum available. In this respect, one option could be the establishment of an MBI Forum.

## 4. CONCLUSIONS

EU believes that alongside regulation and other instruments, there should be increased use of MBI, including trading schemes, taxation measures and subsidies, as a cost-effective tool to achieve environmental and other policy objectives, both at Community and national levels. This would be in keeping with the Sustainable Development, Lisbon and Better Regulation Agendas.

The new energy and climate policy agreed in Europe implies nothing less than a new industrial revolution over the next 10 to 15 years. It will require a substantial change in the way Europe deals with energy with the final aim of achieving a real low carbon economy. Several policy areas - at the national as well at the European level - will have to contribute and to be adapted in order to lead to this ambitious objective. Market-based instruments will be important parts of the efforts to achieve real change through changing incentives for businesses and consumers. On top of this important long term role, these market-based instruments also carry important advantages for fiscal, other environmental and allocative purposes addressed in this paper.

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# SOME ASPECTS OF THE HUNGARIAN SPATIAL- AND SETTLEMENT DEVELOPMENT

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**Abstract:**
The never before seen sum of the possible financial resources at Hungary's disposal supported by the European Union in the programming period 2007 to 2013, indicates a historical chance in connection with the fulfillment of the development objectives, especially the spatial objectives in Hungary. In order to the optimal utilization of the financial resources it is needed to continue the decentralization process – started in 1996 but refracted in 1999 – and to strengthen the regional institutional system. The efficient utilization of the financial resources co-financed by the EU and the Hungarian government also requires such a planning mechanism, which considers both the national specialities both the international spatial development experiences, and is based on a wide professional and political consensus.
This paper aims to survey the most important milestones of the formation of the Hungarian spatial policy, especially the ones of the spatial- and settlement development. Also the evolution process of the Hungarian self government system will be explored, principally in connection with the relationship between the municipality development and EU grants. Finally the most important projects of the Municipality of Szeged will be demonstrated.

**Keywords:**
EU regional policy, spatial development, municipality development

## 1. INTRODUCTION

After the access of Hungary to the European Union, spatial planning comes more and more to the front, because the financial supports of the European Union are based on the completed spatial documents [17]. Ten years ago, the Hungarian Parliament has accepted the Act of 1996. XXI. on the regional development and physical planning in 1996. This has been a high level and complex regulation of the spatial development in Hungary [3]. Its further importance is, that among the candidate countries, Hungary has adopted firstly the legal conditions of the regional institutions regarding to the principles and requirements of the European regional policy. According to the act, spatial development in Hungary is based on national and regional planning documents, concepts, programs, and physical plans [15].

## 2. SOME ISSUES OF THE HUNGARIAN SPATIAL POLICY UNTIL 1996

The first legislative provision in connection with the spatial- and settlement development was the Act of 1937. VI. on the physical planning of cities, housing and construction. The law obliged the cities to complete city development plans [21], furthermore compelled the cities with high level of exactitude to prepare land use plans and general settlement plans. After the second world war, the Institute of Physical Planning (the so called TERINT) has been established in 1949. The general aim of the TERINT was to coordinate the socialist industrialization and the town-planning. Additionally, its task was to register all spatial and settlement changes, and to work out several plans. Its significance might be the completion of the first regional planning works, like the one of Zagyva-valley, Borsodi area, Baranyai area.

As for local legislation, in 1949 and in 1950 the Constitution, and later the first council law introduced a council system that was completely alien to the Hungarian conditions, by copying the soviet model [9]. From the beginning, the major function of this system was to accomplish the central decisions of the white trash dictatorship that aimed to change society and economy mainly with means of the polity, leaving little local independence. Similarly to the first one, he Second Council Law in 1954

also rejected the idea of local municipality [10]. There was a decrease in the councils' duties in administration and authority but the councils' spatial and settlement developing tasks slightly increased. The councils were regarded as the lengthened arm of the central state organization delegated by the monolithic party-centre. In the so-called dual subservience the centre managed the county by primacy means, the county managed the townships and most of the towns and the township councils managed the villages. This local dependence attached serious lack of local democratism, nominal votings and elections preceding the real free elections. Council boards were politically insignificant, as council leaders, close council meetings and closed executive board meetings decided on important issues beforehand, and the council meetings mostly just accepted these decisions. From the aspect of city development, we cannot disregard that the panel program that started in the second half of the 1960s wasn't based on local decisions, either.

The decree with legal force of 1955. XXXVI. on the regulation of town- and village settlement determined the system of town- and village settlement, and dealt with the notion of regionalism more thoughtfully, than ever before. Thanks to this legislative provision, From the end of the fifties on, the number of regional plans increased significantly. In 1965, the National Settlement Development Plan has been completed, which surveyed the Hungarian settlements, and the development trends. In 1970, the National Settlement Development Concept has been worked out, which has been adopted by the Hungarian government after a wide dialog with the local and departmental authorities in 1971. According to the concept, all the settlements have been classified into development categories. The financial resource provided for each settlement has been dependent on the category of the concrete settlement.

This dual subservience remained during the later "reforms" of the council system, the laws didn't provide much more local independence. The council system was only the executor of central programmes. But these programmes didn't involve local needs that could have given a special image to settlement developments and that could have implemented developments in a way that would have fulfilled local needs the most. As local regulation didn't have any latitude in other developments either, settlements got poorer and poorer, regardless of their size.

On the whole, the Hungarian spatial policy before 1985 can be characterized with a settlement view instead of a spatial view. This policy was city-centric, which underplayed the role and importance of territorial units. In this period, the spatial policy was strong centralized in Hungary.

From 1985 till 1996 the Hungarian spatial policy can be characterized as a transitional one. The resolution of the Parliament Nr. 12/1980-85. aimed to develop the lagging behind territorial units, so this legislative provision was the first, which declared the spatial view instead of settlement view. In the middle of the eighties, it has been realized, that the development of separated settlements is not efficient, complex territorial units has to be taken into consideration and developed. In the decentralization process of the Hungarian regional policy, the Act of 1990. LXV. on the local governments counts as a substantial milestone, which pronounced the local demand on decentralization.

From 1991 till 1995, the spatial development efforts have been supported by a separated money fund in Hungary. The Spatial Development Fund had a very varied function: to support employment level expansion and economic restructuring in lagging behind regions, to support the creation of crisis management programs on the level of regions and sub-regions etc. It also has been emphasized, that during this transitional period the regional policy of the European Union has been also in Hungary get to know, and started the receipt of the core principles [4], but its effects has been only in the next period perceptible.

## 3. MILESTONE IN THE HUNGARIAN SPATIAL POLICY

The adoption of the Act of 1996. XXI. on regional development and physical planning meant a turning point in the field of regional planning, institutions, financial and economic regulation and EU-integration. 1996, the year, when the act came into force is the beginning of the third stage of the Hungarian spatial policy. This legislative provision set its regional developments goals, overall objectives – therefore the partition of competences between the Parliament and the government – in compliance with the regional policy of the European Union. This act forms the basis of the Hungarian spatial policy [15].

The Country Report of the European Union in 1998 gave a very positive evaluation on the Hungarian regional policy, because the adopted act was unique amongst the candidate countries. One of the most important significances of the act was to define and to clear the most important notions of the theme, like region, sub-region, spatial unit, regional development etc. Furthermore the act defined the tools, financial resources and the institutions of the regional development. The notion of regional planning was given a high priority also in the preparation for the drawing of Structural Funds and the evaluation of the country alike.

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The act set up the possibility of applying the regional policy of the European Union by containing the most important core principles of the EU's regional policy, like concentration, partnership, additionality, regional applications etc. Furthermore the act fulfils the requirements of justice, equity and solidarity, and the general cohesion objectives of the European Union [3]. Dissociation of the institutions into national, regional, and sub-regional level also can be evaluated as a big step in the efforts of decentralization. The act ordered to complete spatial development documents first of all on the level of regions and counties1. This is a very important issue from economical view, because foreign direct investment and enterprise development need a well documented background, because spatial documents contains significant information to support investment decisions (for example about externalities).

The progress of the Hungarian spatial policy come to a sudden standstill in 1999. The act of 1999. XCII. on the modification of the act of 1996. XXI. on regional development and physical planning can be evaluated as a withdrawal in the decentralization efforts in the spatial policy. The significant changes in the membership pattern of the Regional Development Councils are on the way back to the centralization: the preponderance of the ministries, its right of veto, the exclusion of the local economic actors (chambers, Council of Labour), the membership of deconcentrated organizations (Office of Agriculture) are steps towards the centralization. The European Union passed strictures on this issue, just as on the inadequate utilization of the financial resources: spatial resources have been used as resource replenishment by municipalities and their institutions so they didn't catch they original target group, the enterprises.

The European Union also crabbed Hungary in connection with the NUTS-2 level regions: the defined seven regions didn't satisfy the criteria of normative regions defined by the EU: there are not elected, only delegated representatives on regional level, and the Regional Development Councils don't have disposal on own financial resources.

In 1998, the first National Spatial Development Concept (OTK) has been approved by the Hungarian Parliament (Decree 35/1998 (III.20.) of the Hungarian Parliament) order of the Parliament). This Concept has been the first complex and strategic development document in Hungary, which has been the principal document of Hungarian spatial development policy, regional development. It gave orientation for different instruments of regional policy, and formulated guidelines in order to reduce regional disparities. As a framework document it contains the development perspectives of the country and its regions, outlines the long-term regional development objectives and laid down the guidelines for the elaboration of the different development programs. In addition, the document provided regional planners and stakeholders with the necessary information [6].

## 4. NEW TRENDS IN THE HUNGARIAN SPATIAL POLICY

According to the act of 1996, XXI[2], the National Spatial Development Concept should be analyzed every six year. As a result of three comprehensive evaluations on the emergence of Hungarian spatial development policy and the regional processes of the country a new concept was elaborated approved by the Hungarian Parliament at the end of 2005 (Decree 97/2005 (XII. 25) of the Hungarian Parliament). The new concept sets up the principles of a more complex spatial development policy, which must be integrated into all other policies. At the same time these policies also should be integrated through the development of regions by the process of decentralisation.

The new OTK lays down the spatial perspectives of the country, and the long term objectives in harmony with them. Furthermore it draws up medium-term objectives and spatial priorities, tools, institutional conditions, and contains the targets of the regions.

The new National Spatial Development Concept contains the following innovations in comparison with the National Development Concept of 1998 [7] [20]:

- it is strong committed to accelerate and strengthen decentralization and regionalism in Hungary
- it defines a more complex spatial policy, than ever before: a spatial policy with widespread functions, integrated into the general development policy

[1] In connection with this point of the act, the following legislative provisions should be mentioned:
- 184/1996. (XII. 11.) Statutory order on the adoption process of spatial development concepts, programs and physical plans.
- 112/1997. (VI. 27.) Statutory order on the information system about spatial development and physical planning.
- 18/1998. (VI. 25.) Departmental order on the contents of spatial development concepts, programs and physical plans.
- 23/2001. (II. 14.) Statutory order on the modification of the 184/1996. (XII. 11.) Statutory order on the adoption process of spatial development concepts, programs and physical plans.

[2] The act of 2004. LXXV. on the modification of the act of 1996. XXI. on regional development and physical planning and other related acts has gone back to the way of decentralization, because it abandoned the preponderance of ministries in the membership pattern of Regional Development Councils. Furthermore this act established development councils also on the level of sub-regions.

- nearby the objective of decreasing regional disparities also the objective of spatial efficiency (competitiveness) and sustainability comes into the limelight
- it consists of a cross-border thinking.

In harmony with one of the most important core principle of the EU regional policy, the subsidiarity, the National Spatial Development Concept of 2005 puts down only such spatial objectives and task, which are valid for the country in general. These objectives of the OTK are results of a widespread consultancy process with the regional development agencies. The concept provides a wide elbow-room in spatial planning for the regions on several aggregation level, especially for the NUTS-2 regions. These territorial units are defined as the primary aggregation level in the decentralized development policy. During the spatial planning process of the NUTS-2 regions the general objectives written in the OTK should be taken compulsory into consideration [7] [20].

## 5. DEVELOPMENT POLES IN THE NEW SPATIAL POLICY

The National Development Concept (OFK), as an overarching development concept fulfils the role of a country strategy has been elaborated in 2005, parallel to the National Spatial Development Concept. Because of this fact, their main findings are the same: both of them define development poles in Hungary. "*... in order that development is not limited to the area of the capital, the monocentric spatial structure should be resolved. [...] The whole country requires development poles to catalyze competitiveness, and which are organic elements of a harmonious, polycentric, cooperative town network system. [...] Hungary's development poles are: Debrecen, Miskolc, Szeged, Pécs, Győr, and Budapest.*" [7]. According to the concept, the most important task of the development poles are to facilitate innovation activity and help the spreading innovation in the region. They also should contribute to decrease regional disparities in Hungary.

The Decree 96/2005 (XII. 25) of the Hungarian Parliament on the National Development Concept and the Decree 97/2005 (XII. 25) of the Hungarian Parliament on the National Spatial Development Concept defined Szeged as a development pole also on the level of legislative provisions with other 4 cities listed in the decrees (Figure 1).

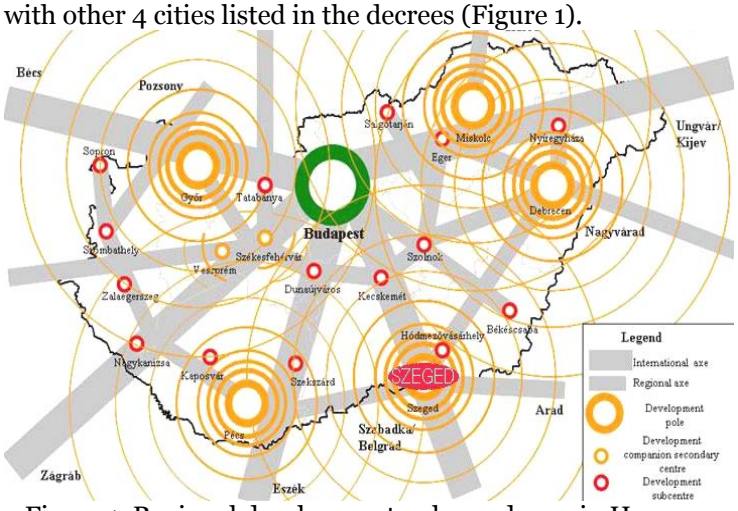



Figure 1. Regional development poles and axes in Hungary
*Resource*: own editing figure based on OTK (2005) p. 39

Consequently, Szeged, as a defined development pole, with some other preferential cities together plays an accentuated role in the new spatial policy of Hungary. From the point of view of our research it also has to be emphasized, that both OTK and OFK highlight to increase the capacity for specialized research and development of the departments that are competent to instigate defined and significant development [7]. The core competence of the development pole program in Szeged is the biotechnology.

Based on this, in the following part of this paper we will concentrate on Szeged city. In the next few chapters we will enhance the most important milestones from the history of the Municipality of Szeged, than some of its relationships will be surveyed with the most important institution of the development pole competence, the University of Szeged.

## 6. CHANGE OF THE REGIME AND THE EVOLUTION OF SETTLEMENT DEVELOPMENT'S LOCAL SELF-GOVERNMENTAL LEGAL BACKGROUND

The change of the regime challenged people not only on a national but also on a local level: in Szeged, just like in all other towns of the country, the first general municipal elections were held in autumn 1990 as a significant step to developing democracy. It put an end to the council system and new type of local self-governments replaced them, which, contrary to common councils, could be founded in each settlement.

The political necessity of founding local self-governments, which have their own rights, wealth and income sources, met the national and international economic and professional efforts started in this issue several years before. The new legislation threw the whole council system out, building on municipal traditions and historical values instead. Dr. Balázs Horváth, the Home Secretary of the

Antal-government initiated that the Act of 1990 LXV. should include those basic requirements that the 1985 municipal Charta of the Council of Europe contains, and that József Eötvös, the Cult and Educational Minister of the revolutionary government of 1848-49 drew up as follows [1]:

„ We demand the personal independence to be maintained;
we demand the decisions that are of interest only for certain segments of citizens,
for example a town or the inhabitants of a county,
to be made only by those whom these issues concern!" [12]

The major basic requirement and the quintessence of the new local self-governments system is municipal independence, changing the local self-governments into owners and economic organizations, which could proceed to settlement development based on local interests.

## 7. THE ECONOMIC GROUNDS OF LOCAL SELF-GOVERNMENTS' DEVELOPMENT SOURCES IN THE 1990's

The economic background of local self-governments that became legitimate by the democratic elections radically changed compared to the council system. At the change of the regime, the Act of 1990 LXV. significantly changed the conditions of settlement management and placed it on a new basis. From this point, local self-governments had their own properties, and could manage their own budgetary incomes and expenses independently. In addition, they could alienate the items that had been taken away from the state property and had been given to the municipalities (suck as roads, institutions, buildings, barracks etc). It was a milestone for settlement development because settlements suffering from financial sources could use their properties as collateral when asking for development aids or applying for tenders, or they could even sell, privatize these properties. Possessing own financial resources, local self-governments were able to decide on their own settlement's actuation and the direction of their development quite independently.

But this kind of independence did not always mean complete independence in terms of development tasks in the first half of the 1990s. The reason for this is that the municipalities' financial operation and their use of sources is strongly controlled: firstly because the budget of local self-governments is part of the public finance, they get most of their financial fund from the state[3]; secondly because in case of other supports financed by the public finance, the state determines the conditions how these supports can be used, for example earmarked subsidies and allocations[4] based only on national sources, that were significant in this period and that realized several important investments in Szeged in the last few years.

## 8. THE NEW FINANCIAL SOURCES OF THE CHANGE OF THE REGIME: PRIVATIZATION INCOMES, EARMARKED SUBSIDIES, REAL ESTATE BARTERS

In the years following the change of the regime, Szeged couldn't see bigger developments due to a lack of sources. Similarly to other local self-governments the now owner Municipality of Szeged, the county town of Csongrád County, could experience not only the bright side of wealth growth, but also took on a lot of charges after its own ownership developed. Firstly the raising of municipal institutions' costs was almost an impossible task for the local for the local authorities. Secondly, the only significant source of income, privatization, which started due to the possibility to alienate the local self-government's properties, meant not only income but also expenses. These properties were often rather devastated buildings and building sites without public utilities, which had to be upgraded before sale. In most cases it meant restoring building and providing building sites with public utilities.

But in terms of town development and town rehabilitation, the undoubted merit of privatization is that the incomes of selling those properties that had been given by the state meant almost the only sources that could finance more significant projects in the beginning of the 1990s. Due to such incomes several buildings' reconstruction was started in the town (e.g. the restoration of Dóm square).

In the following years the local self-governments' independence in decision-making was damaged by the lack of other developments sources independent of the budget. Due to the Act 1990. LXV. local self-governments could manage local developments in their own jurisdiction, but without proper financial background they could implement only the developments which enjoyed central state support. This statement is confirmed by how the incomes of the privatization of municipal properties (building sites, buildings, etc.) were used, as according to central legislation these incomes could be

[3] The bigger part of the incomes of the local self governments consist of state assigned taxes, normative contributions of the state budget, local taxes, incomings of its own economic activities and fees [11].

[4] According to the Act 1992. évi LXXXIX. the Hungarian Parliament supports some of law definied local investments in order to stabilize the actions of the local self-governments. If a local self-goverments fits to the state spezialized criteria sytem it gets the earmarked subsidies automatically. Beyond this adequace the ermarked allocations were avialable just in competition: in order to get state subsidies local governments have to create competitive project ideas for a ranking list.

used only to restore buildings (mainly residential properties), which were almost the only reliable financial background for building restorations besides earmarked subsidies and allocations in the beginning of the 1990s [11]. It includes the restoration of Szeged's historical centre, which, after the small renovations of the 1980s, appeared only point wise in the beginning of the 1990s, and was limited to certain institutional and residential buildings. From the end of the decade bigger and bigger projects were started with conscious town rehabilitation planning, such as the one billion-forint restoration of Kárász street – Klauzál square, the restoration of so-called 2nd block within Kárász, Somogyi, Kelemen and Kölcsey streets, and the 800 million-forint rebuilding of the dual roundabout at Dugonics square and the transformation of Tisza Lajos boulevard, which were remarkable to improve the city centre's traffic conditions.

For the sake of using the available sources independently, the local self-government has often tried to find other ways of utilizing its properties to gain alternative economic benefits. After the change of the regime the acquired buildings were taken into account not only as properties that could be sold, but they also gave the possibility for different organizations to join economically. The "Universitas property barter programme" that was started in the middle if the 1990s together by the local self-government and the university as their first development programme in the middle of the 1990s serves as a good example for that. It meant that the university, which covers the whole of the city's area, and the municipality swaps properties on the grounds of mutual benefits with the approbation of Szeged's General Assembly. József Attila University and Juhász Gyula Teacher Training College, the legal predecessors of Szeged University possessed a notable number of properties [18].

## 9. SOURCES APPEARING WITH THE PRE-ACCESSION TO THE EUROPEAN UNION (Phare, ISPA)

The city of Szeged started to work out investment concepts based on new sources in the second half of the 1990s. The reason for this was that the basis of Pre-accession to the European Union became available such as PHARE, ISPA and SAPARD. From these, mainly the pre-accession programmes of PHARE and ISPA were significant from the point of settlement development. Since these programmes – mainly ISPA – supported mostly cohesive investments, the main direction of developments was also limited to remedial projects.

Due to the shift in the direction of the targets of PHARE programmes in 1997, the programme's funds could also be used directly for institutional developments and supporting investment [2]. In autumn 2003, approaching the deadline of using the pre-accession's funds, an application was handed in to restore a square that belonged to the historical part of the city centre of Szeged. Competitive factors started to arise as part of the project as the application included not only rehabilitation, but also creation of workplaces. The reason for this was the establishment of a biomonitoring system at the square, that monitors the pollution level of the air, and to operate this system, experts had to be trained and employed, and other new employees were also hired through cooperation with civil services and the employment centre, who had to look after the renovated park. Thus the idea of partnership, that is a keystone of the grants of the European Union, concretely appears in this 1.1 billion-forint project.

Another important investment of Szeged, which aimed to establish the city's total sewerage system, also got started in this period. Hungary's biggest investment of this kind was implemented from a total gross budget of more than 23 billion forints, using sources from Brussels, ISPA funds, and it meant that 253 kilometres of drainage was built altogether in the city and in the neighbouring villages that joined to the programme.

The main aim of ISPA was to prepare the counties awaiting the accession to welcome the Cohesive Fund's supports, and to solve the concrete problems of traffic and environmental infrastructure, that were hindering the accession. So the supporting programme had remedial aims firstly, and not to improve economic competitiveness. We mustn't forget though, that as an indirect effect of this investment, the number of people employed in local construction increased significantly – even if temporarily -, because 80% of the contractors working on this project were local entrepreneurs, this way local employers and employees could also benefit from the rehabilitation, and it also enlarged the budget of the municipality because of the entrepreneurs' local taxes (mainly trade and communal taxes). Besides the restored roads and completed drainage system, a further benefit of the project was the strengthened local entrepreneurs, who could use this work as a reference and who, this way could apply for similar projects in other parts of the country with great chances.

## 10. INCREASE IN DEVELOPMENT SOURCES BETWEEN 2004 AND 2006

With Hungary's accession to the European Union on 1st may 2004, unprecedented financial sources became available for national and local developments. Between 2004 and 2006 675 billion

forints were available for certain development priorities in the frame of the National Development Concept (NTF). According to the basic aims[5] drawn up in the NTF, there were calls for tenders in five operational programmes (OP): Economic Competitiveness OP, Environment and Infrastructure OP, Agricultural and Rural Development OP, Human Resource Development OP, and Regional OP. From these Operational Programmes mostly GVOP, KIOP, and ROP provided possibility to implement bigger investments. The support rates were around 50-80%, but in many cases raising the 10-15% own source was also a difficulty. Despite the extended funds, this problem could have discouraged a lot of local self-governments from potential development possibilities, but the Hungarian government established a tender possibility based only on national sources to help the local self-governments. The ministry of Home Affairs has called a tender every year since 2004 "to support local self-governments' own sources for the development tenders of the European Union" and it has supported a lot of local self-governments' development ideas, that gave fund for the own source of a successful application for an operative programme[6].

In 2005 the Association of National Municipalities' Union's standpoint on the T/17700. bill of the 2006 Budget of the Hungarian government also drew attention to the problems of local self – governments' development sources. According to this bill, the extensive reform of local self-governments, that could make the operation of each settlement economical [14], does not come true again in 2006. According to the starting point and the accepted bill, which was mainly unchanged compared to the original one, there wasn't a change in the duties and jurisdiction, the conditions of management regulations remained basically unchanged, the financial conditions were damaged[7], so for the next budgetary period of the European Union between 2007 and 2013, the ability to finance bigger municipal investments remained a key question of development policy.

## 11. NEW DIMENSION: THE DEVELOPMENT PERIOD OF 2007 -2013

Certain chapters of the presently effective national development document, New National Development plan (hereafter UMFT) enhanced the development possibilities of local self-governments. The 675 billion-forint fund available in the frame of NTF got ten times more in the period of 2007-2013 and it provides a possibility for more specific aims (Schedule 1.).

Schedule 1. Operational Programmes of the New National Development Plan (UMFT)

| Priorities | Operational Programmes | Financial Sources (billion HUF) |
|---|---|---|
| Development of Economy | Economic Development OP (GOP) | 690,0 |
| Development of traffic and transport | Traffic and Transport OP (KÖZOP) | 1703,2 |
| Renewing the Society | Social reform OP (TÁMOP) | 966,0 |
| | Social infrastructure OP (TIOP | 538,9 |
| Environmental and energetical development | Environment and Energy (KEOP) | 1140,0 |
| Spatial Development | OPs of the 7 regions of Hungary: | |
| | Nyugat-dunántúli OP | |
| | Közép-dunántúli OP | |
| | Dél-dunántúli OP | |
| | Dél-alföldi OP | |
| | Észak-alföldi OP | 1609,4 |
| | Észak-magyarországi OP | |
| | Közép-magyarországi OP | |
| State modernization | State reform OP | |
| | Electronic government OP (ÁROP) | 140,7 |
| ÚMFT (communication and coordination) | Excecutive OP (VOP) | 87,2 |
| TOTAL (billion HUF) | | 6875,4 |

Resource: own editing based on UMFT (2007, page 9.)

According to the Decree 96/2005 (XII. 25) of the Hungarian Parliament on the National Development Concept and the Decree 97/2005 (XII. 25) of the Hungarian Parliament on the National Spatial Development Concept defined Szeged as a development pole also on the level of legislative provisions with other 4 cities listed in the decrees. The long term aims of UMTF is enlarging employment and ensuring permanent growth. As for the latter one, according to the UMFT Integrated Settlement Development Strategy, the support for the economic growth of the settlements that are

[5] The National development Plan (2004-2006) drafts three general goals (competitive ecomomy, more effective human resource and well-balanced spatial development) in order to improve the living standard sin Hungary [5].

[6] In the year 2005 a municipality managed project with the name of „Integrated Development of the E-government in Szeged" was granted by the EU. The total project budget was 670 million HUF (appr. 2,3 million EUR). Beyond the 540 million HUF EU grant the municipality got other 78 million HUF as an own source subsidy from the Hungarian Government [19].

[7] According to the Act of the annual Hungarian Budget in 2005 the local self-governments got 1349,8 billion HUF (appr. 4,49 billon EUR) as state financial source which was half billion HUF less than in the previous year [13].

development centres predominates mostly in polycentric, cooperative settlement network system [8]. To ensure a long term, balanced spatial development, there is a need to compensate the capital's economic dominance and to change the monocentric structure of the country, which they want to establish with functionally assigned settlements and emphasized developments based on technological innovation. This idea was rather weakened later, in the phase of planning and social discussions, but because of the central role of 5 "pole cities" the possibility of some key investments (based mainly on equity) didn't disappear. As a matter of fact, cities that are assigned as competitive poles do play a key role in determining their area's competitiveness with their innovation potential.

Although UMFT also underlines the importance of settlements and the settlement system from the point of competitiveness in this case, it is probable that these settlements have also come to the front in case of other kinds of project concepts' central and EU funds – usually developing basic settlement functions (Schedule 2.).

Schedule 2. Some hugh project of the Szeged competitive pole[8]

| Operational Programme | Project | Project leader | Total Budget (Billion HUF) | Grants (Billion HUF) |
|---|---|---|---|---|
| TIOP 2.2.7 | Infrastructural development in the Heathcare competitive poles (building a new clinic centre next to the river bank of the Tisza) | University of Szeged | 12,366 | Data no aviable |
| GOP 1.1.2 | Development and strengthen of the Research & Develpment centres: DEAK – Research and Development | DEAK Cooperational Development Shareholders company | 2 | 0,99992 |
| TIOP 3.1.1 TIOP 3.1.1 - TISZK | Infrastructural development of the TISZK organization (human resource development) | Consorcium with the Municipality | 0,992 | 0,892 |
| KÖZOP -2008-5.2 | Development of the Eletric Public Transport system in Szeged (reconstruction of the old lines, building a new tramline, procurment of new vehicles) | Municipality Of Szeged | 29 | 25 |
| DAOP 5.1.2/C | City rehabilitation ( rehabilitation of main streets and the old Mars square) | Municipality Of Szeged | 3,3 | 2,1 |
| TIOP 1.3.3./08/1 | „Agóra Pole" cities: development of the innovative and cultural infrastructures of cities | Municipality Of Szeged | 1,9 | 1,71 |

Resource: SZMJVÖ (2009)

## 12. SUMMARY

The reform of the institutional system in the Hungarian spatial development takes place very slowly. The institutional system set up for the access was not consequently built on institutions of regional development, which disappointed the regions [22]. The effective establishment of the seven NUTS-2 regions has not been achieved yet, though some encouraging efforts happened. The 6. § of the act of 1999. XCII. on the modification of the act 1996. XXI. ordered to set up regional development councils, hereby the regional framework has been defined by legal means. Some competences and tasks have been delegated to regional level, but the regions possess neither elected representatives nor own financial resources, although those later two are very important from the point of view the European Unions definition on regions.

The correct using of some core principles (decentralization, subsidiarity, partnership) requires to rethink decision competencies, to decentralize the power, to strengthen the autonomy of the local communities [16]. The institutional framework of the spatial policy in Hungary is strongly attached to the public administration, especially to the counties. Economic development is unfortunately only second priority in the distribution of financial resources, entrepreneurs are not able to enforce their interests. The counties hesitate to be partners of each other, although an efficient spatial policy requires a successful concentration of forces on each territorial level.

[8] Szeged, the county town of Csongrád county – as well as Győr, Pécs, Debrecen, Miskolc, Veszprém-Székesfehérvár got Development Pole function according to the 2230/2005. (X.26.) government order and they got 100 million forints fund to work out their Development Pole Programme. The pole programme is worked out with scientists, research and engineering experts in module system, similarly to research-engineering development programmes.

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# THE STRENGTH OF INTELLECTUAL PROPERTY PROTECTION AND THE TRANSFER OF TECHNOLOGIES

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**Abstract:**

In the wake of the 21st Century achievements of the intellect are gaining in importance in production. Who has the knowledge, also has the advantage in competition. Countries are striving to produce knowledge, or else acquire knowledge elsewhere produced to remain competitive.

Intellectual property rights (IPR) facilitate technology transfer by assuring foreign innovators that transferring knowledge produced by them into the country they will still be able to collect returns.

In this paper I am going to present one possible way of measuring the effect of relative IPR protection strengths of trading partners on the magnitude of technology transfer between their countries.

**Keywords:**

IPR, Intellectual Property Rights, patent-index, technology transfer, international trade

## 1. INTRODUCTION

In the last decades it becomes increasingly clear, that those countries will be able to benefit from the new kind of international competition which can better adapt to the challenges of the knowledge-based economy. Knowledge is gaining in importance as an input to the production process. Therefore it is in the best interest of the countries and governments to facilitate knowledge production and try to manipulate its international spread in their own favour. Intellectual property rights (IPR), or property rights more broadly, are institutions which are taken as given or exogenous by neoclassical economic models. In this paper, however, what is seen to influence knowledge production and diffusion is the design and especially the strength of this institution itself. The IPR regime is not an exogenously given variable any more, but can be adapted endogenously to reach a desirable outcome. I tackle this problem from an institutional point of view.

The economic aspects of institutions have just recently started to be explicitly investigated. Starting with the influential works of R. H. Coase as far back as the 1930s, the new institutional economics a) views institutions as not being neutral, but influencing economics outcomes, b) rather than discarding the whole apparatus of the neoclassical economics, tries to link functioning of the institutions with the marginalist methodology and c) tries to use institutional variables as endogenous within the neoclassical framework. One of these institutions endogenously inserted into the neoclassical economic model is the institution of property rights.

Thinking about property rights found its way to economic thinking only recently. In his 1960 paper, the Problem of Social Costs, Coase emphasises the economic importance of property rights. Property right in economics means “actual power to control or affect the use of an object, or some aspect thereof” [5]. This controlling or affecting can typically mean 3 things: a) usage of the object (usus), b) appropriating the returns thereof (usus fructus) and c) the transferring of these rights partly or fully to another person (abusus). Clearcut property rights and their guaranteed enforcement are perquisites of (but not guarantee) a well-functioning, Pareto-optimal market economy.

The third of these rights is in connection with the freedom of contracts and trade. As Makaay writes ([5], p. 248., italics mine): “A person who controls the use of an object may find it *profitable* to allow another person to use it, [...] To this end, the owner enters into an agreement with the other person. The agreement [...] *confers* on him or her *some economic*

*property rights*." The above quote implies that either using our property ourselves or selling it to someone is driven by the profit-motive and leads to the efficient usage of the property. If there are any limitations to any of these parts of the property (that is, limiting the economic property right that can be conferred on someone, or limiting this conferring itself), efficiency cannot be ascertained.

We also have to be aware of the fact, that the property right system is not static, but dynamically changing. Since it is, in the institutionalise view, an endogenous variable, it is not merely a given factor that determines other variables, but is itself dependent on other economic variables and processes. The tailoring of property rights to different objects with different characteristics can be a natural, evolutionary process, left to the market, but more often than not it is done by the government. This is the case with products of the intellects, or, as I will refer to them, knowledge. The creation of knowledge is encouraged through better or worse IPR systems in every country. The spreading of knowledge, however, will depend on the international differences of these IPR protection systems from country to country.

## 2. INTELLECTUAL PROPERTY PROTECTION AND TRADING WITH INTELLECTUAL PRODUCTS

Establishing a clear intellectual property rights (IPR) system makes trading with intellectual product possible. The possibility of trading in turn leads to specialisation, meaning that producers can have the necessary knowledge and technology from the researchers, and researchers do not have to bother with the commercial development of their ideas, like they had to in earlier centuries [4]. Knowledge can then be acquired from specialists through the market. This specialisation and cooperation is rendered possible by the market for intellectual products by way of intellectual property protection measures. Research and development can be detached from production.

There exists a number ways to transfer knowledge[1] from one country to another. "International technology transfer refers to the process by which a firm in one country gains access to and employs technology developed in another country" ([1], p. 23.). This has many ways and methods, that can and has been both theoretically and empirically explored. The possible ways include international trading in technology-intensive products, international flow of foreign direct investments, cross-country licensing, or even patenting in a different country. International trading in intellectual products is one the market-conform ways technologies can spread in the globalised world[2]. Clearly established national intellectual property rights regimes enables trade in intellectual property, but national differences can influence this trade. As to how exactly national differences in the strength and design of the IPR system influence international trade in knowledge, no generally accepted theoretical explanation has yet emerged in the literature. There are at least two characteristics of a country's IPR regime, that can influence the inter-country flow of intellectual products, namely its design and its strength. The effects of both have been explored at the model level. The model of Taylor [11][12] explore how the differences in design between countries affect knowledge transfer. Design differences mean the symmetry of asymmetry of protection, that is whether foreign inventions enjoy the same protection as domestic or not. The model's conclusion is, that the more symmetric the IPR protection, the more it encourages knowledge creation and transfer. In Naghavi's model [6] the strength of the protection determines the outcomes, namely whether the foreign company will enter at all the domestic market, and if yes, will it be by way of direct investment or export. These models conclude that more symmetric and stricter IPR protection attracts more knowledge into the country.

[1] In this paper I am talking about knowledge transfer in a very general sense. The model I use and the empirical test of its predictions are at the macro level. These do not say anything about the actual process, how knowledge is being transferred from one country to another. Neither is it important here, how individual firms find out, what knowledge and what innovations it is worth to acquire from outside the home country, or what determines the regional spreading of knowledge and innovations. Although these are all certainly important questions, I will concentrate here only on the aggregate, macro level.

[2] As opposed to certain non-market-conform ways like non-market transactions and spillovers [1].

## 3. EMPIRICAL STUDIES OF THE LINK BETWEEN IPR STRENGTH AND TRANSFER OF TECHNOLOGY

To test empirically, whether a link between the strength of IPR systems in a country and transfer of technology to that country could be established, two questions have to be answered: first, how to measure the strength of national IPR regimes, and second how to measure the magnitude of transfer of technology.

For the measurement of the strength of IPR regimes, Ginarte and Park developed a composite index in their 1997 paper [3][3]. Their index measures IPR strength along 5 dimensions, giving a number 0-1 to each, and then taking the sum of these to be the patent index, thus ranging from 0 to 5. The five dimensions are coverage (meaning what can and what can not be subject of protection), membership in international treaties (the Paris Convention, the Patent Cooperation Treaty and the International Convention for the Protection of New Varieties of Plants), enforcement (whether the legislation provides adequate mechanism for the law to be enforced), and restrictions to exercising IPRs (eg. compulsory licensing), and duration of protection.[4] The higher value a country is scoring in this index, the more strict IPR protection is taken to be in that country.

For the measurement of the magnitude of transfer of technology many different indicators can be used. [1] enumerate 4 basic channels through which technology can flow from one country to another: through a) international trade, b) foreign direct investment, c) licensing agreements and d) cross-national patenting.

In their original study [3], the aim of the study was to examine, what determines the Ginarte-Park Index as a dependant variable. In [8] the authors conducted an empirical study to examine whether a statistical relationship can be established between the strength of IPR regimes as an independent variable and technology transfers, either in the form of foreign direct investment or in the form of technology-intensive merchandise import as a dependant variable. They conducted a regression analysis where they used the above mentioned Ginarte-Park Index to measure the strength of the IPR system as an explaining variable[5]. Beside that, their regression analysis has many control variables (like country-risk or per capita GDP), accounts for individual, country-specific effects like culture or quality of institutions [8].

In a later paper, Park and Lippoldt present a developed model. [9] has the methodology of what to measure and how to measure. They regress a) stock of inward FDI, b) technology-intensive merchandise imports and c) technology-intensive service imports to the Ginarte-Park Index of Patent Rights. In their paper, they use data from altogether 120 countries, which they divide into three groups: developed countries (25), developing countries (68, including Hungary) and least developed countries (27). What they find is, that 1% rise in the Ginarte-Park index is accompanied by a 1,65% rise in inward FDI to developing countries (as opposed to 11,2 to developed and 1,66 to least developed countries). A 1% rise in the Patent Right Index goes together with 1,34% rise in merchandise imports to developing countries (compared to 9,86 to developed countries and 0,54 to least developed countries). Also, the coefficient for service imports to developing countries is 0,99 (9,99 to developed countries and 0,97 to least developed countries).

## 4. IPR STRENGTH AND KNOWLEDGE INFLOW TO HUNGARY

Neither the original 1997 study by Ginarte and Park, nor the 2003 study by Park and Lippoldt includes Hungary. Park in his 2008 paper ([10] p. 2.), however gives the values of the Ginarte-Park index for Hungary. For the years 1960-1990 Hungary scores an average of

[3] Beside this Ginarte-Park index, empirical studies use another, called Rapp-Rozek index to which due credit is given both in [3] and [1].

[4] In a 2008 paper [9], this patent right index is developed further, and an index for the strength of copyright protection and trademark right protection is included.

[5] The strength of intellectual property regime is certainly not the only determinant of knowledge diffusion. Some other influencing factors, the effects of which could even be studied at the model level might be the extent of the market, the quality of the labour force, the infrastructure, political stability etc.

2,20. For the year 1995 the index is 4,04 remaining unchanged for 2000, and rising to 4,5 to the year 2005[6]. Having the scores of the patent right index for different years, and having the model of [9], we can see, whether the Hungarian data support my predictions.

Park and Lippoldt give in their 2008 paper an interpretation of knowledge-intensive products and services, listing those parts of merchandise imports and service imports which are the most likely to bring along with them the transfer of new technologies to see how these are related to the strength of the IPR system[7]. In the case of the merchandise imports these are: pharmaceuticals, office and telecom equipments, organic and inorganic chemicals, electrical and electronic products, aircraft and spacecraft-related products and optics and precision equipment ([9], p. 37). In the case of services imports they list communication services, computer and information services and royalties and license fees ([9], p. 43). I also acquired data for Hungary in these categories.

Table 1 shows foreign direct investment, technology-intensive merchandise import and technology-intensive services import for the years 2000 and 2005 into Hungary. As a reference, I indicate in the first column the Ginarte-Park index for Hungary.

Table 1: knowledge transfer to Hungary (values are in Mio current USD)

| Year | G-P Index for HU | Inward FDI | Technology-initensive merchandise import | Technology-intensive services import |
|---|---|---|---|---|
| 2000 | 4,04 | 22 869,9 | 16 101,3 | 461,0 |
| 2005 | 4,50 | 61 970,1 | 32 842,4 | 1 956,8 |

Source: MNB, KSH, UNCTAD

Even if we take the strictness of IPR protection as a determinant of knowledge inflow into a country, it may not be the absolute, but the relative strictness of the protection that matters. Next I will use the Ginarte-Park index of countries to measure the differences in the strictness of IPR protection between trading partners, and see whether and how this influences knowledge inflow as understood by Park and Lippoldt ([8] [9]). Based on the above studies of Park and Lippoldt, *my prediction is, that as domestic IPR protection gets stricter relative to that of the trading partner's, this encourages knowledge inflow, while as it gets looser, it discourages knowledge inflow*.

Having data on the knowledge-intensive merchandise and service inflow into Hungary broken down to countries of origin it is now possible to see, whether any connection can be seen between change in Hungary's relative IPR strength to its trading partners and the change in stock of inward FDI, technology-intensive merchandise imports and technology-intensive service imports, respectively. To see this I used data for only those countries, for which [10] gives a Patent Right Index, which is, 120 countries. Not having the control variables the original study used I made a plot diagram of the percentage changes in inward FDI stock, technology-intensive merchandise import and technology-intensive service import against change in the patent right index of the trading partner compared to Hungary. I tried to identify a pattern. *According to my prediction, the dots should scatter around a positively sloped trend line.* From the sample I excluded those items, where trade or FDI stock was 0 in at least one of the years, and also excluded outliers, where the change in either way was more than tenfold during the five-year interval. After these exclusions my data account for 86,7% of the inward FDI stock in 2000 and 76,68% in 2005, in the case of merchandise import these percentages are 99,45% and 98,58, respectively and for the services import they are 97,28% and 83,42%, respectively. I got the plot diagram on figure 2 for all three categories.

What the figures show, instead of a positively sloped trend line, is a kind of "reverse funnel". The reverse funnel can be read meaning, that the change in the relative IPR strength does not, per se, determine technology transfer through these channels, but a greater positive change in Hungary's relative IPR strength is able to encourage technology transfer, while the smaller the positive change or the greater the negative change, the less it is able to do so. Put another way, the relative strengthening of the Hungarian IPR protection allows for greater variation.

[6] The Patent Rights Index for Hungary is, however, different, being 3,71 in 2000 and 3,37 in 1995 ([7], p.40).

[7] The model certainly also uses control variables.

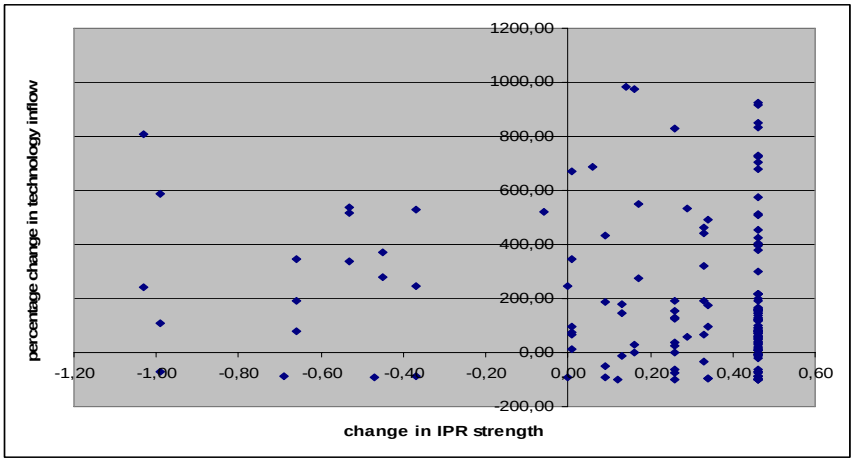



Figure 2: technology inflow in relation to change in relative IPR strength in Hungary
Source: KSH, MNB

## 5. TECHNOLOGY-INTENSIVE TRADE BETWEEN HUNGARY AND ROMANIA

Table 2 shows the trade in technology-intensive merchandise and services between Hungary and Romania in the years 2000 and 2005, for which Patent indexes are available.

Table 2: technology-intensive trade between Hungary and Romania (in Mio current HUF)
Source: KSH, MNB

| | 2000 | 2005 |
|---|---|---|
| to H from RO | | |
| **Patent right index for H** | **4,04** | **4,5** |
| tech-intensive merchandise | 20 881,5 | 64 673,0 |
| tech-intensive services | 957,7 | 7 385,9 |
| to RO from H | | |
| **Patent right index for RO** | **3,72** | **4,17** |
| tech-intensive merchandise | 29 046,4 | 157 320,5 |
| tech-intensive services | 79,0 | 6 445,3 |

The data in the table throw light on some methodological problems already present in the previous section's conclusions. First, the variables to be explained (value of merchandise and services traded) are calculated at current prices, thus any rise in it is partially a result of inflation. Second, the increase in value is higher in merchandise trade then in services trade, the percentage increase however is just the opposite, the base being substantially lower in the services case. Third, even if relative strengthening of IPR protection would allow for higher technology-intensive product and service inflow, if there is nothing to import, then this effect can naturally not work out. Typically, technology-intensive product and services are being generated in countries with higher patent right index than Hungary or Romania. This is reflected in the fact that around 60% or technology-intensive merchandise and around 80% of technology-intensive services come to Hungary from countries with higher patent right index, like Germany, the United States, Japan and the United Kingdom.

## 6. CONCLUSION

Theoretical studies show, that the actual shape and built of a nation's intellectual property rights protection system can and does have effect on the international flow of intellectual products through the markets. If this is the case, different countries can shape their IPR regimes to profit more from the international flow of knowledge, while this can be a disadvantage for others. This way, appropriate fine-tuning of the IPR system can become a new way of competition between countries and also a new possibility for levelling off. Endowment with or accessibility to knowledge might be less predetermined, constrained than endowment with natural resources, capital or labour. If it can be proven that the type (strength) of IPR systems as a new tool in the hand of a national government can influence international flow of capital and technology transfer, than using Ghosh's words we can speak

of a „new mercantilism", of a new tool a government can use to compete more efficiently at the international level ([2], p. 85).

It is up to further studies to examine, how varying strength of IPR systems influence other kinds of technology transfer, like the international flow of knowledge workers and human capital, and the resulting knowledge products.

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# REGIONAL SUSTAINABILITY INDICATORS

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**Abstract:**
Besides the measuring of global sustainability it is important to discuss the regional sustainability in detail. Regional sustainability can provide useful information for strategic planners for implementing sustainability goals. Many methods have been developed for regional sustainability assessment. Graymore et al. [7] explored ecological footprint, wellbeing assessment, quality of life, ecosystem health and natural resource availability. In my study I examine that from this assessment which is/are suitable for measuring regional sustainability with special regard to ecological footprint which is an officially accepted sustainability indicator in several countries.

**Keywords**:
regional sustainability, ecological footprint, wellbeing assessment, sustainable society index

## 1. SUSTAINABILITY - REGIONAL SUSTAINABILITY

The unsustainability and the potentially self-destructive character of the current socioeconomic processes have become a problem to be considered by public opinion and the researchers of environmental issues. It is a scientific fact that these processes can restrict the socioeconomic options in the near future by irreversibly ruining certain unsubstitutable ecosystem services. The humanity determines the level of natural capital[1] by three factors: size of population, consumption and technology. The humanity's effect on environment is appearing in lost of ecosystem services, degradation of biodiversity and deforestation.

The definition of sustainable development has become one of the most common expressions recently. According to the Brundtland Report [3] (also known as Our Common Future), sustainable development requires development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

This definition, however, does not provide proposals for moving towards sustainability, furthermore ignores the limits of growth in connection with population and economy. In addition, the conclusion that the economic growth is sustainable can be drawn. However, the sustainability of environment, society and economy is rather based on physical laws of nature such as the laws of thermodynamics. In my study I concentrate on sustainability in environmental aspect. There are several definitions for environmental sustainability as well, but there are common points, for example the preservation of ecosystem and biodiversity, the creation of equilibrium between inter and intra generations and the restructure of economic system.

The concept of carrying capacity is closely connected with sustainability. Generally, the carrying capacity is the maximum population that can live in long run without a considerable degradation of the area. According to the ecological footprint (detailed later on), the carrying capacity (biocapacity) of the Earth shows that how many resources the Earth can produce in a sustainable way to satisfy human's demand (expressed in global hectare). To achieve sustainability society and economy have to stay within the given area's natural capital. This means humanity's effect on ecosystem must not threat its function, which has an effect on society and humanity well-being and survive. The necessary and sufficient condition of sustainability is that the population can be on or under the level of carrying capacity. Consequently, for humanity sustainability means the life within the carrying capacity of the Earth.

There are some definitions for regional sustainability as well, Graymore et al. 's [7] definition rhymes to the concept of sustainability, namely it „requires the human population to live within the

[1] Natural capital is defined as the stock of environmentally provided assets, which provide a flow of useful goods and services (renewable, non-renewable and generally non-replaceable) [5].

limits of the region's supporting systems (social, economic and ecosystem), ensuring equitable sharing of resources and opportunities for this and future generations in the region". According to Wackernagel and Yount [18], regional sustainability is „the continuous support of human quality of life within a region's ecological carrying capacity".

There are several sustainability indicators, maybe the most known are ecological footprint (EF), sustainability society index (SSI), natural resource availability, human development index (HDI), environmental sustainability index (ESI), index for sustainable economic welfare (ISEW), etc. These approaches of sustainability are from different aspects but none of them can fill perfectly the part of sustainability. In my study I am going to emphasize the importance of ecological footprint, because its use is widely accepted.

## 2. CRITERIA OF REGIONAL SUSTAINABILITY INDICATORS

To choose the adequate indicator for measuring (regional) sustainability, it is necessary to collect the possible indicators. Firstly, I examine which factors and criteria the sustainability indicators have to be suitable for. Then I collect the indicators that can be adequate for measuring regional sustainability. Finally, I study that from the presented indicators which can be used to determine regional sustainability and are suitable for criteria.

As we can see, many sets of indicators exist, but it is important that a sustainability indicator has to be suitable for some criteria. I highlight in Table 1. the main characteristics [2, 7, 12].

Table 1. The main characteristics of sustainability indicators

| KERK-MANUEL 2008 | BÖHRINGER-JOCHEM 2007 | GRAYMORE ET AL. 2008 |
|---|---|---|
| Relevant | Connection to the definition of sustainability | Assesses regional sustainability |
| Measurable | Represent holistic fields | Easy use |
| Recent and regularly updated | | Simplifies complexity |
| Independent from each other | | Usefulness |
| | | Information not lost during aggregation of data |
| Reliable | | Transparency |
| **Available data (public sources)** | | |
| **Available data (for all countries)** | | |

There are several criteria of sustainability indicators. In fact, for measuring regional sustainability it is necessary to choose the relevant indicators from sustainability assessments for which there are adequate data. According to the regional aspect, I use Graymore et al.'s [7] set of criteria which is very detailed (Table 2.) As for regional managers (beyond the former criteria in Table 1.), it is necessary that a regional sustainability indicator has to be related to policy, strategic planning, decision making and be suitable for communication to a range of audiences.

## 3. POSSIBLE REGIONAL SUSTAINABILITY INDICATORS

For measuring regional sustainability Graymore et al. [7] examined the relevance of five indicators': ecological footprint, wellbeing assessment, quality of life, ecosystem health and natural resource availability. Hereafter I generally present the ecological footprint and wellbeing assessment from these indicators, and complete the list with sustainable society index.

## 4. ECOLOGICAL FOOTPRINT

The ecological footprint measures humanity's demand on the biosphere in terms of the area of biologically productive land and sea required to provide the resources we use and to absorb our waste (global hectare – gha) [19]. The size of the ecological footprint is connected with the following factors: *population, consumption per capita and technological efficiency in terms of ecology*. The ecological footprint calculation is a multiple-stage process and the indicator can be determined with a simple formula:

$$I = P \bullet C \bullet T$$

where I is Impact, P is Population, C is consumption per capita and T is technology, which is used for consumption and production.

Table 2. Criteria of sustainability assessment methods

| A. OVERALL EFFECTIVENESS OF SUSTAINABILITY ASSESSMENT AT REGIONAL SCALE |
|---|
| **1. Assesses regional sustainability** |
| •Equity intergenerational and intragenerational |
| •Level of human activity |
| •Level of pressure on supporting systems |
| •Status of supporting systems |
| ◦Ecosystem |
| ◦Social |
| ◦Economic |
| **2. Data availability and accessibility** |
| •Uses existing data |
| •Data is locatable and accessible |
| •Data describes the region |
| •Data collection is cost effective (money and time) |
| •Ability to assess sustainability without all data |
| **3. Assessment is easy to use** |
| •No complicated calculations |
| •No specialist knowledge required (e.g. matrices) |
| •No specialist software required |
| •Easy to follow method |
| •Easy to use |
| •Small indicator set (i.e. manageable data set b40 indicators) |
| •Not time intensive (i.e. less than 3 months to complete) |
| **B. METHOD** |
| **4. Assesses sustainability directly** |
| •Produces an overall sustainability score/index through aggregation of indicator data |
| •Aggregation method is logical |
| •Objective assessment of sustainability |
| •Integrated assessment including relationships between indicators |
| **5. Information not lost during aggregation of data** |
| •Indicator performance is reported |
| •Sub-system/dimension performance is reported |
| •Overall system sustainability is reported |
| **6. Transparency in method used to produce results** |
| •Method was clear and well documented |
| •Easy to understand how final results were derived from indicator data |
| •Simplifications and assumptions kept to minimum to reduce impact on results |
| **C. USEFULNESS OF RESULTS** |
| **7. Simplifies complexity of sustainability and facilitates communication to a range of audiences** |
| •Easy to understand and interpret what results mean for regional sustainability |
| •Result can be described in a single page report card |
| •Able to visually represent the results |
| •Sustainability reported at a range of levels |
| ◦Detailed indicator performance |
| ◦Sub-system/dimension performance |
| ◦Overall system sustainability |
| **8. Usefulness of the sustainability assessment results** |
| •Time and data efficiency of assessment |
| •For regional managers |
| ◦Sustainability reported at a range of levels |
| ◦Relates to policy, strategic planning, decision making |
| ◦Points out where management actions are needed |
| ◦Targets or thresholds to measure against |
| ◦Can be used to assess trends overtime |
| •For community capacity building, social learning |
| ◦Result easy to understand |
| ◦Simple to use |
| ◦Data accessible |
| ◦Demonstrates links between sustainability and community activity |

To determine the ecological footprint five major consumption classes are set up: food, home/residence, transport, consumption goods and services. Naturally, to have a more exact analysis these classes can be divided into further classes. Consequently, the ecological footprint helps to determine the available natural capital on the one hand and the ecological consumption of people or community on the other hand, thus we can measure whether the given community is sustainable or

unsustainable. In this way it can be proved that social policy is necessary in case of population, consumption and technology (eco-efficiency) [11].

There are several criticisms in connection with the EF because there are some weaknesses, but at present there is no tool for sustainability which is complete and none will satisfy everyone perfectly. Furthermore, the ecological sustainability is not absolutely measurable, especially not with a one-dimensional indicator [4, 9, 15]. Nevertheless, based on our present knowledge, we regard *EF as the most comprehensive sustainable indicator and in several countries – Switzerland, Germany and Finland – it has become the official sustainable indicator* [16].

It is worth noting that nowadays the ecological footprint of humanity exceeds the bio capacity of the Earth (1,8 gha) with 25 %, as large as the ecological deficit. *This means that the demand of the humanity on the biosphere exceeds the carrying capacity of the biosphere* [19]. For this reason, the ecological footprint of humanity has to be decreased below the world-average. According to the estimations, *by 2050, it will have overshot with 200% if the humans do not change their lifestyles and initiate new, environment-friendly technologies, such as solar energy use.*

The ecological footprint per capita is determined by the standard of technology and personal consumption. Thus, the ecological footprint per capita can be reduced by introduction of new technologies. In the literature of sustainability, eco-efficiency[2] has a significant role in relation to technological change; increase of eco-efficiency is regarded as the principal tool of sustainability. An enterprise/national economy is more eco-efficiency than the others if it produces a certain output with less environmental effect. Simultaneously, in the literature the *rebound-effect* is well-known whereby eco-efficiency improvement which resulted by introduction of a new technology may affect against the conservation of resources. At the same time relative eco-efficiency increase, which is induced by technological change, enlarges the scale of biosphere-transformation in absolute amount instead of decreasing it [1].

The ecological footprint is a consumption-based indicator, so the problem of geographical substitution can be eliminated. The ecological footprint considers that developed countries may set out their harmful activities to other (developing) countries.

The main advantage of ecological footprint is that required data is available from standardized database and presents a clear, understandable message that is useful in decision making. The ecological footprint can be measured in global, regional and national level, but in sub-systems data may be unreliable.

## 5. WELLBEING ASSESSMENT

The wellbeing assessment has been worked out by World Conservation Union (IUCN). This method insures equal weight to people and ecosystem and combines the indicators into a Human Wellbeing Index (HWI), Ecosystem Wellbeing Index (EWI), Wellbeing Index (WI), and Wellbeing/Stress Index (WSI). The subsystems of wellbeing assessment are differentiated in 10 areas (Figure 1).

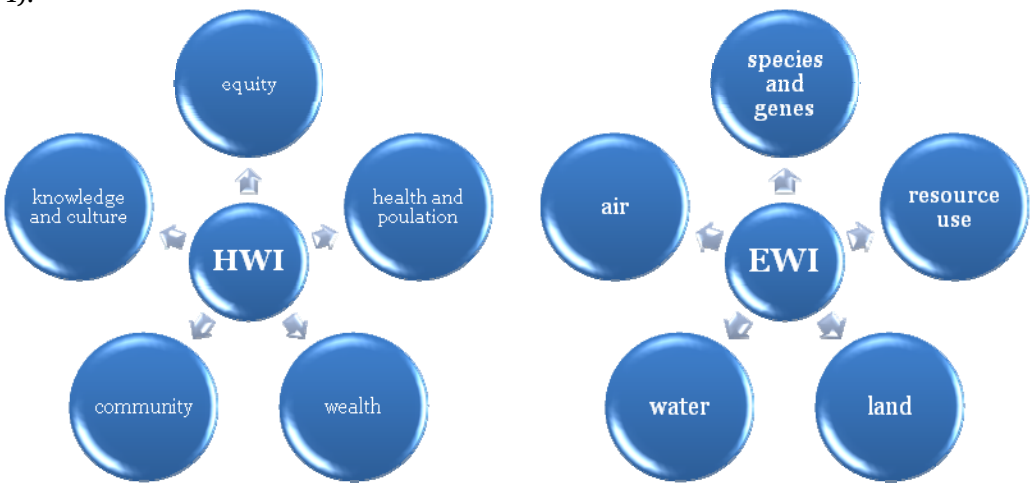



Figure 1. : The subsystems of wellbeing assessment

The IUCN regularly publish reports about problems of environment protection. The Wellbeing of Nations surveys determine 180 countries according to human development and environmental

[2] Eco-efficiency is ratio: value of product or service/environmental effect. That is increase of eco-efficiency means augmentation of this ratio.

protection. Sweden is in the first place, although the survey also terms it as a country with "ecosystem deficit" and Hungary is in the 44th place. The HWI is a better indicator for measuring socioeconomics conditions than GDP and covers more aspects of human wellbeing than Human Development Index [10]. According to HWI, the report highlights that the world's major population live in countries with poor or bad HWI, furthermore the difference between the minimum and maximum values is rather huge: the median HWI of the top 10% of countries is almost eight times that of the bottom 10% [10]. As far as EWI concern it shows that environmental degradation is widespread. There is no country that has good EWI; almost the half of the countries has poor or bad EWI.

The WI shows how well societies combine human and ecosystem wellbeing, the WSI is the ratio of human wellbeing to ecosystem stress, in other words the society's effect on environment. The last two indexes highlight that none of the countries is sustainable in the world and also show that generally poverty goes with low demands on ecosystem and inversely. Furthermore, 116 countries of the 180 examined countries are double deficit countries, which means that they simultaneously have weak environmental performance and inadequate development.

The wellbeing assessment emphasizes that sustainable development is a combination of human and ecosystem wellbeing. The assessment shows that ecosystem wellbeing is very important but the humanity does not deal with the problem sufficiently.

Graymore et al. [7] found that the wellbeing assessment is the most suitable for measuring regional sustainability, considering that this indicator was the only one which met most of the criteria. According to the ecological footprint, the authors emphasized that there were problems with the availability of regional data.

The Wellbeing of Nations report about wellbeing assessment was published only once in 2001, since then there have not been any reports, consequently, annual data cannot be compared in contrast to ecological footprint. Furthermore, wellbeing assessment is based on several indicators, which makes it very complicated.

## 6. SUSTAINABLE SOCIETY INDEX

The Sustainable Society Index is a newly developed index, which integrates sustainability and quality of life. The SSI is based on public data from scientific research institutes and international organizations (WHO, World Bank, UNESCO, FAO). The SSI consists of 5 categories and 22 indicators (Figure 2).




Figure 2. Categories of SSI

The first calculation was published in 2006, when 150 countries were examined. Then it was updated in 2008. The SSI combines the main aspects of Quality of Life and Sustainability, which are relevant to the development towards sustainability. The index is based on the extended definition of the Brundtland Commission.

According to the results, the high income countries score generally high on the categories of Quality of Life (Personal Development, Healthy Environment and Well-balanced Society) and low on the categories of Sustainability (Sustainable Use of Resources and Sustainable World). On the other hand low income countries show a quite opposite picture. On the list, Africa has the lowest score in the category of Personal Development and Healthy Environment, Well-balanced Society and Sustainable Use of Resources, however. in the category of Sustainable World Africa is the first [12].

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In 2008, 151 countries were explored. According to the method, the level of sustainability was measured in 3 steps: the 22 indicators was measured and expressed in a score, then the scores were aggregated into the scores of the mentioned five categories, finally these scores were aggregated into one figure [13]. All scores were expressed on a scale from 0 to 10. The average SSI score was 5, 7 in 2008.

One of the most important disadvantages of SSI is the lack of reliable data, furthermore the disposable data is short for the time being (it covers 2 years).

## 7. SUMMARY

In my study I presented that it is very important to measure (environmental) sustainability and regional sustainability within. I highlighted that there are several methods to measure sustainability; however, to choose the proper assessment the main criteria has to be clearly defined. I showed the categories of Graymore et al. [7], which is quite detailed and it can help to find the adequate method. I put emphasis on the presentation of three indicators: ecological footprint, wellbeing assessment and sustainable society index. In my opinion ecological footprint can be an adequate indicator for determining regional sustainability.

I think the major problem is that there are countless sustainability indicators and new indicators have been discovered year by year. It would be necessary to choose one indicator which is adequate and to improve it.

The main object of my study was to examine regional sustainablity indicators, because in the near future I would like to test the mentioned indicators and their criteria in the Southern Great Plain in Hungary to measure regional sustainabilty of this area. I would like to study this three indicators based on the list of criteria of Graymore et al. [7].

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# ROLE OF PROXIMITY IN INFORMATION TECHNOLOGY CLUSTERS (IN SZEGED AND ITS SUBREGION)

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**Abstract:**
Geographical proximity plays a crucial role in improving the innovative capacity of firms, but today by using infocommunication technologies, knowledge-intensive firms can have successful co-operation in spite of great geographical distances. Benefiting from geographical and organized proximity, cluster form.
Utilizing the advantages of proximity, cluster development appeared in the city of Szeged and in its subregion. Empirical research shows that all the facilities are provided in the software industry for clustering, where further development can be reached by the strengthening of the dimensions of proximity.
**Keywords:**
geographical proximity, organized proximity, knowledge-intensive cluster, software industry

## 1. INTRODUCTION

Clusters are today considered to be the basis of local, regional and even national politics in many countries. They are the new poles of competitiveness dominating the economic map of the world, serving as major tools of development in the global economy. Regional clusters are local systems of production, where companies and institutions in a particular industry in one place create an innovative system of business and non-business relations. Yet the competitive advantage of clusters rests not only on spatial concentration. The appearance of modern information and communication technologies (internet, mobile phone etc.) revealed that innovative companies and laboratories might cooperate with each other thanks to the common knowledge base, professional language, behaviours, cultural background etc. in spite of geographical proximity. New channels of information and knowledge transfer shaped, influencing the process of production and development. This phenomenon draws attention to create new approaches to examine clusters and the advantages deriving from physical and relational, in other words, organized proximity too.

Information technology (IT) plays an important role in the development of knowledge-based economy. IT and this way software industry, has become an international leading branch, which contributes to the development of information society. Clusters appeared as successful economic development tools in less developed countries after the developed ones in the European Union. The formation of a software cluster based on the dimensions of proximity has yet not been measured in Hungary, but it became reasonable in the less developed region (NUTS level 2) of the South Great Plain and in its 'knowledge island', Szeged and its subregion.

With a view to realize future opportunities for clustering in the software industry, the first step is to examine the advantages of geographical concentration of software companies and related institutions in Szeged and in its subregion, afterwards to identify the presence and strength of other factors of proximity to which interconnection can be traced back. To explore the chances of cluster development is Szeged, it is indispensable to see the example of foreign clusters operating in the field of information technology.

This paper has one purpose: to demonstrate and analyze the relevance of proximity in clustering. Firstly, we introduce the concept of proximity, and describe the notion of geographical and organized proximity, then we define clusters in terms of proximity. Finally, we propose to examine cluster formation in practice, in case of the knowledge intensive software industry in Szeged and in its subregion.

## 2. INNOVATION AND DIMENSIONS OF PROXIMIT

Proximity is a critical criterion in firms' choice of where to locate its productive units. Location and geographic concentration have become key factors in the diffusion and exploitation of knowledge, especially in the context of innovation, cluster development and knowledge spillover. Proximity reduces uncertainty, solves the problem of coordination, facilitates the interactive learning and thus

has a positive impact on the economic performance and growth of a region [6]. Most regional, national development programs on regional growth emphasize factors like the nearness of high-tech firms and universities, the proximity of experts and researchers or similar sectors.

Taking a closer look at the use of proximity in theoretical and empirical approaches, we find that its concept used in many way: we may talk about geographical, cultural, organizational, technological, cognitive, institutional proximity [5, 8, 15] etc. All these dimensions are certainly not identical, but refer to 'being close to something measured on a certain dimension [5]. As Ann Markusen [9] described, proximity is a "fuzzy concept". In many cases companies in proximity, but in the geographical sense, can have successful cooperation due to the common language, common skills, experience, social or institutional background, as we can see in the example of software companies in Bangalore, in India, which develop software products and carry out the order of software companies in the USA. The appearance of infocommunication technologies in the 1990s explicitly changed the value and the necessity of geographical and other dimensions of proximity. Literature [2, 12,14,15] usually defines two main types of proximity: geographical and organized proximity.

When the proximity concept is used, what is often actually meant is geographical proximity, which is signified as either spatial, local or physical [5]. Geographical or regional sciences traditionally use the notion of proximity, defined as short geographical distance. Distance basically means 'spatial non-identity', - not being in the same place - [10] and measures the amount of physical space between two units (individuals, organizations, towns etc.). Short distance brings the individuals together, favours information transfer and facilitates the exchange of knowledge, especially tacit knowledge. Agents in geographical proximity, benefit from knowledge externalities. The diffusion of knowledge generates positive externalities if knowledge flow increases the productivity of activities of research and development (R&D). Empirical studies prove that firms near knowledge (tacit and even in case of codified knowledge) sources can have better innovative performance than firms located elsewhere [1].

For today, it has become clear that it is wrong to associate proximity with its geographical meaning. Organized proximity, which is not geographical but relational, is defined as the ability of an organization to make its members interact. The organization facilitates the interactions within itself between employees and with other entities outside the organization. Organized proximity is built on two types of logic. Firstly, when two members of one organization interact, they are in proximity, because their interaction is facilitated by (common, explicit or implicit) rules, routines and behavior that they use and follow. This is the so-called 'logic of belonging' of organized proximity, which develops cooperation between researchers and engineers in the same firm [15]. Secondly, organized proximity reflects the 'logic of similarity'. Two individuals are close to each other, because they are 'alike", they speak the same special language; they share a system of common interests, beliefs and knowledge in the same cultural sphere.

The researchers of the so-called "Dynamics of Proximity" group have developed the notion of relational proximity that includes the spatial dimension of relations. The most frequently examined dimensions in addition to geographical ones,- as the critical assessment of Boschma [1] underlines, - are the cognitive, organizational, institutional and social proximity. These four categories together are based on the notion of organized proximity. The concept of cognitive proximity that has been developed by Nooteboom [11] is generally defined in terms of common knowledge base and expertise among agents. Actors in cognitive proximity have similar knowledge base, thus they transfer knowledge and communicate with each other more effectively. The notion of organizational proximity means relations in the same space either within or between organizations, and refers to the similarity between individuals sharing the same reference space and knowledge [1]. Organizational arrangements are mechanism that coordinate transactions and enable the transfer of information and knowledge. Actors are in institutional proximity, because they pertain to one institutional framework at macro-level. Relations and interactions between actors and group of actors are regulated by a set of common habits, routines, (business) practices, rules and laws. Social proximity can be defined in terms of relationship between actors at the micro level embedded in the same social context. Actors share trust based on friendship, kinship and experience [1]. If business relations (within an organization) are more socially embedded, the possibility of a better innovative performance is available.

The dimensions of proximity are strongly linked to each other. All types increase the effectiveness of learning, and have a positive effect on the production of knowledge-based externalities.

As noted above, knowledge spillover is an essential element in the development of innovation process. Although, the high geographical concentration of firms, universities and research centres in a region belonging both to the same or different sectors, is not enough to explain the innovation capacity of a local area. It is necessary to define the channels through which the knowledge spreads. Capello and Faggian [2] introduced the concept of relational space, and explored the connection between physical and relational space, as preconditions of knowledge spillover (Figure 1.). Relational space is

created by the set of all relationships (market, power relationships) and cooperation between firms, different agents and individuals, who are characterized by a strong sense of belonging and similarity. The approaches of physical and relational space are outstanding tools to analyze the innovation process.

On the one hand pure physical space is the geographical proximity to firms in the same sector (to exploit localization advantages) and to firms in different sectors (to exploit urbanization advantages) and to typical places where knowledge is produced, like in universities and research centres. Economic actors in physical proximity have the opportunity to contact each other, where the spread of knowledge and the production of geographical knowledge spillovers are managed more easily. On the other hand organized proximity and its dimensions (according to the original notion of the authors it is defined as cultural proximity) are the base of the formation and existence of relational capital, which is formed by explicit and implicit cooperation among actors. Actors have the capability to interact and to share common values, which is the fundamental element of collective learning [2].

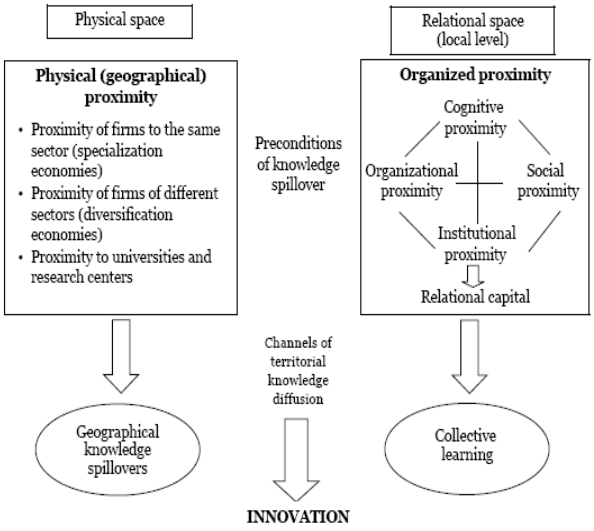


Figure 1. : Physical and relational space

Firms in cognitive or organizational proximity might be able to communicate without face-to-face contact using modern communication technologies (which have spread since the 1990s), thereby overcome the problems caused by large geographical distances [5]. Taking the new role of information and communication technologies into account, we can state that geographical proximity is necessary, but not sufficient in interactions and cooperation. That is why literature differentiates permanent and temporary geographical proximity [3].

## 3. CLUSTERS IN TERMS OF PROXIMITY

The concept of proximity provides a framework for analyzing the different spatial organizations, like clusters. Clusters exist, their numbers are increasing and more and more policies are implemented to promote their development, and there are many reasons that describe their success. It became clear that geographical proximity is necessary in innovation and research activities, and facilitates the flow of information and knowledge between actors. Michael Porter [13], too, emphasizes the fundamental role of geographical concentration in case of clusters and defines cluster as '*geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities*'.

The existence of clusters rests not only on geographical proximity, but also on several other factors. The economic relations shaped between cluster participants are embedded in the social network and the latter often have strong territorial roots. Synergy between interconnected partners does not form, if they are not in social proximity. Also cooperation may occur between actors from different organizations, but it happens due to the same university origins or social and family network. Social proximity reduces the uncertainty, just like cognitive proximity. This is true in case of cluster members and especially in case of newly entering companies, when they search for new knowledge. As a rule, firms' aim is to find partners in vicinity of their own knowledge base. Another important factor is, that geographical context of economic interactions is largely conditioned by the role of institutions.

Cluster members are not only located in the same area, but they form a strong system of innovative relations, and cooperate with each other in their own interest to exchange technology, to transfer knowledge. In terms of proximity, clusters are described as the intersection of strong geographical and strong organized proximity [7]. For example if organized proximity is strong, but geographical proximity is weak, it characterizes non-localized interactions, like value chain.

## 4. HOW MUCH PROXIMITY MATTERS IN THE SOFTWARE INDUSTRY IN SZEGED AND IN ITS SUBREGION

To investigate the dynamics of proximity, in particular in the high-tech sector, we focus on the case of the software industry in Szeged and in its subregion. The endowments of the key region of development underline the necessity of mapping a software cluster. Sufficient knowledge base is available, ensured by the university background, educational and research activities, the big number of

university students (around 30.000 students), newly graduates, and finally by the Faculty of Informatics (with nearly 500 newly graduated students annually). These factors ensure the fluent re-production of the labour base annually, and the birth of new enterprises found by qualified, young workforce. A circle of software enterprises is built, and the first initiatives have already appeared to have more efficient cooperation (cluster) between companies, although the effects of these are still hardly perceptible.

Our aim is to understand how geographical and organized proximity and its dimensions determine the process of clustering in knowledge intensive activities in less developed regions. The growing application of information and communication technologies appears to indicate that there is a weakening need for geographical proximity, and cause the 'death of distance'. This has not triggered a collapse of 'near and far' in the reality of individuals and organizations, not for actors staying in less developed, peripheral regions [7]. Usually, these firms are dependent on knowledge resources from outside the region too, as we will see in case of Szeged too.

ICT plays a special role in the software industry too, and contributes to its characteristics: products (software and teleservices) have an immaterial nature, and their transportation to business partners and consumers can happen directly through modern ICT tools, which reduces transportation costs. Software companies continue intensive development activities and ICT allows its management and coordination from a distance. Software companies form different business associations like clusters, which operating separately or connected to other high-tech industries (e.g. biotechnology).

## 5. THE PROOF OF GEOGRAPHICAL CONCENTRATION

The software industry is a potential leading branch in the micro-region of Szeged. Mapping the base of a future software cluster, firstly it is necessary to prove the existence and concentration of the basic input factors in the region. We examine whether the software industry has achieved a specialized critical mass in the region using the methodology of location quotient (LQ) [12]. LQ compares the distribution of an activity to some base or standard. In this case the selected base is the employment and the number of enterprises. In Szeged and in its subregion more than 200 companies, and about 550 employees work. To focus on the most knowledge intensive companies in the region, who have the biggest role in the growth of the industry, we only examine limited liability and public limited companies dealing with software development, software consultancy and supply (NACE Rev.1.:72.2.) whose products have bigger added value. The software industry in limited sense is composed of not more than 90 companies.

As a rule, if the value of LQ is more than 1, it indicates a relative concentration of the activity in the area, compared to the region as a whole. The European Cluster Observatory determines a stricter value equal to 2 or more. According to the value of LQ based on the number of enterprises, which is less than 1 in Szeged and in its subregion, we can state that the area has fewer share in the software activity than in other regions in the country, comparing it to values calculated in case of other bigger cities in Hungary. It is interesting that if we measuring the number of enterprises in the capital, in Budapest (where more than 5000 companies work in the software industry), the LQ is 1,256. We got similar results measuring employment LQ. Taking the employment in Budapest into account, the LQ is 1,119 in Szeged and its micro-region, and, it is 2,867 without Budapest, and none of the other rural cities reach this relatively high value. According to this figure, the relative concentration of the software industry is secured in Szeged and its subregion in the number of enterprises and employees, and the industry may be strong enough to grow as a potential leading branch, and also attract related economic activities from the region itself and from other regions too.

The statistical research based on the calculation of location quotients ensured the observable phenomenon, that software industry is specialized in Szeged and its subregion. The results suggest surveying the opportunity of software industry as a potential leading branch for clustering with qualitative research.

## 6. THE ROLE AND STRENGTH OF PROXIMITY

Using the qualitative method of questionnaire, we examine how geographical proximity matters in the software industry, and how strong the organized proximity is between companies.

The role of geographical closeness in the sector of information technology appears in a specific way in Hungary. The number and the intensity of business partnership between companies confirm the well known fact, that there are no significant distances within Hungary, and partners in the capital play an important role even in the software sector of Szeged. Software companies valued geographical proximity as relatively important factor. Beside weaker geographical proximity there is proved organized proximity between companies. They do see and enjoy the advantages deriving from geographical proximity, but the lack of it does not mean a disadvantage especially in some stages of

on-demand software development and services.

There are broad market borders among the IT products and activities. Thought many of the distinguished activities can be relocated, but it is quite obvious that at least temporary geographical proximity is necessary in cooperation. The need of permanent geographical closeness depends on the quality of the technical conception of the software being developed. Usually, face-to-face interactions are required in software development, definitely in the initial stage in functional specification, and in the final stage in integration and technical assistance. Companies in Szeged and in its subregion are solution-orientated. They practice research and development, and focus on design software, instead of making standardized tasks.

The cooperation with competitors has special characteristics. Companies in Szeged and its micro-region cooperate and compete with each other, like companies in clusters. Almost half of the companies have participated in a project with its rival in Szeged, and about two third in Budapest. Typically the cooperation occur only occasionally and focus on research and development, and shall be attained by the companies in organized proximity. The IT market in Szeged and its subregion is mostly dominated by local partners, no matter we examine the relationship between producers and university, rivals, suppliers or customers. More than 70% of the customers, 50% of business partners stay in Szeged and in its subregion. In addition, every second organization participates in product and technology development cooperating with the University of Szeged.

Mapping a software cluster in the analyzed area, the research demonstrated that companies do enjoy the positive externalities of geographical concentration, and strive the conscious utilization of its advantages. The need of (at least temporary) geographical concentration depends on the strength of the organized proximity. Organized proximity and its dimensions (cognitive, organizational, social and institutional) are basic inputs in the innovative cooperation. In the interviews, companies emphasized three factors, as the most important inputs in innovation: attainment of innovative and professional workforce, ideas and technologies through personal and business relations and finally the vicinity of educational and postgraduating programs and institutions. The synergy of partners is substantial to obtain the benefits of innovation-based relationships. Within partners, university appears to be an intermediary in the flow of knowledge and information. It has significant role in the facilitation of collective learning.

Business and personal relations between actors determine an 'industrial atmosphere', where the similarities in knowledge, experience, practices and routines are natural. Cognitive proximity is a pivotal factor in the software sector in Szeged. More than half of the employees and almost 80% of the directors of these companies graduated in the University of Szeged, on the Faculty of Informatics. Companies with the same knowledge background participate in forums, clubs, conferences and other professional programs together. It is favoured to have interaction between company members, because they share a set of common rules, specific know-how and organizational routines. This points out that they stand in organizational proximity too. Different forms of interactions play an important role: the lack of personal and business relations is - as the interviewed firms mentioned - factor that hampers their future chance to grow. More than 80% of the companies stated that personal relationships like friendship of employees within and between organizations ensure the flow of information and knowledge. This process would not be managed without socially embedded relations. Strong social proximity facilitates the affirmation of links, the development of trust-based relations, hence the formation of innovative cooperation.

The problem that faces the software industry in Szeged and in its subregion, that the relations are not consequences of constant or recurrent cooperation. They are supposed to obtain financial sources within a common project or trade development competition. Companies in general are not willing to have regular cooperation, because they fear to loose their market position or to have their good ideas stolen. However, they already stated that they would be ready to work together within a cluster. Solving the problem, the key should be to draw up a conscious development strategy creating the synergy between partners (software companies, university and other knowledge producer institutions and the representatives of local government).

The process of cluster development may speed up due to an effective institutional and governmental background. Governments contribute to diminish market barriers, control market competition, ensure inputs (eg. infrastructure, technology etc.) for economic actors and mediate between companies and institutions, which produce knowledge and labour force. Thus, government may facilitate the cooperation of companies in clusters too.

Companies in macro-level are embedded in one institutional background. They are in strong institutional proximity; they are applied to the same laws, rules and regulations. However actors' satisfaction in connection with institutions is a very different story. Interviewed companies are discontent with the administrative work, legal environment and with the representation of their interests. Local government does not have the sufficient tools to promote relation and also cluster

building, the foundation and registration of new firms, the appearance in external markets, the organization of trainings, clubs.

Companies in the questionnaires admitted the importance of business services and governmental subsidies. The great advantages of these factors are seen in the example of foreign, information technology and software related clusters too, which operate also in less developed regions. In the city of Cork in Ireland software industry is largely driven by foreign direct investment (FDI) attracted by the low Irish corporate tax rates. In the region innovation policy was key for IT cluster development, which promoted R&D and innovation, encouraged spillover of knowledge. Due to this, actors have already created a 'knowledge zone' in Cork. The first factor, which led to the growth of the region, was the financial resources ensured by the government, especially for infrastructure and prosperous business environment development. In the city of Oulu in Finland, substantial public policy efforts were made the ICT cluster flourish. The key preconditions in cluster development were the size and quality of the local knowledge infrastructure (technical university, science park), and the existence of a 'champion' company (NOKIA). IT cluster in Oulu is one of the most competitive ones, be present on the 'cluster map' of Europe.

## 7. CONCLUSION

Our findings ensure that, both geographical and organized proximity exists between the actors in the software industry in Szeged and in its subregion. These have positive effect on its innovative capacity, on the development of corporate skills and on the decreasing of transaction costs etc. The base of researchers and qualified labor force has already been built-up; companies are motivated to deepen their existing business relations, which determine the base of a future cluster.

The relative, national concentration of software industry in Szeged and in its subregion is proved, and in practice, as the qualitative survey revealed, geographical concentration is necessary, but not sufficient to create business and non-business relations. At least temporary geographical proximity and strong organized proximity of actors is needed in the software industry. Companies share the same knowledge background; they are in cognitive proximity, due to the university origins, and the participation in conferences, clubs and forums. They have an extensive system of relations, determined the same behaviour patterns, cultural and social values, rules and regulations, which underlines the existence of organizational, social and even institutional proximity between them. Each dimension of organized proximity separately and also together affects the capacity of innovation and collective learning. There is a lack of more trust-based relations and partnership of companies, local government and knowledge producer institutions, but it can be counteracted by not only occasional, but also frequent cooperation, and by conscious economic and enterprise development.

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# TECHNOLOGICAL CHANGE AND SUSTAINABILITY - PART OF THE PROBLEM OR THE SOLUTION?

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**Abstract:**

In present paper we analyse the effects of technological change on environmental sustainability, considering the approaches of both environmental economics and ecological economics. We touch upon three main issues. First, eco-efficiency and substitution. Second, uncertainty and reflexivity and eventually the Jevons-paradox (or rebound effect). We conclude that the techno-optimist approach of the environmental economics can be seriously questioned. In the existing structure technological change seems to be rather part of the problem than the solution in connection with sustainability.

**Keywords:**

Technological change, sustainability, evolutionary economics, uncertainty, Jevons paradox

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# INFLUENCE OF TRADITIONAL PRODUCTS TO THE REGION MANAGEMENT IN HUNGARY

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**ABSTRACT:**
Region marketing is barely known in Hungary and we have only limited experience in connection with its Hungarian applications. Region marketing is by all means part of marketing. It is a mixture of such activities which purpose is to effectively channel products to the customers. It must be considered, that there is a strong competition in satisfying consumer demand.
Main goal of region marketing is to help discovering the competitiveness and charm of the region in order to reach multilateral development-, economic- and life-conduct objectives. Being a member of the European Union, it is vital for Hungary that its food industry could reserve its traditional role. Numerous high-quality, special products (hungaricums) are produced in the South Great Plain Region. Farming experience – gained throughout centuries - resulted in special, unique products representing national values. Key words: Region marketing, marketing objectives and strategies

**Keywords**:
region management, region marketing, traditional products

## 1. INTRODUCTION

Regional marketing is a new concept, which is not widely known in Hungary, there are only very few and limited experiences with it. It is a total of all the activities and at the same time a way of thinking, the aim of which is to take a product to the customers very efficiently (Berács, 2002). The task of regional marketing is to explore the competitive assets and attractions of a region, to help the realization of the plans in order to support achieving the goals of economic and community life (Lakner-Hajduné, 2002).
In the South Great Plain Region several top-quality products are made and these products are Hungarian specialties (Piskóti, 2002). In this immense competition an image formed about a country, a part of a country or about a region has a considerable influence on the decision of customers – both on the national and international market.

## 2. ROLE AND NECESSITY OF MARKETING STRATEGY IN THE REGION

### 2.1. Necessity of region marketing strategy in the South Great Plain Region

- The South Great Plain Region, similar to the other regions of Hungary is an artificially made formation which does not have independent internal government. One important condition of the maintainable competitiveness of the region is the foundation of independent internal identity which grounds effective regional cooperation (Juhász et al, 2006/a)
- Even currently, numerous organizations conduct marketing activity which are not coordinated with each other, and as a result they give contradictory pictures. Thus, it is necessary to coordinate region marketing activity, applying a uniform frame.

### 2.2. Role of the marketing strategy of the Region

- Basic document from the aspect of regional level organizations and institutions, reliable starting point for the marketing activity which provides information for the business organizations of the region.
- Draws the intentions and projected future image for the population and public opinion.

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## 3. ASPECTS OF SITUATION SURVEY BASING THE MARKETING STRATEGY IN THE SOUTH GREAT PLAIN REGION

Region marketing has to rely on the sources of the region, thus it is vital to conduct a situation survey before the workout of marketing strategy (Figure 1.).

### 3.1. Results of situation survey

The South Great Plain Region is the largest region of Hungary, expands to one-fifth of the area of the country. Its population of 1.36 million gives 13.4 % of the country's population. The region lies on flat land and thus, the most important natural resource of the region is arable land. This region also provides significant proportion of the country's hydrocarbon energy resources. From the 37 towns of the region, 4 have county rights. Employment situation is about average, but differs greatly by counties: most favourable in Csongrád County (proportion of active wage earners 36 %), average in Bács-Kiskun, and unfavourable in Békés. Population structure by education level improved continuously in the past decade, the proportion of secondary and high-school graduates increased steadily (Juhász et al, 2006/b).

Level of communication network exceeded the average of other regions as did tube gas supply. Public water supply was also appropriate but the sewer network was quite undeveloped. An outstanding endowment of the region is education, but GDP is well below national average (Töpfer et al, 2005).

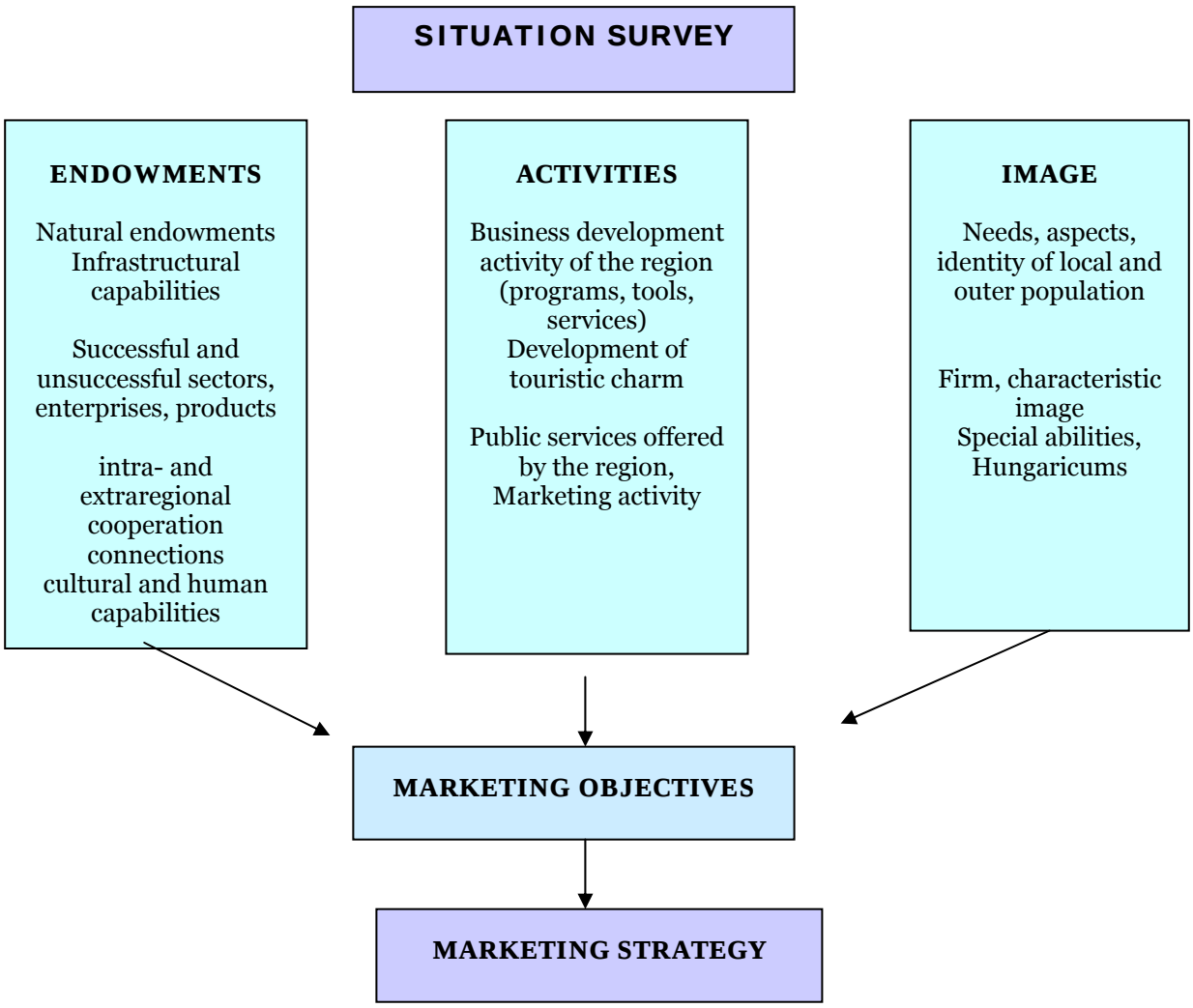



Figure 1.: Aspects of situation survey basing marketing strategy

### 3.2. SWOT analysis of the region

**Strengths of the region:**

- Role of agriculture is dominant in the Region, the food industry is competitive even by international comparison;
- Number of sunshine hours is very high and the average yearly temperature is also amongst the highest in Hungary;
- One of the busiest international transportation lines towards South-Eastern Europe crosses the Region;
- Number of tertiary educational-, research- and cultural centers is outstanding in national comparison.
- Many famous firms with high level of professional culture and brands connected to them works in the Region.
- There are a number of unique, excellent quality „Hungaricums" produced, which are unambiguously characteristic to the region.

**Weaknesses:**

- The GDP per capita has remained unchangedly below the national average in the past years;
- Quality and quantity of transportation infrastructure is insufficient;
- Proportion of foreign capital is lower than the national average;
- Many small regions of the Region belong to the group of small regions currently being in critical position.

**Threats:**

- Regional effects of the EU's Agricultural Policy;
- Uncertainty of the Balkanic policy;
- Appropriate environmental protection agreements and cooperations wouldn't be signed with the neighbouring countries;
- Sharpening competition between the domestic region and the regions of neighbouring countries.

**Possibilities:**

- Growth of the role of euroregional organizations;
- Affirmation of the South-Western European gate role with the reconciliation of the Balkanic situation (Müller, 2007);
- Change in consumer preferences;
- Positive international image of certain kinds of foods;
- Demand for unique, special provincial products.

Based on the results of situation survey it can be stated that the South Great Plain Region wants to be positively distinguished and also to shape a clear image. In case the efforts will be successful in the future, the region would gain domestic and foreign sources and in addition, the capital flow to the region could become more intensive.

## 4. MARKETING STRATEGY OF UNIQUE, SPECIAL QUALITY REGIONAL PRODUCTS IN THE SOUTH GREAT PLAIN REGION

One of the problems of the South Great Plain Region lies in the relatively limited number of such well-known, unique products which determine a clear, united image. And even if some are present, they exist separately. In the same time there are numerous „Hungaricums" produced in the region, which are available for conserving local traditions and forming the image of the Region. Definition, management and protection of the group of these products with the tools of active marketing policy could contribute to positively influence the image drawn from South Great Plain Region. They facilitate stabilization of special producing districts, affirmation of local economy and the melioration of the income conditions of the population.

Region-specific products (e.g.: Kecskeméti barackpálinka) which fulfil strict regulations and requirements could be the key elements of the marketing strategy of the South Great Plain Region.
Quite important, that the unique products of the Region should remain real „Hungaricums" and behind trade-marks constant, guaranteed quality must appear (Ferencz, 2004).

## 5. TASKS OF THE REGION IN MELIORATING THE MARKET SITUATION OF HUNGARICUMS

Instead of mass production the sortiment of traditional, special products should be broadened given the fact that experiences of the centuries-long production already brought up those „Hungaricums" which represent the outstanding qualities and national values of the region;

- High-level professional skills, training and flexible marketing activities are needed;
- Origin, trade-mark and adept information must be indicated on the packaging of the products;
- Forming of support systems must be conducted in such a way that it could facilitate establishment of special production structures and concentrate on resurrection of the values of the region.

## 6. CONCLUSION

Material and immaterial products which are manufactured in, and are representative exclusively to the Region should be supported practically in regional cooperation. Beside measurable economic profits the following advantages can be achieved:

- conservation of traditions and cultural heritage, strengthening the idea of belonging to the same community among the people living in the region;
- forming the peculiar image in the competition among the regions and in the accelerating globalization processes of our days.

It can be expected only as a result of a long-term, coordinated marketing strategy that the image of South Great Plain Region becomes widely known and attractive. One precondition of this is that the Region should successfully represent the selected image and to develop a positive affection for its „Hungaricum" products. This affection could be formed inside the region by positive local-patriotism, while outside the region with the sympathetic and valuable features.

This is important because the South Great Plain Region has its competitors by now – certain domestic and neighbouring country regions. In the future, the enhancement and specialization of the competition between regions could be expected. The South Great Plain Region only has its chance to effectively join the domestic and international competition if conscious preparations and image-forming takes place.

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# SUSTAINABLE DEVELOPMENT AND THE ECONOMIC CRISIS

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**Abstract**

One of the constituents of the sustainable development is economic sustainability, along with the social, environmental and institutional dimensions.
In business, there are only companies which manage their economic sustainability as no amount of excellent social and environmental performance will prolong the life of a company that is economically unsustainable.
It is only obvious that economies and communities are to a high degree affected by business failure and economic instability having a disastrous effect on people. However, businesses that only measure success against financial indicators, such as turnover and profit, increasingly risk failure. A broader perspective on sustainability is now emerging, based around reputation, full cost accounting, ability to add value and the management of knowledge.
Summarizing specific challenges, it is critically important that the European Union has resident (citizen) capacity to carry out strategic planning on a continuing basis. While this capacity will in the short-term necessarily have to depend on externally supplied expertise, more institutional strengthening will be required to ensure the development and institutionalization of planning and policymaking capacity at both national and state levels.

## 1. GENERAL CONCEPTS REGARDING SUSTAINABLE DEVELOPMENT

The term of „sustainable development" appeared in earlier decades due to a high number of environmental movements. It was first defined by World Commission on Environment and Development (WCED) as the development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." [1] This definition is clear enough, not requiring any further explanations. But there are two more questions worth thinking about: Why should we think about the future generations and how can we implement a sustainable development?

Referring to the first problem, taking into consideration the sustainable development not only helps our children, grand-children, grand-grand-children and so on, but also helps us. It helps us live a better life in a better world reducing pollution, uncontrolled waste dumping, controlling the resources which, in the end, reflects in the increase of our life expectancy. Moreover, from the economical point of view, we will be able to better fulfill our needs, as individuals, as long as we take into consideration a good management of our personal resources and we keep our consumption levels under control.

However, how do we get to the sustainable development? Starting with 1992, at the Earth Summit, held in Rio de Janeiro, the EU identified the need for sustainable development in Europe. There has been developed a strategy (which was renewed in June, 2006) that focuses on climate change and biodiversity. The challenges identified which European Union has to face are:

- Climate change and clean energy
- Sustainable transport
- Sustainable consumption and production
- Conservation and management of natural resources
- Public health
- Social inclusion, demography and migration
- Global poverty

Unfortunately, although the first summit concerning sustainable development took place 17 years ago, the progress in this direction is still not very significant and visible. This is also due to the different ways of understanding and implementing the concept of sustainable development in EU's state members mostly characterized by the reticence towards this concept met in poorer countries. Many state members tend to believe that the implementation of a good sustainable development strategy is expensive, thus unaffordable or they even consider it "a brake to development". In this

situation, it is no wonder that the strategy did not achieve its goals. Still, new goals have been set, among which the limitation of the climate change and the reduction of the greenhouse gases by 20 percent by 2020. How and if this targets will be met, remains to be seen.

## 2. EU SUSTAINABLE DEVELOPMENT POLICY

The main focus of the European Union Sustainable Development Strategy (EU SDS) is to progressively achieve the change in the current unsustainable consumption and production patterns and the non-integrated approach to policy making. Of course this can be obtained only by succeeding in raising awareness among communities in order to improve the quality of life for both the nowadays generations and the future ones. Being able to efficiently manage and use resources to trigger the ecological and social innovation potential of the economy, building up a prosperous and protected environment, as well as social cohesion. The cross cutting policies are:

1. Education and training.
2. Research and development.
3. Financial and economic instruments.
4. Communication, mobilizing actors and multiplying success.

Obviously three main actions are most significant in achieving the goal and these are – implementation, monitoring and follow up. Starting September 2007 a new rule has been set – the Commission has to submit every two years a progress report on the success of the implementation of the above mentioned directions in the European Union and the Member States, as well as on future actions and targets.

The two issues that keep coming up in the debate are the quantification of the progress made by EU and the Member States in implementing EU SDS and the setting of future targets.

In this respect, a very high importance is given to the climate change and clean energy. All the Member States , as well as EU, agree that this is a very important theme, therefore the number of initiatives that have been taken. One example would be the focus on renewable energy and biofuels which has caught the public's eye. Unfortunately, not so much attention is being paid to post-2012 emission reduction and adaptation to climate change, which is becoming a more and more urgent matter. In what concerns the climate change and clean energy there is a lack of coherence between objectives and actions. Thus the adaptation to climate change has no corresponding actions attached to it and therefore we need strategies to reach the already mentioned objectives. There are policies such as agriculture, trade policy, research and technology development which although are not directly connected to the climate change issues can influence the sustainable development and mainstreaming energy.

In the field of sustainable tourism the energy use and the greenhouse gas emissions are in focus. The problems concerning the sustainable tourism refer to separating the economic growth and energy consumption from the increase in demand for transport. This can be helped by providing a real market price for the different means of transport. Improving the technology in the field is another way to help the sustainable tourism in what concerns the obvious energy consumption and emissions. The transport by air demand is highly increasing in Europe, being estimated to double by 2020.

With regard to the progress, there are limited reasons for showing optimism in the area of sustainable transport. The growth of freight transport volumes has outpaced economic growth since 1995 and growth of passenger freight transport has exceeded economic growth between 1990 and 2002. Growth in transport related energy use has exceeded growth in energy use in all sectors: transport's share of total energy consumption is rising and oil provides 98% of the energy used by the transport sector . Greenhouse gas emissions from transport are increasing and it is questionable whether targets in this area can be met. Although harmful, polluting emissions are decreasing, air quality problems in European cities still persist. A shift to environmentally friendly means of transport is unfortunately not a reality at the moment: road freight transport is still dominant and continues to grow; passenger air transport has increased significantly; passenger car transport shares have remained constant. The pollution through noise is as well on debate, although there is not, at the date, a valid data in support of the negative effect it has on the quality of life.

Obviously, *the challenge faced by all the Member States to apply the measures for a sustainable development is great.* It requires good inter-ministerial cooperation and horizontal methods of working, along with the ability to synthesize all outputs varies considerably between the Member States.

## 3. ECONOMIC RECESSION – AN OPPORTUNITY FOR TRANSFORMATION

The issue of origin and nature of economic cycle is one of the most important and the oldest unsettled problem of economy theory, still a very actual problem. A lot of the most famous scientists-

economists studied phenomena of economic cycles, economic dynamics and development. Among them one can name: Karl Marx, Wicksell, Mitchell, Tugan-Baranovsky, Gassel, Schumpeter, Kondratyev, Harrod, Hansen, Aftalion, Clark, Spiethof, Kuznets, Pigou et al. and, according to Hansen, this problem had not been solved till the time of his work (40s of the 20th century) (*Hansen, 1997*). By analyzing, comparing and contrasting the works of economists of the second half of the 20th century, it is possible to say that his statement remains true until now. Methodology that exists today in economics and its sections – theory of economic dynamics and theory of economic development – has come from classical mechanics [*Kondratyev, 1998; Schumpeter, 1982*). Today is a time of complexities. It looks that the organization of universal system is complex, intricate and functions according to non-linear laws. The idea of complexity itself became the focus of scientific thought. Non-linear physics and physics of open systems have occupied their place in educational and research processes of physics (*Zaslavsky and Sagdeev, 1988; Klymantovich, 1999; Bar Yam,1997*). The concept of self-organization of physical objects is confirmed as open dissipation systems. Fundamental categories of physics are newly interpreted from the position of new knowledge of complexity. The same phenomenon can be observed in economics as well. Wide diffusion of knowledge, including methods, occurs among different branches of science. Interdisciplinarity of research is one of the fastest spreading scientific methods. Our work is inter-disciplinary. It is an attempt to consider economic problem from position of non-linear physics, or, more exactly, - from position of physics of non-linear wave processes. So we are aware that "pure" physicists interested in economics can reveal triviality and even dilettantism in stated context and they will be right.

Economists, acquainted with physics, can reject the very method of approach and they will be right as well. It is due to the fact that economics studies human objects, the ones possessing reason and right to choose and making decisions, i.e. biological objects, while physics studies physical objects.

In such times, when companies struggle to remain on the market, a good question arises: can we still afford to focus on sustainable development?

Some claim that now is the best time to do that and that right now it should be clear to everyone that we can not go on as we have been.

Always in the face of challenge, a lot of new opportunities appear. We just need to seize the moment and make the most of them. Our future (as individuals and as a society, as a whole) depends on it.

The "big questions" here are: how do we build a more sustainable society with lower energy and resource use? How do we create the "green jobs" that will be needed to deliver these solutions? And how do we create a societal infrastructure that will be more resilient to the challenges of climate change and its impacts on our food and water supplies?

The amount of investment needed for energy, urban infrastructure, water, transport and food supply, to mention a few, will be tremendous, but we can not allow these investments to lock us into an unsustainable future. The infrastructure we invest in today will be with us a long time (50 years or even more). It is vital that governments remember this when designing the future infrastructure. They need to look forward to the low-carbon economy of the future and focus on investments in new energy systems, transport solutions, energy-efficient buildings and water and urban infrastructure. Making the right decisions now will spur new industries, create "green jobs", change our lives and secure our future.

We need to be thinking across the board, and outside of the usual constraints. With vision, foresight and planning, the world can be re-shaped. Imagine, for instance, a life in the future, where our homes and industries are powered by low-carbon energy, where transport runs on clean fuels, where even the poorest people have easy access to clean water, where our buildings and household appliances consume less energy, and where workers equipped with new, "green" skills are employed in the abundant jobs these new industries create.

All these represent opportunities for new businesses and growth. But the achievement is not possible by thinking in silos and within narrow national borders. A global view is required. We must take advantage of these opportunities. Future generations will not thank us if we fail.

## 4. ECONOMIC SUSTAINABILITY

One of the constituents of the sustainable development is economic sustainability, along with the social, environmental and institutional dimensions.

The term of economic sustainability does not only refer to achieving economic growth every year, but also at understanding that economic growth is only sustainable if it simultaneously improves our quality of life and the environment.

Along with ways of a business to operate and its financial stability, economic sustainability involves the generation of community capital, such as local sourcing, employment, partnerships and investment.

In business, there are only companies which manage their economic sustainability as no amount of excellent social and environmental performance will prolong the life of a company that is economically unsustainable.

In time, there have been set certain models of the sustainable development, therefore it is well-known that in order to obtain the sustainability each of the four subsystems (economic, social, environmental and institutional) has to maintain its capability to survive and evolve, while the connections of the subsystems must enable a permanent co-evolution. It has always been a challenge to identify the perfect level of complexity for descriptions and models in order to develop adequate analysis and to avoid wrong prognoses and this is sometimes beyond the analytical capacities of current economic theories. In this way, a system analysis perspective is presented as a framework for debating the co-evolution of economy, society, and nature. In this context, the economic, social, environmental and institutional sustainability of the economy can be defined and economic theories can be assessed regarding their usefulness for the description of a complex evolving system, like the economy.

In business, there are only companies which manage their economic sustainability as no amount of excellent social and environmental performance will prolong the life of a company that is economically unsustainable.

It is only obvious that economies and communities are to a high degree affected by business failure and economic instability having a disastrous effect on people. However, businesses that only measure success against financial indicators, such as turnover and profit, increasingly risk failure. A broader perspective on sustainability is now emerging, based around reputation, full cost accounting, ability to add value and the management of knowledge.

However, the present tax system acts in the direction of discouraging small business as it encourages waste, discourages conservation, and rewards consumption. The tax system needs a major overhaul to favor the legitimate and critical needs of the small business community. Retention of capital through retained earnings, efficiencies, and savings is central to small business competitiveness. Current tax policies often act to unfairly penalize small business.

To sum up, sustainable development is and always will have to be taken into account as it decides not only the economical welfare and growth, but also the quality of life.

Summarizing specific challenges, it is critically important that the European Union has resident (citizen) capacity to carry out strategic planning on a continuing basis. While this capacity will in the short-term necessarily have to depend on externally supplied expertise, more institutional strengthening will be required to ensure the development and institutionalization of planning and policymaking capacity at both national and state levels.

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# ECONOMIC AND MARKETING EXAMINATION OF TRADITIONAL HORTICULTURAL PRODUCTS AMONG THE COSTUMERS IN HUNGARY

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**ABSTRACT:**
The high demands on the international food markets can only be fulfilled with added value products from either quality or food safety aspects. Our 'Hungaricum' products answer these requirements, which access to the market has to enhance via effective marketing activity. The paper looks for answers about the domestic market of Hungaricums and their possibilities on foreign markets. The main task of the future is to drawing the customers' attention to the special quality products and working out a strategy for their competitiveness.

**Keywords**:
economical and marketing analysis, traditional specialty products, SWOT analisys

## 1. INTRODUCTION

In the late eighties in the developed Western European countries started the process during which the consumer demand increased for the country/region specific, multi-generation, high quality products produced in a traditional manner. Hungarian horticulture and food industry based on it are one of the most important fields of the national economy. The standard and the position of food industry define the market possibilities of a national agriculture, the competitiveness of agricultural/horticultural products (Berde, 2003). In the world of globalization more and more people all over the world realise the importance of preserving local traditions. This especially applies to the products with excellent quality which represent national worth (Juhász et al, 2006). Hungary, by its geographical location, is especially suitable for the production of special food products with high quality (Ferencz, 2005). The globalization has brought new challenges for our food economy, therefore the use of the trademarks and geographical indications guaranteeing special quality should have a priority increasingly in order to step up the market competitiveness.

## 2. MATERIALS

### 2.1. The definition of Hungaricums

According to the survey, the cluster of Hungaricums is preferred and well-known among the Hungarian consumers. Taste, quality, traditional features of the product and personal experience are the most important factors of being named as Hungaricum.
In the Hungarian agriculture the usage of Hungaricum as a word is wide spread for groups of products. Generally Hungarian "inventions" or traditional methods, techniques are associated with this attribute. A precise definition is needed in agriculture and food industry to determine the borders of Hungaricums to be able to use it as an affective marketing tool.

The following definition can be applied:
*"An animal species, a plant variety, a food industrial process, technique that is linked to the Hungarian people, the Hungarian characteristic, Hungarian result, the producing culture and a product that is derived from the above listed features which has been for long centuries, for long generations or in the past became proved that it belongs to Hungary, it is acknowledged ion foreign countries and can be associated with Hungary"*

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In case of Hungaricums the geographical indication also very important. The European Unions' system of geographical indications, such as PDO, PGI is close terms and some of these products are nominated for and under the process of gaining the protection.

### 2.2. METHODS

The questionnaire is the most important tool of the primary market research. During the qualitative research standardised survey was used, which suited to give numerical data. The standard characteristic of the questionnaire made possible the comparability of the answers of different consumers (Churcill, 2000).

The data collected during primary research were evaluated by a mathematical-statistical method. In the investigations SPSS 10.0 for Windows and LISLER 8.30 program package were applied. The gathered data were evaluated by the following procedures: multidimensional scaling, correspondence analysis and confidence interval.

Multidimensional scaling (MDS) is analysing quality variables. The substance of MDS is based on the distance matrix. There are two criteria for MDS grouping:

1. If the data concerns one thing (variable or object) than MDS is one kind.
2. If there are two aspects to consider: objects and variables, it is a two way MDS.

In this research the second type was used. (Füstös et al, 1986)

Perceptual maps were created by correspondence analysis using both nominal and ordinal variables. Correspondence analysis is a descriptive, explorative technique which analyses one or two variable cross tables and explores relationships between them (Jobson, 1992).

In surveys the expression of result in percentage is not always adequate and sometimes misleading because seemingly different observations are not always statistical different (Lévai et. al, 2000).The calculation of confidence intervals is especially useful when socio-demographic sub-samples are in different size. This kind of assessment is statistically more reliable than point assessment.

## 3. RESULTS

### 3.1. The SWOT analysis of Hungaricums

| STRENGTHS | WEAKNESSES |
|---|---|
| The products have good and excellent characteristics and are delicious. Their quality exceeds of the competing substitute products. | The integration is low in case of vegetable and fruit products. |
| The rural regions have traditional growing and production processes. | There is a lack of product brand development. |
| Experience and professional skills in production, processing and occasionally in research are typical. | The promotion activities are not enough. Liquidity problems exist, mainly for the small farmers. |
| Quality is determined by the features of the production sites, the soil and weather conditions. | The product revenues are not concentrated therefore there are no funds for marketing promotion. |
| A latent demand exists for special, country-style food products both on the local and on the international markets. | The processing level of some specialty products is low. |
| Several products have their own event, and certain products even have other marketing tools. | Deficiencies exist in packaging and brand development, primarily in the fields of vegetable and fruit production. |

| OPPORTUNITIES | THREATS |
|---|---|
| The changes in consumer trends aid the introduction of the products on the market. | The consumers do not get familiar with and do not accept the product. |
| The demand can be increased by the introduction of modern packaging with distinguishing features identifying the origin. | Counterfeiting may worsen the general view on certain products. |
| The market can be influenced by integration and concentrated supply. | The profitability of product preparation does not increase. |
| The demand for the products can be increased by a prepared media package. | The threat that consumption trends having an opposite effect may result in the influx of import products (the specialties of foreign countries). |

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### 3.2. The consumers' evaluation of Hungaricums in Hungary

According to the results of our Hungarian researches there is correlation between the age of the consumer and the buying frequency. Researches show that people aged 36-40 are the most frequent consumers of special, Hungarian products.

In the questionnaire it was also studied where the buyer prefers to purchase the Hungaricum products see on Figure 1. They give preference the specialist shop where the consumer faces the factors influencing the value judgement relating to the quality of the product. The communication of these explored values towards the consumer is a task of major importance in order to increase the consumer awareness and competitiveness of the product. It is apparent that the consumer found the assortment of the specialist shops satisfactory in all cases. They criticized that there are not enough of these specialist shops at national level.

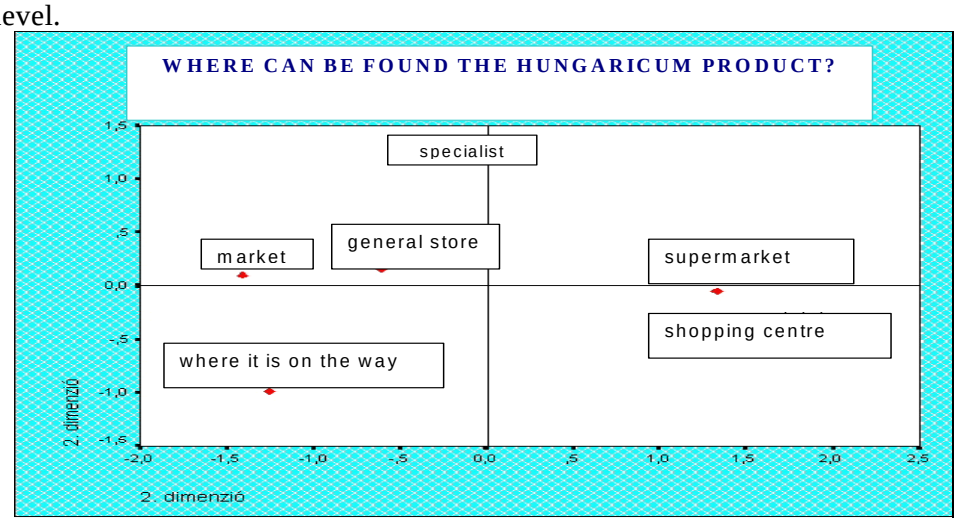



Figure 1. The place of purchase of the Hungaricum products

Specialized shops are mainly in bigger cities and only for processed food, such as Pick's salami shop, Palinka shop. There is a big gap between horticultural almost unprocessed products and processed, convenient food.

Fruits and vegetables are in worse position on the market about 50% of them sold on traditional markets without packaging and one can be never sure what buys. There is an initiative nowadays that the biggest Hungarian Producers' organization is standing up a shop chain for their famous fresh fruit and vegetables.

Figure 2. demonstrates the uniqueness and general quality of Hungaricum products. According to the data consumers like and appreciate these products. Uniqueness has also high value although there are dozen of fake or similar products on the market. The general quality judgement is quite good although the food scandals of the last few years made it worse than before. Consumers do not believe in food quality as easy they did a decade ago. The first few top features of Hungaricums are Hungarian, traditional, the part of our gastronomy and safe. These characteristics can only be used as marketing tools in the domestic market; on foreign markets they may be only useful as a piece of special gastronomy. Only a few percent of the questionnaires mentioned them as possible export products which are regrettable and hopefully is not true.

In Hungary the price of a product is still an important buying decision factor. It has smaller, but recognisable influence in case of special products, on niche markets like Hungaricums. Consumers agree on that Hungaricums have higher price offering a price premium for their producers, but feel that the current difference is too high, difference can be from 20-100% (Figure 3.).

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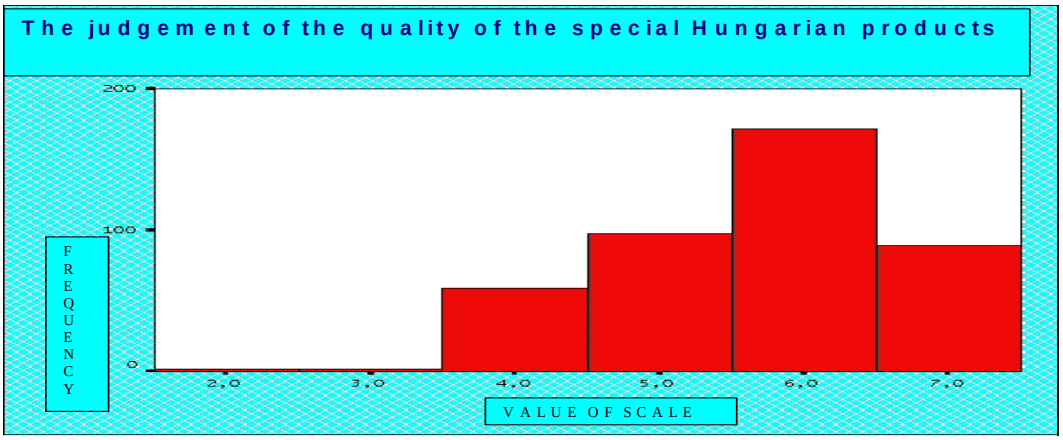



Figure 2. The judgement of the quality of the special Hungarian products

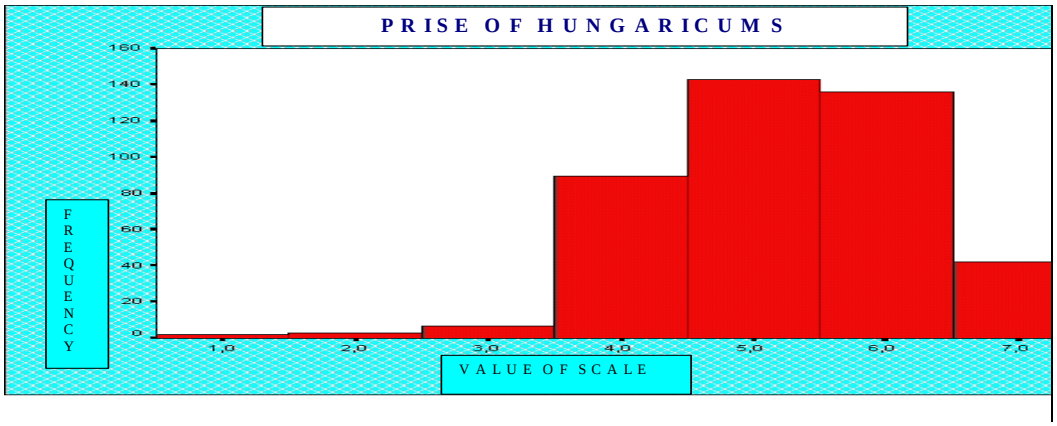



Figure 3. The price of the special Hungarian products

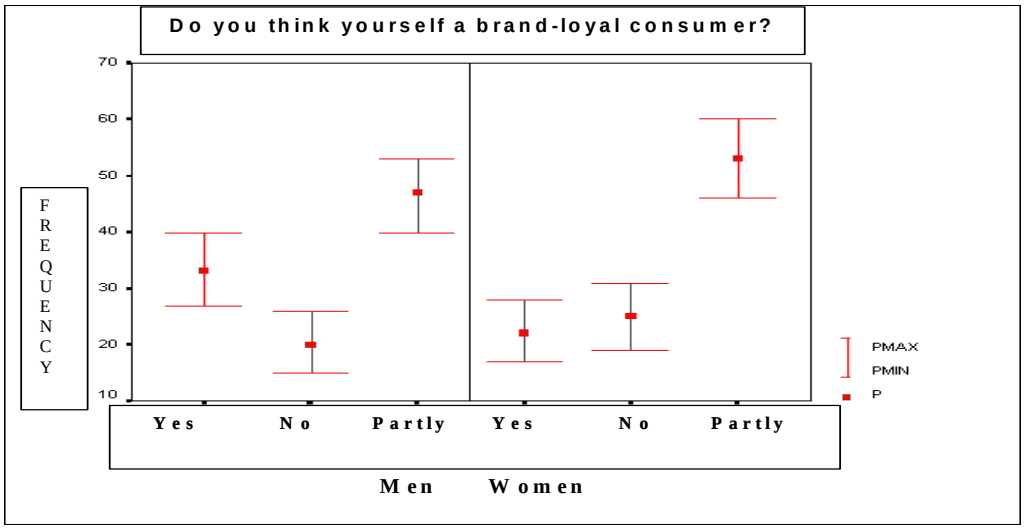



Figure 4. Brand loyalty broken down by sex

The most influential factors of their buying are packaging, price, knowledge and experience. They find very important the effect of advertisements. The consumers meet the advertisements of these products primarily on TV, in press, at exhibitions and fairs. In their opinion these advertisements influenced them in buying these special products, but they find the amount of these advertisements insufficient, require more, and would use more types of incentives. To sum up, it can be stated that market demands the rise of applied marketing means and give special importance to information and advertisement message. In the field of information there is so much to do in Hungary. The superficial knowledge of consumers can become the barrier of market improvement; therefore our results should be spread out

widely. The brand loyalty is the consumer's attachment to a given brand. It helps the consumers to process the information and to motivate their decisions (Olin, 200). The genders think themselves partly brand-loyal to the same proportion on the perceptual map in Figure 4. Significant difference cannot be identified between the sexes among the non-brand-loyal consumers. A bigger proportion of the males called themselves brand-loyal. According to a previous survey Hungary-loyal consumers were higher ratio than brand-loyalist, 62% of the answers said that a Hungarian brand (with controlled quality) has to be launched to the market, and in our opinion Hungaricums are able to serve this demand.

The traditional, unique property is the property originating from the traditional raw material, traditional technology and traditional composition used during the food production. It can be readable that the buyers of the unique, special products know the typical properties of these products because that is why they decide to buy them. In case of products of traditional, unique property the quality difference compared to the conventional products lies in the special production method most of the time (Neggi, 2007). There are several state-run programs in Hungary connected to food stuffs, but their marketing is not enough and the different but same purpose systems result misunderstanding among consumers in Hungary.

Quite important that the unique products of the country should remain real "Hungaricums" and behind Trademarks, constant guaranteed quality must appear. The national application of the European certification system of the protection of origin and special characteristic would ensure the legal protection of the Hungarian products in the single internal market of the EU against counterfeiting and use of other unfair marketing tools. The inclusion of our products with registered trademark in the list of the approved products by the European Commission would have a significant marketing value and it would help to increase the competitiveness of our products. It is therefore necessary to introduce this system in Hungary as soon as possible. The European Union provides assistance for the member states in the framework of its rural development policy to help the production and sales of the products with registered trademark. In order to help the evolution of these activities in the small settlements of rural areas where the only way of living is provided by the agriculture one mode of employment and so the permanent provision of the population's income can be the labour intensive production of the products with registered trademark. The 40-45% of the answerers deliberately looks for Hungaricum products. As for men the percentage is higher than in case of women. This difference however is not significant. Therefore we can not say that men search there special domestic products more. n open question looked for the answer to know which Hungaricums are known the best. Tokaji Aszu proved to be the number one (like abroad). It is significantly different from any other mentioned Hungaricums. Pálinka won the second position, but it is not significantly better-known as onion (of Makó). Then the animal species and the products processed from them continue the list.

## 4. CONCLUSIONS, PROPOSALS

The identification of the resources available to us, the search for newer resources, the elimination of threats and the expansion of relationships are among the basic tasks. It is very important to evaluate the external environmental effects. The opportunities we will actually realise and the threats we will be able to prevent are to be seen after our internal resources are revealed. Generally it is practical to repeat the SWOT analysis every 2-3 years, or more frequently as needed, and to compare it to the previous examination results. Why is it important to deal with the production of the unique products with registered trademark and of special quality?

- Having observed the trends of the European Union and other developed regions of the world since the middle of the nineties, it can be experienced that the food quality has an emotional approach as well.
- The consumers evaluate not only the mg/kg but they demand that the product should be exactly the same as it has been produced for many lifetimes.

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- The products representing characteristic regions, uniqueness, specialties differing from the others, high quality standard with registered trademark should be offered in the overstocked solvent market with the use of the appropriate marketing tools.

Specific tasks:

- To increase the popularity and the market revenues of the Hungaricums noted, and to simultaneously enhance the situation of the producers and the processors associated with the products.
- The processing of the products by preserving the Hungaricum nature to increase the added value that is recognised on the market.
- The application of well-selected marketing tools helps in the development of the regional and the national „image". The Hungaricum products are not well marketable on their own, but together with the appropriate „historical and cultural background".
- These are the tasks of major importance to make the consumers aware of the unique quality of the traditional products with registered trademarks and to develop a marketing strategy to increase the consumer awareness and the competitiveness of the products. In my opinion, the community marketing tools can be used to the efficient realisation of this aim.
- The consumer in this case does not purchase merely a product – products are available anywhere – but also flavours, aromas and traditions.

Tasks to meliorate the market situation of Hungaricums:

- Instead of mass production the assortment of traditional, special products should be broadened given the fact that experiences of the centuries-long production already brought up those „Hungaricums" which represent the outstanding qualities and national values of the countries;
- High-level professional skills, training and flexible marketing activities are needed;
- Origin, trade-mark and adept information must be indicated on the packaging of the products;
- Forming of support systems must be conducted in such a way that it could facilitate establishment of special production structures and concentrate on resurrection of the values of the country.

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# MANAGING PRODUCTION ACTIVITIES USING THE BALANCED SCORECARD STRATEGIC MANAGEMENT SYSTEM

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**Abstract**:
The work deals with the way in which organizations should choose the BSC solution which meets the company's requirements best so as to fulfill its individual needs.

**Keywords**:
Management, organization, balanced scorecard, strategy

## 1. THEORETICAL CONSIDERATIONS

The leaders of modern organizations are confronting with a series of challenges, generated in the first place by the extremely dynamic character of the world in which we live. In order to keep up with the people around, it is necessary to create a permanent alignment to the novelties appeared on the economic market, but also in the IT field. We are living in the century of speed, everything we do needs speed and precision, that is why all the activities undertaken tend to be automated.

The use of an adequate management method can ensure organizational success. If until now the focus was on the financial success of organizations, now more and more important are the customers, employees, collaborators. Within the management instrument, the Balanced Scorecard analyses the four perspectives: the customers, learning-development, internal processes and the financial field.

*The Balanced Scorecard (BSC) is a strategic management system that manages the company's activities depending on its vision and strategies.* This concept was presented for the first time in the 1992February issue of Harvard Business Review by professors Robert Kaplan and David Norton.

At the highest conceptual level, the BSC is defined as "*a frame that helps organizations to transpose the strategy on operational objectives so as to control both the organizational behavior and performance*" [1].

The system consists in 4 processes:

- The transposition of the vision on operational objectives;
- The communication of the vision and its connection to individual performances;
- Business planning;
- Feedback, learning and strategy adjustment depending on the course.

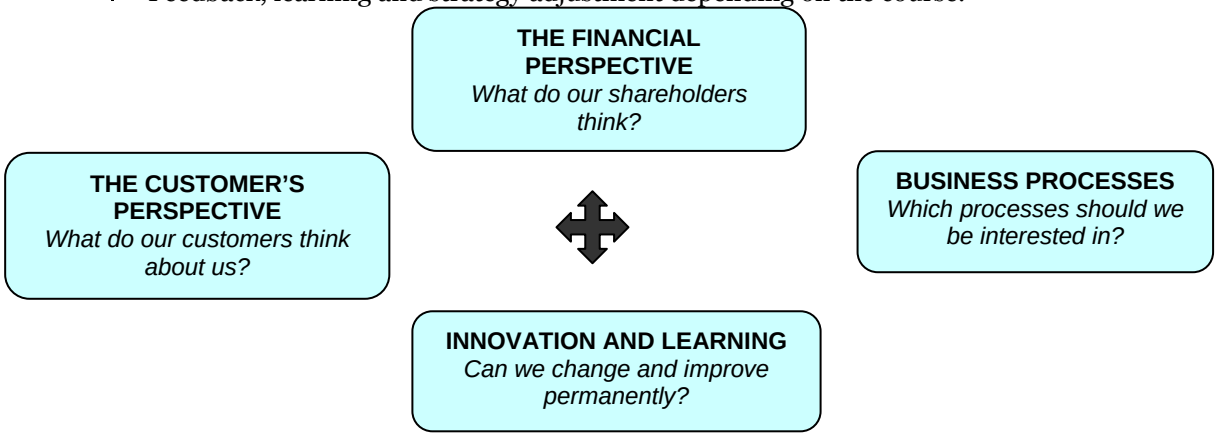



Fig. 1. The BSC principle from the 4 perspectives [1]

The Balanced Scorecard looks at a business strategy from all perspectives and allows the division of the strategic objectives in individual objectives and actions down to the last operational level. The BSC can contain both *quantitative* and *qualitative objectives*.

The strongest point of this instrument is the fact that it binds long-term strategic objectives with short-term actions. Most control and management systems of companies are built around financial indicatives and targets which place little emphasis on the long-term strategic objectives, thus a discrepancy being created between strategy elaboration and its implementation.

*The managers who use the BSC do no longer count only on the short-term financial indicatives to evaluate company performances. The BSC allows them to use the 4 processes which, used separately or together, contribute to the correlation of long-term objectives with the short-term actions [2].*

The first process, "*Vision translation*" is the process which helps managers reach consensus in the organization regarding organization vision and strategy. Most times, despite the good intentions of top-management, assertions of the following type: the best in the x category, number 1 supplier, cannot be easily translated in operational terms which deliver action directions at the local level. So as people to act according to the statements from the vision and strategy, they must be expressed in an integrated set of objectives and measures, agreed upon by all the executive directors, which should describe the success factors on the long-term.

The second process, "*Communication and relating*", allows managers to communicate their strategy upward and downward the organization steps and to tie it to individual objectives and the department objectives. Traditionally, the departments are evaluated according to the financial performances and the financial motivations are tied to the short-term financial objectives. The BSC gives managers the certainty that all the organization levels understand the long-term strategy and that both the individual objectives and the departmental ones are in line with it.

The third process, "*Business Planning*", makes it possible for companies to integrate their financial and business plans. Almost all companies implement changing plans, each with their managers and project counselors, competing for the executive seniors' time, energy and resources, frequently leading to disappointments regarding the program result. But when the managers use ambitious objectives for the BSC, as a means for resource allotment and priority settlement, they can understand and coordinate those initiatives which lead to the long-term strategies previously set.

"*Development and learning*", the fourth BSC process offers the company the possibility of strategic learning. The existence of feedback and the process evaluation focused on the company, its departments or the individual employees, ensures meeting the financial objectives previously set.

## 2. THE BSC WITHIN THE ORGANIZATION

The BSC offers a valuable instrument to the employees for a better perception of the organizational environment. It also supplies information to the management when the organization starts to document itself and develop the control measurement indicatives, which will shortly lead to reaching the desired goals and fulfilling the organizational visions.

The result is that the day-to-day operations are created starting from a common point of view about where the organization is heading to on the long-term. If the scorecard is segmented on activity areas, the operation control will be perceived as being a lot more relevant than in the previous models. The employees will become more cooperative and motivated and thus more open to change and decided to implement the new decisions of the organization.

Thus, the organization becomes more open to the learning process, more receptive and it is developing its competences permanently.

All this make it necessary for the scorecard to be introduced and used continuously in best conditions. Taking into consideration the fact that the use of the scorecard is simple, the resource involvement and top management contribution are often underestimated. The scorecard project is easily perceived as a more elaborated project on the measurement of organization performances. It can also meet with opposition from the employees, who could see in this project only a method of work inspection.

So, how can then this process be conceived so as to avoid these impediments? The following structure can be used [3]:

- *For what type of activities must the scorecards be created?* The first decisions which must be reached are connected to the starting point. The scorecard usefulness for nonprofit organizations is also taken into consideration: personnel units, governmental agencies, etc.
- *Initial scorecard development.* Launching the project in the adequate direction is of vital importance.

- *Scorecard introduction and use – process visualization*. Continuing the previous item, the wished connection between strategy through control and learning and back to strategy is shown.

Only by continuous use of the scorecards can real wins be obtained for the organization. In this stage, the support for the project can decrease, because the managers believe that the scorecards have been introduced successfully**.**

## 3. THE ADVANTAGES AND DISADVANTAGES OF THE BSC

The Balanced Scorecard has proven to be an efficient management work frame. It has the following functions [1]:

- *Transforming strategy into action;*
- *Aligning the organization to the strategy;*
- *Strategy performance as everybody's task;*
- *Continuity of strategy performance;*

The system is the basis of the organization's strategic success, but the strategy is implemented through initiative, innovation processes, by heading the activities in the direction of organization development.

The following ten assertions come to support the argumentation of using the Balanced Scorecard method:

1. Cost reduction, productivity increase;
2. Such a valuable measurement system enables an organization to align its activity to the suggested strategy. With this system, the organization can receive the desired answer so as to guide its future actions.
3. The measurement of process efficiency enables a rational settlement of the process fulfillment order.
4. Enables managers to identify the best practices for activity performance.
5. The information obtained based on the system allow quicker and better budget decisions, and also offer control on the processes made in the organization. It can also reduce the risk.
6. The accountancy and the financial department are working with concrete data.
7. Performance indicatives are obtained, which can be compared with the financial results of the competition, thus setting the organization situation and position.
8. The estimation of future costs can be done with great accuracy, all this due to the experience gained in previous projects.
9. The method allows the measurement of performances and initiatives following the strategy.
10. The system makes it possible to measure the indicatives and to determine the likelihood of their increase in value.

Since its first appearance in 1992, the Balanced Scorecard concept has been adopted as a new approach of the control management both in business and by governments.

It is used to describe the ambitions and achievements of the organization. It has proven useful for [2]:

- *Communicating the strategy of both the employees and managers;*
- *Fulfilling the activities that follow the strategy before the fulfillment of the activities whose end is to meet current needs;*
- *Monitoring and awarding these activities;*

The Balanced Scorecard is based on the following principle: "*doing the things that are necessary, doing them properly, rewards will be obtained in the future*".

The benefits of using this method can be synthesized as follows:

- *The Balanced Scorecard contributes to aligning the performance indicatives with the strategy at all organization levels;*
- *Offers management a full business image;*
- *The method facilitates communication and understanding the business goals as well as the strategy at all organization levels;*

Some authors state that the system is not a new method of measuring and interpreting a firm's situation, but rather a logical presentation of what has to be done so as to follow the chosen strategy. The Balanced Scorecard is an organized split work frame which enables the strategy implementation and fulfillment at all the levels of an enterprise by binding the initiative with the objectives and actions. The system offers a full image of the enterprise performance, combining the financial indicatives with other important performance indicatives within the relationships with customers, internal processes, research and development.

As any other method, the Balanced Scorecard has certain disadvantages:

- *This approach is not fix, it takes a lot of time to define a set of scorecards;*

- *The implementation of a Balanced Scorecard system in an organization implies the detailed study of all the existing problems, then defining an action plan, all these involving a long period of time.*

For example, Kalpan and Norton divide the life cycle of a business in three stages: *growth, maturity and decline*. Three financial themes are also usually set: *income growth, cost reduction / productivity increase, and resource user*. In fact, instead of wishing to increase the level of the performance indicatives, a lot of companies concentrate on the risk of not fulfilling these indicatives. Then, when it is strategically important, these organizations will want to incorporate the management risks within the financial perspective. In conclusion, it is important for all objectives and indicatives set in the other perspectives to be tied to one or more objectives of the financial perspective.

The creation of a Balanced Scorecard involves a considerable period of time for everybody whose performances are being measured.

Setting the strategy is time-consuming, but it does not use so much time as finding and defining the performance measurement indicatives for each perspective does. Usually, people hardly agree on what and how is being measured.

Moreover, a large number of people are involved in building a BSC, and these people's approval is very important both for building and implementing the instrument. It can happen that a Balanced Scorecard is well-built, but its disapproval by the employees, as well as their lack of involvement will make the model useless. There is also the risk of too many indicatives being selected. This is a problem because it is very difficult to use and interpret too many results.

Certain indicatives can by objective, others subjective. The subjective indicatives, by definition, involve the judgment of a person, so there are chances for them to be wrong. There is always a question, namely "must the indicatives set subjectively be used"?

The Balanced Scorecard is a management system, not only a measurement one which allows the organization to set its strategy and vision and to put them into practice. The instrument offers the feedback of the business internal process and external indicatives, instead of wishing to continuously increase the strategic performances and results. After being fully developed, the Balanced Scorecard instrument transforms the strategic planning from an academic exercise into a nervous center of the organization.

## 4. CONCLUSIONS

For the present-day organizations information is no longer the basic component. Because the organizations administer a too big volume of data and information, the manner in which the relevant information is selected and used within the organizational actions and in decision-taking is of extreme importance. The ecosystem that underlies a Balanced Scorecard is made up of visions, missions, organizational values and competences, strategies.

It is important for certain fundamental observations which express the BSC's importance and value to be reiterated:

- Only 10% of the organizations that define a strategy are capable of successfully fulfilling it;
- The strategy of an organization must be clear and synthetic;
- The BSC is a strategic management and performance system;
- The BSC translates the organization's strategy into concrete actions;
- The BSC explains and clarifies an organization's strategy from both the management's and employees' point of view;
- The BSC is a communication instrument, not one of control/constraint;
- The BSC allows the alignment of the component structures and organization members to the strategy set by the management team.

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# ECONOMIC THEORIES, INSTITUTIONS, REGIONAL COMPETITIVENESS

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**Abstract**

Spatial competition and competitiveness stands high on the agenda of regional research. These concepts are open to discussion even today, and scholars of different economic schools starting from different premises treat them differently. The aim of this study is to review what the major economic schools of thought have to say about leveling regional differences, about spatial competition and regional competitiveness. Based on different theoretical foundations even within regional sciences different hypotheses are articulated and accordingly different conclusions are drawn about for example the possibility of convergence between regions with various endowments at diverse state of development. As we see it, this is another example of the interdisciplinary character of regional science at work, as getting from different assumptions to different conclusions do not so much question the credibility of our science but calls attention to its versatility and problem-sensitivity.

**Keywords**

Regional competitiveness, schools of economic thought

## 1. INTRODUCTION

Different schools of economic thought start out from different premises, and view certain problems from different angles. The aim of the article is to show after a short review of a few selected schools, how many different relevant answer can be given to the question important to researchers of the field: how to handle spatial differences, spatial competition and regional competitiveness and their mechanisms. Based on different theoretical foundations even within regional schiences different hypotheses can be articulated, and accordingly different conclusions can be drawn about the possibility of convergence between regions at diverse state of development with various endowments. These apparent contradictions should not question the credibility of our science, but rather call attention to its versatility and problem-sensibility.

In the arguments about spatial differences and regional competitiveness in connection with it we can witness remarkable diversity of different schools of thought. A fundamental question is, wether market automatism in itself is sufficient to moderate spatial differences in a given economy, wether spatial convergence emerges in every market economy? Otherwise it is possible, that the invisible hand of the market cannot guarantee this, and outside intervention is necessary.

## 2. THE CONCEPT OF REGIONAL COMPETITIVENESS

We are going to use the standard definition of competitiveness ([5] [7], p278.) of all the recognised competitiveness-definitions, according to which it is „the ability of companies, industries, regions, nations and supra-national regions to permanently attain relatively high income and level of employment, while open to international (global) competition”. Here we will call competitiveness the permanent success in spatial competition, the ability of continuous economic development, which in turn manifests itself in the growth of GDP and thereby also welfare.

## 3. SCHOOLS OF ECONOMIC THOUGHT

We selected seven schools of economic thought out of the diverse macroeconomic and alternative schools which we consider relevant. Next, let us review the main concepts and theories of these. The seven schools are:

1. classical economics,
2. neo-classical economics,
3. keynesian economics,
4. theory of endogenous growth,
5. New Trade Theory,
6. Institutional economics,
7. Evolutionary economics

Reviewing these seven selected schools we will concentrate on whether and how spatial competition can at all be interpreted in terms of the school, and whether levelling off of spatial differences can happen as a result of market mechanisms.

**Classical economics** considers division of labour and its necessary consequence, trade and accumulation of capital to be the key to economic growth [12]. Investing in capital and trade will facilitate specialisation, enhance productivity and the output growthrate. Trade between countries happens according to the absolute differences in productivity, according to absolute advantages [9].

Ricardo prooved, that division of labour and trade between countries can be profitable even in the presence of relative (comparative) cost-advantages [18]. The market prices of goods will necessarily reflect the relative magnitudes of labour and capital needed to their production. This happens through the market, through competition. The ordinary profit (normal profit in today's jargon) thus attained by producers will guarantee maximal welfare. „...that [is what] prevents the market price of commodities from continuing for any length of time either much above, or much below their natural price. It is this competition which so adjusts the exchangeable value of commodities, that [...] the remaining value or overplus will in each trade be in proportion to the value of the capital employed." ([16], p60.). Competition is thus a central concept in classical economics, but is something which governs only the acts of individual economic actors. The problem of spatial competition can not be interpreted as a relevant question in the age of the industrial revolution.

The **Neo-classical school** is undoubtedly competition-centric [10]. It further develops the classical thoughts mainly building on microeconomic grounds. Two things seem important in connection with our topic: the marginalist methodology and the hegemony of self-regulating market mechanisms. Both of theese point in the same direction: there is no alternative to free competition. Reaching Pareto-efficient resource allocation through competitive mechanisms there are generally no welfare losses. The comparative advantages and disadvantages also advocated by the neo-classical school will necessarily fade away in the long run [6]. However, the dominance of market clearing prices on the micro and macro level leads one to the conclusion, that any non market-conform phenomenon (government intervention or any other market restrictions) will result in welfare loss.

Despite all these the underlying assumptions of the neo-classical model – perfect information, constant return to scale, long run equilibrium, perfect mobility of factors and perfect competition – and the tools adopted by it make the interpretation of regional competitiveness impossible. A strength of the neo-classical growth model of Solow is to identify technology as the main factor of growth, which is in accord with the generally known understanding of competitiveness. Technology is, however, an exogenous variable in this growth-model, which means, that development will affect every regions alike. Due to the absolute mobility of factors – inclucing technology – any kind of potential difference initially present between regions is bound to disappear over time. If the model does not allow for regional differences, it will also not allow for levelling regional differences.

The **keynesian school** by acknowledging that markets may not necessarily clear, tacitly acknowledges regional differences as well [10]. The keynesian theory agrees, that market is a fundamental institution of the modern economies, but it is unable to guarantee

on its own the maximum of social welfare, and has to be supplemented with active government interventions. Less than full utilisation of resources (most notably low rate of employment) causes welfare losses, thus active regional governmental action is indispensable. The same is true at the regional level: on the longer run more can be gained by the intervention of a higher level of government than could be lost by the lack of it.

The model posits a level of national income that can deliberately influenced, and one possible interpretation of this is, that the crowding out effect – much advocated by the neo-classicals – do not prevail at all, or only to a smaller degree. Because of this, the Pareto-efficiency criterion is not affected, while through the well-managed governmental interventions and their multiplicated effects the undesirable regional productivity (competitiveness) differences are moderated or the desirable competitive advantages can be strengthened. The accompaniment of this process is the growing demand along with higher level of employment, which is the motor of the keynesian economics.

An important characteristic of the keynesian school is the recognition of spatial differences, of the effects of government interventions on conjuncture cycles and of underlineing the importance of capital-intensity on economic growth [9]. This is the first school which recognises the roles institutions and central and local governments play in determining economic growth and development, which is one of the most important factors influencing regional competitiveness according to empirical studies. The tools and concepts of this school of thought are thus capable of serving as a foundation for regional economic development and deliberate moderating of spatial differences. Put another way: the spontaneous functioning of the markets can hardly lead to regional convergence, this can much more likely to be reached by a deliberate institutional intervention.

The **endogenous growth theory** studies economic growth through explicitly modeling technological advancements and accumulation of human capital [8][17]. In contrast to the neo-classical assumption of exogenous technical development, this is no more coming from outside the model in the endogenous growth theory, but is itself a result of decisions made by rational economic agents. Accumulating human capital necessitates communication between people and the transfer of allready acquired knowledge, the accumulation of new human capital is therefore a function of human capital allready owned. Also, a critical level of human capital have to be reached, below this level it is unable to generate any substantial growth. Spatial differences in productivity due to regionally different endogenous growth in technology and human capital can permanently prevail.

Another basic type of endogenous growth models puts innovation as the center of its enquiry [20]. The manyfold application of an invention results in constant horizontal product differentiation, and ultimately the efficiency of the economy grows. Monopolistic competition emerges as dominant market structure and occasional differences in application of inventions will lead to the development of competitive advantages and disadvantages.

Endogenous growth theory is able to study spatial competition, but this will happen on inperfect markets, where permanent competitive advantages develop.

The most important novelties of the endogenous growth theory are the recognition of technology, knowledge and the regions' own endowments as endogenous variables of the model, which are fundamental in determining competitiveness. According to the model, accumulation of knowledge calls forth increasing return to scale, and thus rising productivity is the result of spatial diffusion of knowledge and technology, wich do not imply any kind of automatism decreasing regional differences. It is noteworthy, however, that deliberate regional (economic) policy aiming at encouraging the growth of these endogenous factors can be an effective tool to moderate regional differences.

The **new theory of trade** has as its starting point the monopolistic competition model of Dixit and Stiglitz, the spatial reformulation of which was an acchievement of the new economic geography [6][21]. Economic schools of thougth from the 1990s on began to stress, that due to the globalisation the conventional concepts and tools of earlier economic schools are less aplicable to the functioning of modern economies, like the new kind of competition. Spatial economics or the new economic geography started to develop at the beginning of the 1990s, as the most influential stream of „re-discovering geography" [7]. Krugman set the focus of his research on the location of production, within which he modeled the changing of

the spatial structure of economic activity, emphasising spatial concentration. His main assumptions are increasing return to scale, inperfect competition, decreasing transportation costs and local externalities [1].

According to Krugman, each country or region specialising along comparative advantages can win. As a Pareto-efficient spatial equilibrium emerges from the centripetal and centrifugal forces, it is pointless to talk about spatial competition or competitiveness. A logical corollary from the above is, that regional differences in productivity are the result of different levels of spatial specialisation, agglomeration and clustering. Although many of the concepts of this school rhymes with the logic of regional competitiveness, the whole structure of spatial economics is not suitable to study competitiveness, as it concludes that spontaneous market processes formulate iter-regional differences [7]. Spatial differences, however, can satisfactorily be explained by its help.

**Institutional economics** has at the focus of its enquiries the explanation of economic, social and political institutions [4][11]. They study why and how different institutions emerge that govern human behaviour and organise different interactions. It is noteworthy, that by institution we do not mean organisations, but fundamental characteristics of the functioning of an economy, like private property, market, intra-firm coordination. This school emphasises the concept of institutions along with transactions and transaction costs associated with them. According to Douglas North, the share of transaction costs (which are indispensable to the efficient functioning of an economy, but which are beyond the neo-classical cost concepts) within the total costs in the economy can reach 50%. They are thus absolutely significant.

This school considers competition as a fundamental institution. While the traditional marginalist methodology continues to hold, beside the usual cost functions of production, transaction functions [14] and transaction cost functions [22] are also used. Another cornerstone of the school is the empasising of property rights. An indispensable prerequisite of the Pareto-efficient allocation outcome of competitive markets is the clearness of property rights and their enforcability [15]. This increases the number of the model's explaining variables and regional differences in productivity have to be studied in a *reformulated competition model* using intitutional factors.

Regional competitiveness is determined by the region's broadly defined (macro-) instituional environment and transaction costs associated therewith: search-, information-, communication- and coordination-costs, bargaining and decision costs, monitoring and enforcement costs [9][19]. This extended condition-set reflect the complexity of the current economic processes. The concepts and tools of the institutional economic school are thus appropriate to trace spatial competition and regional processes. Likewise, increasing or decreasing spatial differences can well be handled in the model as the results of the interactions between the narrowly defined economic processes and the institutional factors.

The **evolutionary economic school** puts the emphasis contrary to the mainstream schools on innovation and learning, and stresses the ever-increasing diversity of the economic structure [2] [13]. Heterogenity, differentiation, complexity and uncertainty are focal concepts of this school [9]. Economic growth is determined substantially, but not deterministically by particular local conditions and historical background. These conditions – most notably prevailing institutional, social and technological conditions – are not exogenous, but part of the „economic evolution". Regional competitiveness is in turn based on the historical past of the region. New technologies, new institutions can, however, displace old ones, and growth can follow a new trajectory, which, due to the nature of an innovation, may only scantly connect to the past. The ability of regions to create novelty and innovation is the factor, which influences their regional competitiveness on the long run, and this ability is powerfully influenced by spatial concentration.

Competition is a central concept in the evolutionary thought, because new variations constantly emerge, which then compete with each other and this competition selects out certain options. This selection is not only possible through the market, but in the basic model it is generally done by the market. Basic assumptions and concepts of this school make it suitable to study regional processes, especially in the case of hubs of knowledge [3]. Changes in regional differences are influenced by changes in the prevalence and intensity of

innovative behaviour in the regions. These changes can be results of spontaneous market processes, so evolutionary economics can handle regional convergence resulting from both market automatisms and institutional (public) intervention. Regional differences are considered to be necessary, but they constantly transforming as a function of the region's succes in generating and absorbing innovations.

From the above rewiev of the different schools of economic thought it can be seen, that each of them emphasises a different aspect of regional competitiveness. Table 1 recapitulates the key concepts and basic thoughts of these schools in connection with regional competitiveness.

Table 1.: highlited points of the different schools of economic thought in connection with regional competition and competitiveness and spatial differences.
Source: Own compilation

| Name of the school | View on spatial competition | Can spatial differences be moderated by market forces? | Key concepts and basic insights in connection with regional competitiveness |
|---|---|---|---|
| Classical Economics | Not applicable in original model | Yes | Specialisation, trade based on division of labour, differences in productivity |
| Neo-Classical Economics | Discarded | No | Model's basic assumptions preclude studying regional competitiveness within the model. Main spatiality-related concept is the concept of externalities |
| Keynesian Economics | Acknowledged | No | Economic policy, government interventions, budgetary expenditures, institutions |
| Endogenous Growth Theory | Acknowledged | Yes | Knowledge and technology as endogenous regional resources |
| New Theoury of Trade | Discarded | No | The model's design is not suitable to study competitiveness. Inter-regional differences in productivity are results of market mechanisms. Concepts related to spatial processes: spatial specialisation, agglomeration, cluster formation |
| Institutional Economics | Acknowledged | Yes | Importance of institutions, spatiality of transactions and transaction costs, importance of property rights |
| Evolutionary Economics | Absolutised | Yes | Regional competitiveness rooted in the region's past, but new technologies, new institutions can start growth on a new path. |

## 4. CONCLUSION

From this review one can see, that the different schools of thought contradict each other in multiple important issues, and thus a consistent theory can not be built up synthetising them. Each of these schools emphasise one particular process, factor or a segment which constitutes an important ingredient of the concept of regional competitiveness. Consequently parts of these approaches can complement each other to contribute to our better understanding of the concept of regional competitiveness. Different economic schools thus do not have to be taken as isolated variants in trying to solve the problem of regional competitiveness, but they all study different aspects of the same object, and so it is worth reconsidering and matching most of their conclusions.

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# REAL-TIME MULTIPLEX PCR ASSAY FOR INVESTIGATION OF THE KINESIN LIGHT-CHAIN 1 GENE A185C AND C406T MUTATIONS

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**ABSTRACT**

The kinesin is the main motor protein in the trafficking system of the mitochondria and other organelles. Genetic variants affecting the function of kinesin were earlier found to be associated with cognitive disturbances and neurodegeneration. A multiplex polymerase chain reaction (mPCR) method, allowing the simultaneous detection of the KNS2 A185C (rs_1054080) and C406T (rs_3742465) mutations has been developed. The new assay was validated by PCR-RFLP experiments: the proposed method and the PCR-RFLP analysis yielded identical results. This suggests the applicability of the mPCR assay for the investigation of KNS2 mutations in population studies.

**KEYWORDS**

kinesin; light chain; KNS2 mutations; multiplex PCR

## 1. INTRODUCTION

The kinesins are main cytoskeleton motor proteins whose function is to transport organelles within cells [2]. These are tetrameric proteins comprising 2 heavy chains (alpha chains, KNS1) and 2 light chains (beta chains, KNS2) [6]. The KNS1 chains provide the tubulin binding site and the ATPase domains, whereas the KNS2 chains are responsible for the specific attachment of the organelle to be moved by the kinesin tetramer. One special transport mediated by direct binding to the kinesin is the axonal moving of amyloid precursor protein carrying vesicles [7]. This transport is inhibited by overexpression of the *tau* protein [4], and this mechanism is enhanced by oxidative stress [10]. Thus, the amyloid precursor protein can be retained in the cells, thereby promoting the accumulation of amyloid β-peptides in the cytoplasm. Both the aggregation of the *tau* protein into abnormal filaments and the accumulated amyloid β plaques are specific for Alzheimer's disease (AD) [5].

Dhaenens et al. hypothesized that a KNS2 dysfunction plays a role in the pathogenesis of AD [3] and investigated the occurrence of three KNS2 polymorphisms in AD. Two of them, in the 5'UTR region (A185C and C406T), displayed no association, while the KNS2 G56836C mutation, located in intron 13 (mistyped by Dhaenens et al., and known as KNS2 G58836), exhibited an association with AD [3, 1]. This association for the KNS2 G56836C variant may result from an altered splicing effect [8].

Kinesins have been presumed to play a role in the pathomechanism of leukoaraiosis, which brings about a cognitive decline in a considerable proportion of the middle-aged and elderly [11]. In large population studies, the investigation of these polymorphisms via the recommended PCR-RFLP method [3] is laborious, expensive and time-consuming.

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## 2. THE STUDY

A real-time PCR (LightCycler 1.5, Roche) assay with melting point analysis has been developed: KNS2 A185C (rs_1054080) and C406T (rs_3742465) mutations were investigated in multiplex PCR reaction. Primers described earlier [3], was modified for equal annealing temperatures which is necessary for the simultaneous amplification. Optimised primer and probe sequences and their concentrations are listed in Table 1.

Table 1. The sequences of the primers and probes

| Primers/probes | Sequences | Cc (μM) |
|---|---|---|
| **KNS2 A185C** | | |
| KNS185 for | AgCgggACTggCTggg | 0.4 |
| KNS185 rev | TCggCTgTgTgAggCACg | 0.4 |
| KNS185 probe | Flu-CCCCTCgCTggTgACTgCT-Ph | 0.3 |
| KNS185 anch | TgCggggCggTAgCTCCg-LCRed640 | 0.3 |
| **KNS2 C406T** | | |
| KNS406 for | TCCCTgTCCCgCTCCTCTTC | 0.4 |
| KNS406 rev | gACAAgAACCCgACCTgAACCTAgAAg | 0.4 |
| KNS406 probe | CCgCAACTCTgTCCCCATCCA-LCRed705 | 0.2 |
| KNS406 anch | Flu-gCCTCCTTCCCggTTTggTCCCg-Ph | 0.2 |

The experimental protocol was the following: Genomic DNA was extracted from 200 μL of peripheral blood anticoagulated with EDTA [9]. All blood samples were kept at –20°C until DNA isolation. PCR was performed in disposable capillaries (Roche Diagnostics). The reaction (10 μL) contained 1 μL of DNA (40-80 ng), 0.4 μM of each of the primers, 1 μL of buffer (LightCycler DNA master hybridization probes 10X buffer, Roche), 0.4 μL of 25 mM $MgCl_2$ stock solution, 0.6 μL of DMSO and the probes (concentrations listed in Table 1). The PCR conditions were: initial denaturation at 95°C for 60 s, followed by 40 cycles of denaturation (95°C for 0 s, 20°C/s), annealing (60°C for 10 s, 20°C/s), and extension (72°C for 12 s, 20 °C/s).

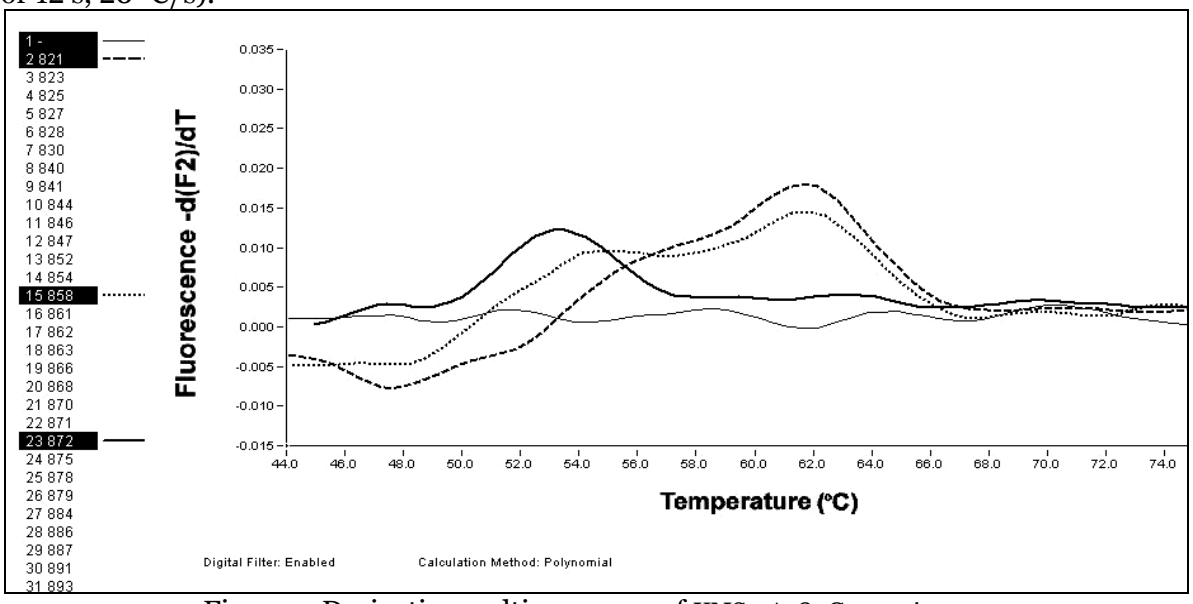



Figure 1. Derivative melting curves of KNS2 A185C genotypes.
**(---- C/C, —— A/A, ····· C/A)**

The melting curve analysis consisted of 1 cycle at 95 °C for 10 s, 40 °C for 10 s, and then increase of the temperature to 75 °C at 0.2 °C/s. The fluorescence signal (F) was monitored continuously during the temperature ramp and then plotted against temperature (T). These curves were transformed to derivative melting curves [(-dF/dT) vs. T]. The KNS2 A185C mutation analysis was happened in the F2 channel (640 nm, Fig. 1.) and the C406T mutation analysis in the F3 channel (705 nm, Fig. 2.)

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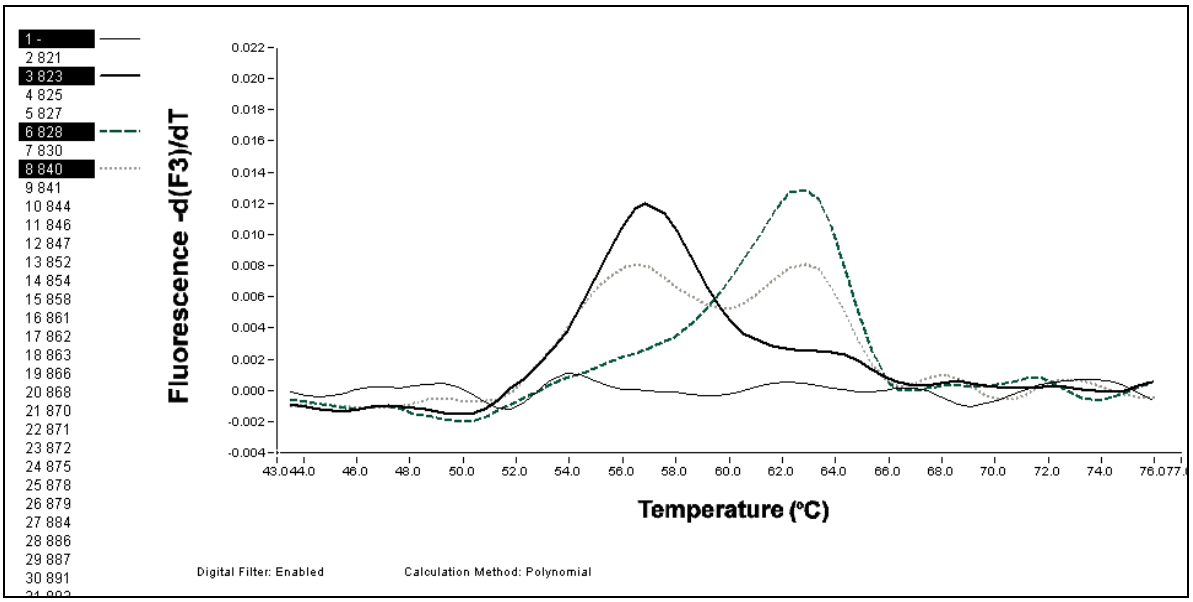



Figure 1. Derivative melting curves of KNS2 C406T genotypes.
**(---- C/C, —— T/T, ····· C/T)**

## 3. ANALYSIS AND DISCUSSION

The new mPCR assay and PCR-RFLP method yielded identical results (tested in 25 cases each): the melting temperatures and restriction fragment lengths are listed in Table 2. Among 251 control patient samples, the genotypes were KNS2 AA185: 16 (6.4%); KNS2 A185C: 104 (41.4%); KNS2 185CC: 131 (52.2%); KNS2 CC406: 143 (56.9%); KNS2 C406T: 94 (37.5%) and KNS2 406TT: 16 (5.6%). The allele frequencies are listed in Table 2. These data are comparable to those previously documented in Caucasian controls [3].

Table 2. Melting temperatures, RFLP lengths and allele frequencies of different genotypes.
*In the original article [7], the isoschizomer *Bfa*I (New England Biolabs) was used. The restriction enzymes originated from Roche Diagnostics (Mannheim, Germany).

| Alleles | Tm (°C) | RFLP (bp) | Allele frequency (%) |
|---|---|---|---|
| KNS A185C | | *Mae*I* | |
| A | 50.6 | 120+37 | 27.1 |
| C | 56.5 | 157 | 72.9 |
| KNS C406T | | *Mae*III | |
| C | 63.0 | 167 | 75.7 |
| T | 57.0 | 132+35 | 24.3 |

## 4. CONCLUSIONS

The results obtained suggest the applicability of the new multiplex PCR assay for the investigation of KNS2 mutations in population studies without the disadvantages of the RFLP-based approaches.

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# NEONATAL SURGERY IN SZEGED, HUNGARY

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**Abstract**

Our clinic is a tertiary level center. We provide surgical service of almost every kind for the four south-eastern counties of Hungary. Furthermore we have increasing numbers of patients from the neighboring regions of Romania and Serbia.

We perform general surgery (thoracic, abdominal surgery, including tumors), urology, traumatology and neonatal surgery. We also care for patients in limited fields of orthopedics, neurosurgery, bronchology and plastic surgery. Recently we have a trend toward performing minimally invasive surgery.

Within neonatal surgery we operate on babies having congenital malformations or acquired diseases for example of the digestive, inspiratory or genitourinary systems. Sometimes we treat exceptionally rare cases, like conjoined twins.

We would like to demonstrate our comprehensive activities. We also encourage all our colleagues in the region to feel free to ask our help, should they encounter a complicated case.

The Pediatric Clinic of the University of Szeged is a tertiary medical center. The Department of Pediatric Surgery provides surgical service for the four south-eastern counties in Hungary. We have patients of all ages from birth to adolescence. Occasionally children are referred to us from remote areas of the country, even from abroad, mostly from the neighboring regions of Romania and Serbia.

We perform general surgery (thoracic, abdominal surgery, including tumors), urology, traumatology and neonatal surgery. We also care for patients in limited fields of orthopedics, neurosurgery, bronchology and plastic surgery. Recently we have a trend toward performing minimally invasive surgery.

A child is a unique surgical patient who is physically and physiologically different from an adult. The differences between children and adults are most marked immediately after birth, when the infant is adapting to extrauterine life. Being one of the four medical universities in Hungary, we are capable of managing almost every possible surgical problem in the newborn. Modern diagnostic modalities are available, including measuring laboratory parameters of body fluids, various radiological techniques like ultrasound, X-ray, computer tomography (CT), magnetic resonance imaging (MR), prenatal ultrasound, prenatal MR.

We have around the clock neonatal transport service, an ambulance car with experienced staff and modern equipment is practically a moving intensive care unit. Yet, it is important to emphasize the importance of prenatal diagnosis of congenital anomalies and planned delivery in a tertiary center. As we use to say: the best possible transportation for a sick infant is in the mother's womb.

Surgical problems in the neonatal period can be congenital or acquired, and can require immediate medical attention or leave time to the medical team to plan the treatment. There are congenital diseases when surgery plays no role, like in anencephaly, which means the newborn has no brain at all, that is incompatible with life. In other cases, the infant suffers from complex anomalies, affecting multiple organ systems, and has poor chances in life expectancy or quality of life, despite multiple surgeries. Some diseases are diagnosed shortly after birth but operation is done later, like inguinal hernia, undescended testis, cleft lip and palate or hypospadias. In this lecture, we concentrate on classic neonatal surgical diseases, which are surgically correctable. Heart surgery and neurosurgery may also be necessary in the newborn period, although these complex procedures are available in our university, but not in our department, so they won't be discussed.

Intestinal obstruction is the most common surgical emergency of the newborn. The common sign is vomiting and feeding intolerance, but the onset and severity depends on the level of obstruction.

Newborns with oesophageal atresia usually have a blind ending upper pouch and the distal part of the oesophagus is connected with the trachea (Figure 1). The baby cannot swallow even his/her own saliva, feeding attempts lead to aspiration. During the operation we close the tracheal fistula and reconstruct the continuity of the oesophagus through a few centimeters long incision.

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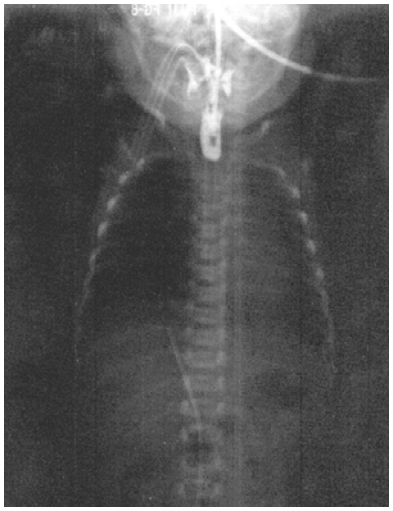


Figure 1: Oesophageal atresia. Note the blind-ending upper pouch



Figure 2: Diaphragmatic hernia. Gastric bubble is in the thoracic cavity



Figure 3:

Duodenal atresia is frequently associated with Down's syndrome. It has characteristic radiographic appearance and nowadays should be diagnosed before birth. There are many different types of the atresia of the small bowel, the operation is performed through laparotomy, and consists of reconstructing the continuity of the intestinal tract. Sometimes a considerably long part of the bowel must be excised.

Less frequently, newborns with malrotation, volvulus, intussusception, intestinal duplications or omphalomesenteric duct remnants need our help.

Many different other diseases, affecting the gastrointestinal system need surgical attention in the newborn, e.g. cystic fibrosis, colonic atresia, anorectal malformations, Hirschsprung-disease. Most of these patients need a palliative colostomy first, the definitive operation can be performed later in life.

Babies with diaphragmatic hernia are born with a hole in their diaphragm, therefore most of the abdominal organs are pushed up into the thoracic cavity, causing impaired development of the lungs (Figure 2). After birth severe pulmonary insufficiency develops and, without complex medical support, the babies die. The operation consists of placing the organs back to the abdomen and closing the diaphragmatic defect.

Discovering severe central nervous system malformations before birth, like meningomyelocele, termination of the pregnancy is offered to the parents, because babies with these anomalies are going to have short and miserable life. Depending on the level of the lesion various symptoms develop, including lower extremity palsy, loss of bladder and bowel control, severe skeletal deformities and hydrocephalus. Should a baby is born with meningomyelocele, the spinal cord must be covered urgently to prevent further injury.

Defects of the abdominal wall, like gastroschisis and omphalocele, not only are severe conditions by themselves, they often combine with other congenital anomalies. Putting back the organs into the abdomen and closing the defect can be extremely challenging (Figure 3).

Various urological anomalies might need surgery in the newborn period to save the affected kidneys from further impairment, e.g. pyeloureteral or ureterovesical stenoses, ureterocele, posterior urethral valve. Different surgical procedures might be needed, from ultrasound-guided percutaneous drainage through ureterostomy to pyelonplasty.

Sometimes, diseases of the gonads require surgical attention. Large ovarian cysts are predisposed to torsion, which stops the blood supply of the organ. Testicles can also undergo torsion. Without operation, the gonads can suffer irreversible necrosis within a few hours. Inguinal hernias can also become incarcerated in the neonate.

Birth injuries can occur at any delivery, but are more frequent during hard labor, breech delivery or in emergency situations, such as bleeding. The injured newborn has significant healing capacity; it is particularly true for the injuries of the musculoskeletal system, while other injuries affecting the nervous system, abdominal or thoracic organs can even be lethal.

We also encounter and operate rare congenital malformations, like biliary atresia, choledochal cysts, cystic adenomatoid malformation of the lungs, congenital lobar emphysema. Various tumors can occur in the newborn, giant sacrococcygeal teratomas for example can actually weigh more than the baby. Sometimes we treat exceptionally rare cases, like conjoined twins.

Hopefully this short lecture has given insight to our comprehensive activities. We would like to encourage all our colleagues in the region to feel free to ask our help, should they encounter a complicated case.

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# GENERAL AND NERVOUS SYSTEM EFFECTS OF LEAD APPLIED IN NANOPARTICULATE FORM INTO THE TRACHEA OF RATS

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**ABSTRACT**

Lead is a heavy metal notoriously harmful for human health and environment. In case of leaded petrol (still in use in certain regions involved in this symposium), and in lead processing and reprocessing industries, airborne particles are emitted, exposing people by inhalation. Nervous system is a primary target of lead, with known consequences like occupational neuropathy and delayed mental development of children. In inhalational exposure, the size of particles entering the airways is crucial. In this study, submicroscopic (mean diameter ca. 20 nm) PbO particles were suspended in distilled water and instilled into the trachea of male Wistar rats (2 and 4 mg/kg), 5 times a week for 3 and 6 weeks. The treated rats' body weight gain was significantly lower than in the controls from the 3rd week on, and the weight of their lungs was significantly increased. Spontaneous cortical activity, recorded in urethane anesthesia, was shifted to higher frequencies in the treated rats. The cortical sensory evoked potentials in the same rats had mostly increased latency, sometimes also increased duration, and decreased frequency following ability on rapid stimulation. Lead in nanosuspension form had access to the brain so the human effects of inhalation of lead nanoparticles can be modelled in rats this way.

## 1. INTRODUCTION

Exposure by lead-containing airborne particles is seen in occupational settings (smelting, processing and reprocessing of lead) and in the general environment in areas where leaded petrol is till in use. Lead is well absorbed from the alveoli [12] and from the intestines[5]. Airborne lead causes primarily exposure by the airways, where the size of the inhaled particles is a crucial factor. Grains of 10 µm or more are trapped in the upper airways while those of 1-10 µm are typically deposited in the alveoli. Even smaller particles – nanoparticles, ultrafine dust - have been newly recognized as having unique characteristics including pathogenicity. Such tiny particles, depositing either in the nasopharynx or in the alveoli [10] are highly mobile and can cross boundaries like the alveolar and capillary wall by mechanisms specific for this size range (transcytosis by caveola formation [20]). Axonal transport of such particles is also known.

Lead is a neurotoxic metal. In lead-exposed humans, various forms of central and peripheral evoked activity, namely sensory evoked potentials and nerve conduction velocity, were affected [1]. Impaired postural balance was seen in lead-exposed workers [28]. The deleterious effect of childhood lead exposure on IQ development and school performance has been amply documented [7,19]. In our previous studies lead, given orally in organic or inorganic form, altered the cortical electrical activity [17,18] and the memory performance [27] of rats.

In the present work - within the framework of the *Regional University Knowledge Centre for Environmental and Nanotechnology, Szeged, Hungary* - lead oxide (PbO) nanoparticles were produced, and their effects on general toxicological parameters and on the function of the central and peripheral nervous system were investigated in experimentally exposed rats.

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## 2. MATERIALS AND METHODS

The experiments were carried out on adult male Wistar rats (280±20 g body weight at start), obtained at the university's breeding centre. They were housed in an air-conditioned room maintained at 22 °C with a 12-h light/dark cycle (light on at 06:00), and free access to tap water and standard pellet. There were 4 groups of 10 animals each: an untreated control group (Con), a vehicle control group (W), and a low dose (LD) and a high dose (HD) group. The doses applied were equivalent to 2 and 4 mg Pb / kg body weight, and were determined on the basis of data about the ventilation volume of rats [25]; and on published inhalation toxicity effects of lead in rats [6,23].

The PbO nanoparticles were synthesized at the Department of Applied Chemistry, University of Szeged in a dry procedure. Pb-acetate was milled with NaOH and the resulting hydroxide was calcined. Particle size (20 - 30 nm) was determined by X-ray diffraction and transmission electron microscopy. For administration, the nanoparticles were suspended in distilled water, and were instilled into the trachea of the treated rats 5 days a week, for 6 weeks. Before and during administration, the suspension was sonicated to prevent aggregation. The instilled volume was 1.0 ml/kg b.w., the vehicle control (W) group received distilled water. For intratracheal instillation, the animals were quickly anesthetized with diethyl ether in a glass jar with air-tight lid, then were suspended on a tilted (60°) board by hanging the upper incisor teeth in a wire loop which held the animal in place and its mouth open [21]. Focussed light was aimed transdermally on the trachea, the tongue was pulled forward with a pair of non-traumatic forceps, and a custom-made laryngoscope was used to gain access to the glottis. Intratracheal instillation was done by means of a 1 ml syringe and 1.2 mm OD plastic tubing, inserted between the vocal chords.

The rats' body weight was recorded weekly. Symptoms of general toxicity were also observed and noted.

On the day following the last instillation, the animals were prepared for electrophysiological recording. In urethane anesthesia (1000 mg/kg b.w ip.), the animal's head was fixed in a stereotaxic frame, and the left hemisphere was exposed by opening the bony skull. Lidocaine (10%) was sprayed on the wounds, and the exposed dura was protected by a thin layer of petroleum jelly. After 30 minutes recovery, silver electrodes were placed on the primary somatosensory (SS), visual (VIS) and auditory (AUD) areas. Electrocorticogram (ECoG) was taken from these areas for 6 minutes and the relative spectral power of the frequency bands (delta, theta, alpha, beta1, beta2, gamma; standard human EEG bands as described in [11]) was determined. Then, sensory cortical evoked potentials (EPs) were recorded. Somatosensory stimulation was done with square electric pulses (3-4 V, 0.05 ms, 1, 2 and 10 Hz) delivered to the contralateral whisker pad of the rat. For visual stimulation, flashes of a high-luminance white LED (driven by 0.2 ms pulses at 1 Hz) were aimed directly at the rat's right eye. The acoustic stimuli were clicks (1 Hz, 40 dB) from a small earphone, guided into the animal's right ear via the hollow ear bar. Fifty stimuli of each modality per rat were applied, and the recorded EPs were averaged. After averaging, latency and duration of the evoked responses was measured manually (for details, see [22]). Finally, compound action potential was recorded form the rat's tail nerve. Two stimulating needles (delivering 4-5 V, 0.05 ms pulses at 1, 20 and 50 Hz) were inserted into the tail base; and another two, for recording, 50 mm distally. From the records, the conduction velocity of the nerve was calculated. The change of the latency of the somatosensory EP, and latency and amplitude of the nerve action potential, with increasing stimulation frequency was also investigated as an indicator of the action of the treatment on the state of the nervous system [22]. The complete electrophysiological recording and analysis was done by means of the Neurosys 1.11 software (Experimetria Ltd, Budapest, Hungary). Following electrophysiology, the rats were sacrificed by an overdose of urethane, dissected, and the relative organ weight of the lungs, liver, heart, kidneys, spleen, thymus and adrenals, related to the 1/100-th of body weight, was calculated. The results were tested for significance with one-way ANOVA and the post hoc analysis was done by Scheffe's test.

During the whole procedure, the principles of the Ethical Committee for the Protection of Animals in Research of the University were strictly followed.

## 3. RESULTS

Lead treatment caused significant retardation in the rats' body weight gain. The difference between group Con and W was moderate (Fig. 1).

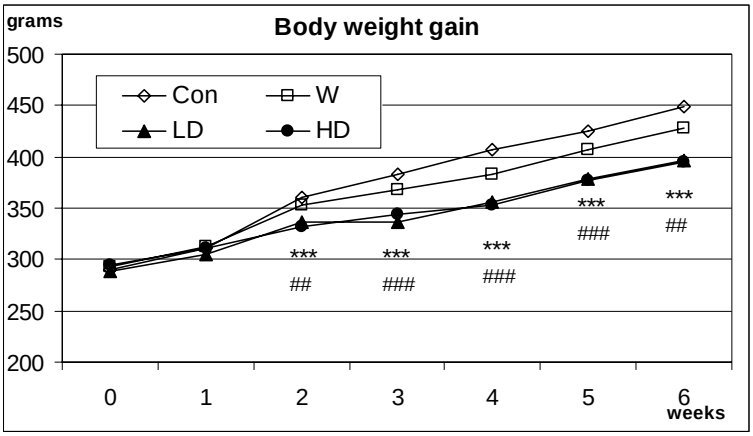



Figure 1. Body weight gain of the rat groups (see insert) during the 6 weeks of treatment. Group means, n=10.
*** : p<0.001 vs. Con; ##, ###: p<0.01, 0.001 vs. W.

The organ weights measured during final dissection indicted massive increase of the lungs and kidneys in both treated groups , and less severe effect on the brain and liver weight. In the HD groups, the lungs had a strongly emphysematous appearance.

Table 1. Relative organ weights after 6 weeks treatment.

| | Treatment groups | | | |
|---|---|---|---|---|
| **Organs** | **Con** | **W** | **LD** | **HD** |
| Heart | 0.255±0.018 | 0.264±0.020 | 0.282±0.032* | 0.267±0.016 |
| Spleen | 0.188±0.025 | 0.176±0.026 | 0.199±0.034 | 0.187±0.021 |
| Thymus | 0.090±0.011 | 0.095±0.026 | 0.103±0.021 | 0.104±0.023 |
| Adrenals | 0.010±0.003 | 0.012±0.004 | 0.013±0.005 | 0.013±0.004 |
| Liver | 3.111±0.208 | 3.201±0.333 | 3.342±0.367 | 3.324±0.164* |
| Kidney | 0.605±0.037 | 0.618±0.038 | 0.721±0.097**### | 0.686±0.038**### |
| Lung | 0.334±0.036 | 0.343±0.028 | 0.515±0.076**### | 0.583±0.059**### |
| Brain | 0.474±0.029 | 0.480±0.022 | 0.529±0.056*# | 0.520±0.048*# |

Mean±SD, n=10. Calculation: [organ weight]/[0.01 × body weight]
*,**,***: p<0.05, 0.01, 0.001 vs. Con; #, ##, ###: p<0.05, 0.01, 0.001 vs. W.

The general trend of the ECoG was activity decrease in the low and increase in the high frequency bands. As seen in Fig. 2, this trend was present in all three cortical areas but the change was significant only in the SS and VIS area and only in the HD group.

The latency of the SS EP was nearly identical in the Con and W groups, and noteworthy frequency-dependent increase was seen only with 10 Hz stimulation (Fig. 3). In the LD group, there was only minor latency increase but the frequency-dependent increase (10 vs. 1 Hz) significant. In the HD group, significant latency increase was seen and the frequency-dependent increase was more pronounced.

In line with the lengthened cortical latencies, the conduction velocity of the tail nerve was reduced in the treated groups (Fig. 4 left). Faster stimulation (50 and 20 ms period time instead of 1 s)was also applied to the tail, and the relative difference of the nerve action potential amplitude and latency, compared to the values obtained with 1 s period, was calculated. As seen in Fig. 4 (right), amplitude decrease on fast stimulation was present in both treated groups while latency increases only in the HD group.

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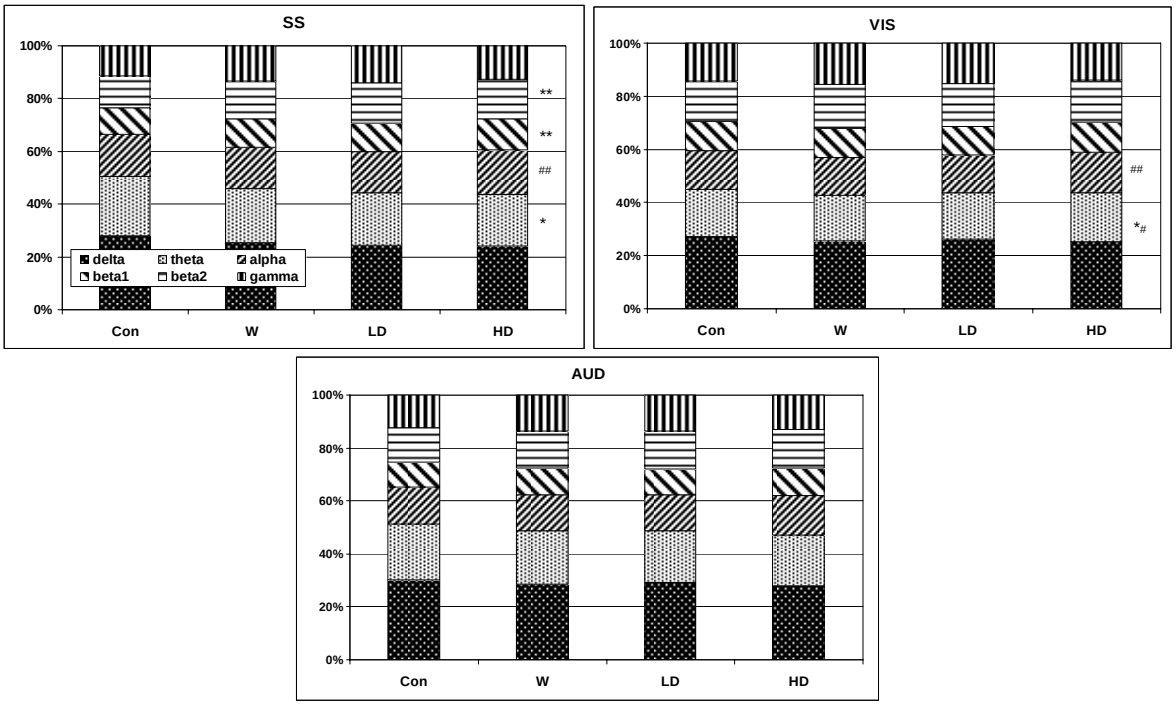



Figure 2. Band spectrum of the spontaneous cortical activity. Abscissa, groups; ordinate, relative ECoG power of the bands indicated in the insert (top left).
Group means, n=10. *,**: p<0.05, 0.01 vs. Con; #, ##: p<.05, 0.01 vs. W.

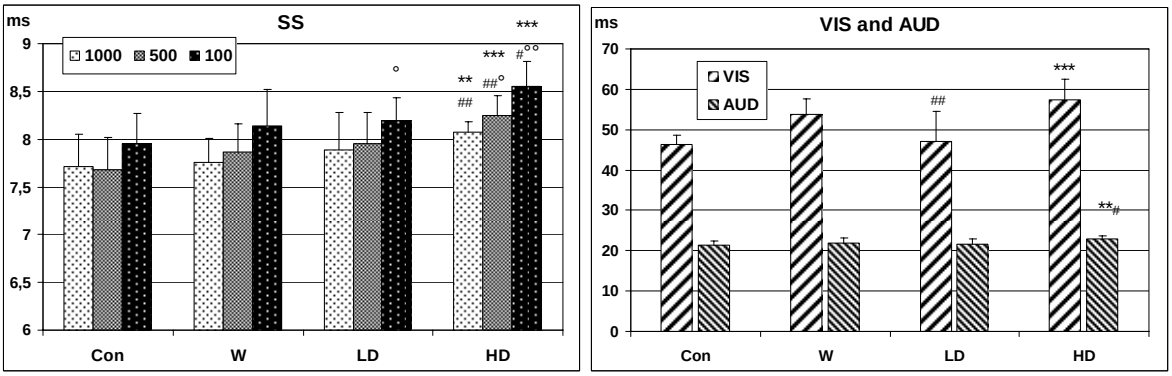



Figure 3. Left: latency of the somatosensory evoked potentials obtained with the stimulation period times given in the insert in ms (corresponding to 1, 2 and 10 Hz frequency).
Right: latency of the visual and auditory evoked potential.
Mean+SD, n=10. Significance marking as before

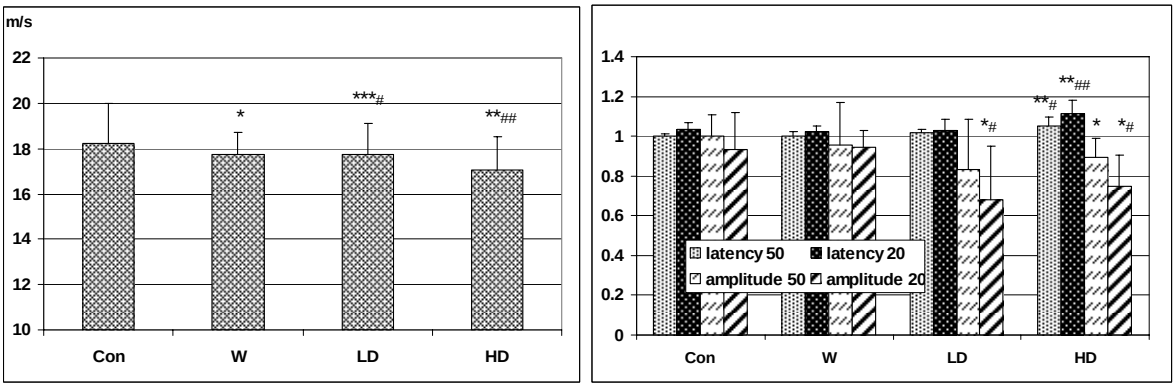



Figure 4. Left: conduction velocity of the tail nerve (ordinate, m/s) in the control and reated group.
Right: relative change of the latency and amplitude of the tail nerve action potential obtained with 50 and 20 ms period time (see insert).
Mean+SD, n=10. Significance marking as before

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## 4. DISCUSSION

The electrophysiological changes in this study were similar to those observed earlier [17,18] in rats treated orally with a dissolved form of Pb. This indicates that, beyond causing lung inflammation and emphysema [16], the nanoparticulate metal was most probably absorbed from the airways and was present in the rats' brain. Intact nanoparticles have the capacity to cross the blood-brain barrier [20]. Or, after phagocytosis, the acidic local environment within the phagosomes [14] may set free $Pb^{2+}$ ions [9] known to cross the blood-brain barrier [3] and even to damage it [8].

The nervous system effects of $Pb^{2+}$ ions may be explained by its chemical similarity to $Ca^{2+}$. Stimulus-evoked release of ACh was reduced (but spontaneous release increased) by $Pb^{2+}$ [26]. This possibly led to increased ascending cholinergic cortical activation and higher typical ECoG frequencies [13,17]. Reduced release of glutamate can, on the other hand, explain the slowed nerve pulse conduction and longer latencies [4] and decreased sensitivity of its cortical receptors [15]. Beyond that, $Pb^{2+}$, by acting on voltage-dependent $Ca^{2+}$ and $Ca^{2+}$-activated $K^{+}$-channels [2,24], could slow down the propagation of action potential, resulting in the observed effects on the peripheral nerve and contributing to the increased latency of the cortical response.

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# THE HEAVY METALS MONITORING IN CANNED VEGETABLES MIX

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**Abstract**

The paper proposes some possibilities for heavy metals detection in canned vegetables mix: Cr, Fe, Pb, Cd, Sn, Al, Zn, As . The heavy metals concentrations have been determinate by AA spectrometry and electrochemical methods: cyclic voltammetry. The monitoring of heavy metals in canned vegetables mix can help evaluate and improve the insufficiently developed technology.

**Key words:**

vegetables mix, heavy metals, AA spectroscopy, cyclic voltammetry

## 1. INTRODUCTION

Vegetables mix and similar products are widely used for taste enhancement of various food products. Apart from their taste properties they also have a high nutritive value due to the content of easily retainable sugars, vitamin C, carotenoids and mineral salts.

Vegetables mix is a produce conserved through decrease in humidity, thus preventing the evolution of microorganisms. Microorganisms require a certain minimum amount of water to develop; bacteria require 35%, yeasts 25% and molds only need 10%.

## 2. EXPERIMENTAL

### 2.1. Samples preparation

Vegetables mix products have been weighed and treated by concentrated nitric acid (67%, Merck, heavy metals free). Samples digestion has been achieved in a 1000W MWS-2 – Berghof type microwave oven using a three-step program: $T_1$=160°C, $t_1$=15 min., $P_1$=40-60% from total power, $T_2$=210°C, $t_2$=15 min., $P_2$=60-80%, $T_3$=210°C →100°C, $t_3$=15 min., $P_3$=0%.Thus resulted solutions have been completed with ultrapure water (RO System Operating Barnstead apparatus) to equal volumes in 25 ml calibrated flasks.

### 2.2. Methods of analysis

#### 2.2.1. AA Spectrometry

The heavy metals content has been determinated by AA spectrometry (International Standard ISO 15586:2003) and cyclic voltametry (Koryta , 1993), i=f(E). AA spectrometry has been achieved with novAA 400 G type spectrometer - Analytik Jena - Germany, equipped with graphite furnace, WinAAS 3.17.0 software for evaluation, control and result presentation, a so-called cookbook, for every element, and a HS 55-1 hydride generator. Calibration curves have been plotted using standard solutions of metals in search.

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### 2.2.2. Electrochemical Methods

Heavy metals such as Sn, Fe, Zn at the electrode surface are affcted by characteristic redox phenomena with can be used to determine their concentration. The voltammograms i=f(E) are obtained using PGZ 402 Voltalab, with VoltaMaster 4, version 7 software (User's manual, *Voltalab®*,2008). A 50 $cm^3$ BEC/EDI X51 V001 electrochemical cell, from Radiometer Copenhagen is part of the Voltalab system. Platinum electrodes ($S_{work}$=7.85 $mm^2$, $S_{aux}$=50 $mm^2$) and standard calomel electrode (SCE) with 0.1M $HNO_3$ support electrolyte have been used in experiments. Recording speed was 50 mV/min. at an apparatus sensitivity of 10 mA. Calibration curves for Fe and Sn have been plotted using metals standard solutions as $I_{peak}$=f(conc.).

## 3. RESULTS AND DISSCUTIONS

Vegetables mix products are obtained through processing of fully mature tomatoes, beans, onions, papricas. Vegetables concentrates are used in the food industry to enhance the taste and nutritive value of various products. There are three phases in the vegetables mixt production technology: obtaining the brute vegetables mixt, conditioning and packaging the product (HOTARARE nr.1197, 2002; ORDIN 1050**,** 2006**)**. When packaging into metallic cans the heavy metals content may exceed the safety limits, and in turn may be detrimental to public health. The two proposed analysis methods have the advantage of being fast and reliable (result accuracy). Five types of these products have been studied, both local and imported: four of them packaged in metallic cans and one in glass bottle, for reference.

The heavy metal concentrations in vegetables mixt determined by AA spectroscopy are presented in Table 1. High values are noted in the case of Fe (which although beneficial to the human body may become an energetic catalyst for some chemicalor biochemical processes), of Sn and of Al, especially in the Italian products.

Table 1. The heavy metal concentrations

| No. | Sample | Concentration, ppm | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cr | Fe | Pb | Cd | Sn | Al | Zn | As |
| 1. | Vegetables mix *Sultan* ( Romanian product, Turkish licence, metalic can) | 0.20 | 29.5 | 0.02 | 0.009 | 4.45 | 33.45 | 7.1 | ** |
| 2. | Vegetables mix *Conserv frig* (Romanian product, metallic can)* | 0.15 | 218.00 | 0.20 | 0.034 | 70.78 | 36.1 | 4.03 | ** |
| 3. | Vegetable mix *Mib* (Romanian product, metallic can) | 0.13 | 16.93 | ** | 0.003 | 12.5 | 23.1 | 6.5 | ** |
| 4. | Vegetable mix *Maxim's*, (Italian product, metallic can)* | 0.18 | 41.31 | 1.9 | 0.109 | 14.8 | 80.2 | 9.0 | ** |
| 5. | Vegetables mix *Buftea* (Romanian product, glass bottle) | 0.26 | 27.61 | 0.16 | 0.017 | 8.24 | 48.56 | 8.79 | ** |

* before the samples were taken the vegetables mix was homogenized at 1500 rpm with an IKA-LABORTECHNIK stirrer, with adjustable rotations and display unit observation
** under limit detection

It has been remarqued the high Cd concentration in *Maxim's* vegetables mix (Italian product).

For the determination of heavy metals by electrochemical methods, the first step was plotting the calibration curves. The methods used for Fe and Sn by means of cyclic voltametry i=f(E) are presented in Fig.1., Fig.2., Fig.3. and Fig.4.

The electrochemical method has only been applied for the higher concentration of metals Fe and Sn. Extracting Fe from the vegetables mixt products using this method has had no results. (Fig. 5.). Note that the Fe voltamogram is lower than the base line of the support electrolyte.

Sn, on the other hand, is present in the Italian vegetables mixt canned in high concentrations Fig.6 and Fig.7. (samples were taken from right next to where the can is welded, for all samples).

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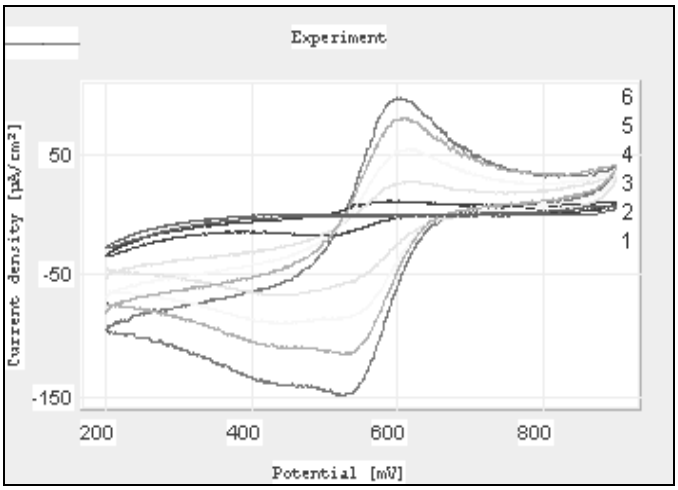



Fig.1. Cyclic voltammogrames for equilibrium $Fe^{3+} + e^- \rightarrow Fe^{2+}$. 1 – support electrolyte HNO3 0.1 M; 2 - c=25.64 mg/L; 3 - c=50.00 mg/L;4 - c=95.24 mg/L; 5 - c=136.36 mg/L; 6 - c=173.91 mg/L

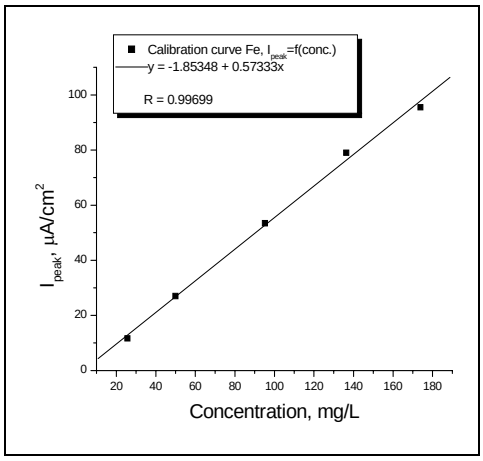



Fig.2. Calibration curve for iron concentration determination in canned vegetables mix, $I_{peak}$=f(conc.), $E_{ESC}$ = 608 mV

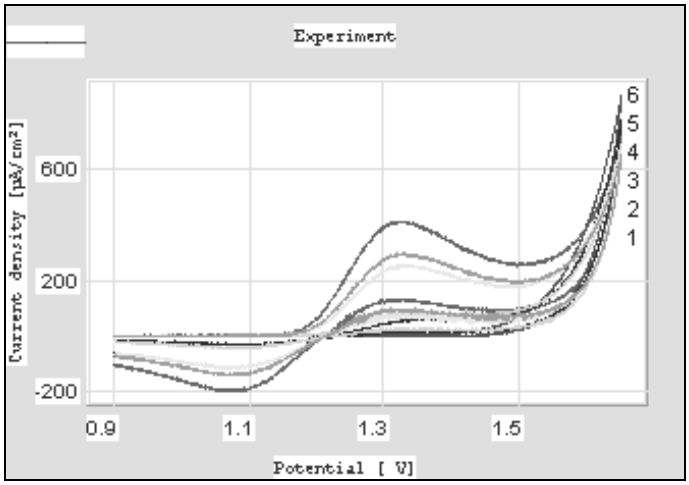



Fig.3. Cyclic voltammogrames for equilibrium $Sn^{4+} + 2e^- \rightarrow Sn^{2+}$. 1 – support electrolyte HNO3 0.1 M; 2 - c=6.8333 mg/L; 3 - c=13.5257 mg/L; 4 - c=20.0816 mg/L; 5 - c=26.5050 mg/L;6 – c=32.8000 mg/L

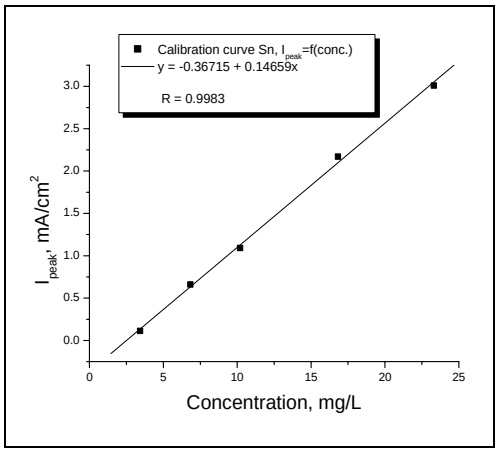



Fig.4. Calibration curve for tin concentration determination in canned vegetables mix, $I_{peak}$=f(conc.), $E_{ESC}$ = 1.375 V

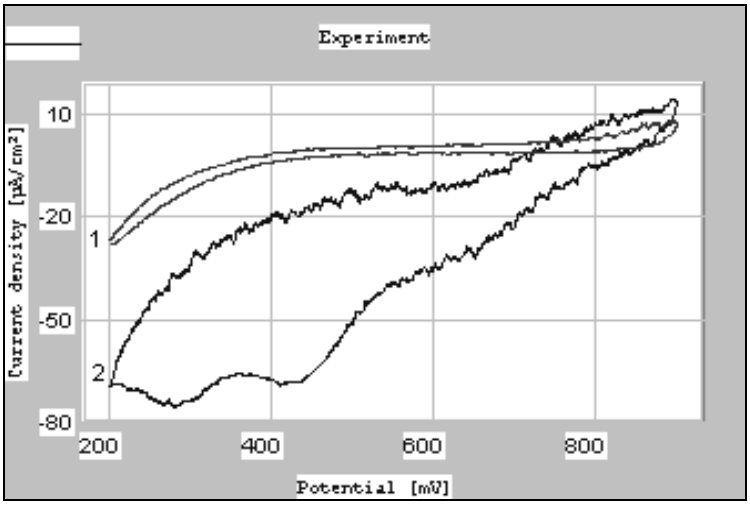



Fig.5. Fe determination in *Conserv frig* (vegetables mix)

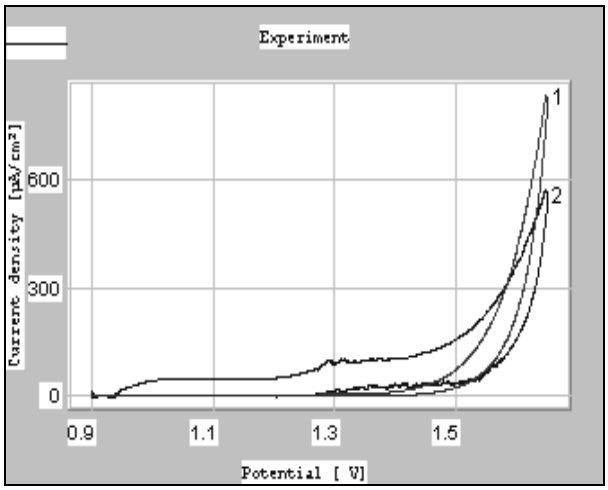



Fig.6. Sn determination in *Conserv frig* (vegetables mix), $E_{ESC}$ = 1.375 V

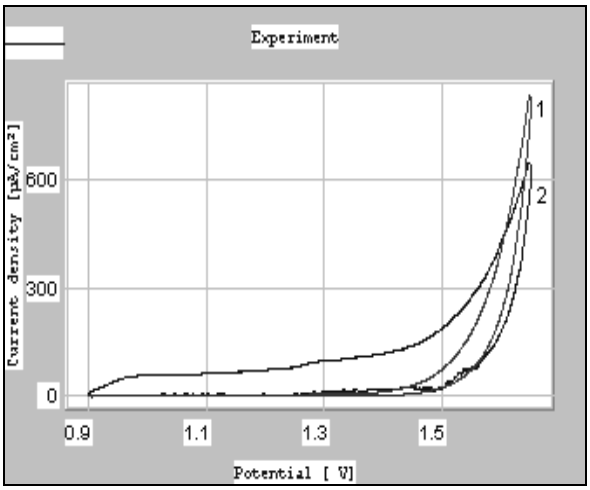



Fig.7. Sn determination in *Maxim's* (vegetables mix), $E_{ESC}$ = 1.375 V

The values obtained using the electrochemical method are c = 3.60 ppm Sn for *Conserv frig* ($I_{peak}$ = 0.1589 mA/cm²) and c = 3.40 ppm Sn for *Maxim's* ($I_{peak}$ = 0.1367 mA/cm²). There are obvious errors in using this method due to all the metal ions which can influence the electrochemical behavior.

## 4. CONCLUSIONS

The environment pollution with heavy metals (Cr, Ni, Pb, Zn, Al, As, Cd, etc.) is due mainly to the activity of humans. Two heavy metals (Sn and Al) showed higher concentrations then legally admitted in canned vegetables mix. Concentration of heavy metals from the polluted environment in vegetables is influenced by different factors and stopped through several mechanisms. The monitoring of heavy metals in canned vegetables mix can help to evaluate and improve the insufficiently developed technology.

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# EFFECTS OF SOME CALCIUM CHANNEL BLOCKER DERIVATIVES ON THE MULTIDRUG RESISTANCE OF CANCER CELLS

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## ABSTRACT

4-Phenyl-3,4-dihydropyrimidin-2(1*H*)-ones were synthetised and evaluated for multidrug resistance reversal activity on a human *mdr-1* gene transfected mouse lymphoma cell line (L5178Y, PAR), and on a human ovary cancer cell line (A2780cis). The antiproliferative effects of the compounds **B1-B6** were evaluated, and the $ID_{50}$ values were determined. Interactions between doxorubicine and some resistance modifiers were also studied in vitro.
The antiproliferative effects of the compounds were in the same concentration range for MDR lymphoma cells, and the $ID_{50}$ values was almost doubled for human ovary cancer cells. A great difference was shown between the compounds on the effect of rhodamine 123 accumulation from ineffective (**B3, B4** and **B5**) to a very effective compound **B2**, FAR values were found between 2.7 and 25.3 at 4 and 40 µg/ml concentration. Two other compounds, **B1** and **B6**, were moderately effective (FAR = 1.5 to 9.5). Possible structure activity relationship will be discussed.

**Keywords:**
calcium channell blockers, MDR reversal, antiproliferative, combination

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# International Comparison of Blood Pressure and BMI Values in schoolchildren aged 11-16 years

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Objective: The present study comprised part of a larger cross-sectional survey performed in Hungary in the period 2005-2006, which was designed to reveal the representative age-, gender- and height-specific percentile values for the SBP and the DBP in Hungarian children aged 11-16 years. A second aim was to determine the prevalence of overweight and obesity. Furthermore, we compared our findings with data on Italian, Israeli Arab, Ghanaian, Chinese and Turkish adolescents.

Methods: Analyses were performed on 14290 Hungarian children aged 11-16 years. All BP measurements were made with a validated, automated, digital device. Criteria recommended by international guidelines were used.

Results: The Hungarian, Italian and Israeli Arab adolescents have higher BP levels than their Ghanaian and Chinese counterparts. The Hungarian adolescents proved to be taller and heavier than their Turkish counterparts, and accordingly have higher SBP levels. The differences decreased with age. The prevalance of overweight and obesity among the Hungarian children was found to be 23.4% (3347 adolescents; International Obesity Task Force criteria).

Conclusions: Regional differences in morphometry and the genetic background, disparate eating habits and other cultural factors may account for differences in BP levels during childhood. Thus, each individual population needs to use its own normal standards to define a measured BP level in childhood. As the prevalence of overweight and obesity is increasing worldwide, it is important that countries carefully monitor the weight and BP status of their children and adolescents.

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# Microvascular reactivity in juvenile essential hypertension

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Examination of juvenile essential hypertension offers a presumably closer approach to the pathogenesis of hypertension, due to smaller impact of cardiovascular risk factors at this age. Our aim was to study the forearm microvascular reactivity of hypertensive adolescents, either lean or overweight.

Nineteen overweight hypertensive (OH), 10 lean hypertensive (LH) adolescent patients and 19 healthy controls were enrolled. Twelve young adult patients on haemodialysis (HD) served as positive controls. Blood samples were drawn for the enzymatic determination of concentrations of oxidized and reduced glutathione (GSSG, GSH). Microvascular reactivity on two sites of the volar side of the forearm was evaluated by means of laser Doppler flowmetry (LDF). An iontophoresis sequence, consisting of three consecutive, increasing doses of either acetylcholine (Ach) or sodium nitroprusside (SNP), and local heating to 44°C (maximal vasodilation) were performed.

Microvascular reactivity was moderately decreased in the two hypertensive groups, and markedly attenuated in the HD patients, as compared with controls. The whole blood ratios GSSG/GSH were significantly higher in all patient groups than in controls, the largest values were found in the HD group.

In summary, a modest attenuation of microvascular reactivity was observed in juvenile hypertensives; its degree was similar in the OH and LH adolescents. This may be related to the increased oxidative stress, as shown by the elevated ratios GSSG/GSH.

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# QUALITY CHANGES IN REGIONAL FOOD PRODUCTS AS A CONSEQUENCE OF CONSERVATION TREATMENT

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## ABSTRACT

The changes in South Hungarian spice paprika powder induced by ionizing radiation, saturated steam (SS) and their combination were studied as a function of the absorbed radiation dose and the storage time. The SS treatment lead to a decrease in color content (lightening) after 12 weeks of storage, together with the persistence of free radicals and viscosity changes for a longer period.

The changes in microbiology, colour composition and free radical content induced by ionizing radiation – a food preservation treatment – were studied in dry onion samples as a function of the absorbed dose. Typical onion species from South Hungary (Makó), South Serbia and Poland, with variable quality and colour composition, showed markedly different responses to ionizing radiation.

The results suggest that ionizing radiation is a more advantageous method as concerns preservation of the quality of spice paprika. In addition, the measurement of the above characteristics is a useful tool to determine the critical dose of ionizing radiation to achieve the desired microbiological purity and to predict quality changes.

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# EFFECT OF CHLOROPHYLL *A* AND *B* ON MULTIDRUG RESISTANCE OF CANCER CELLS

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## ABSTRACT

Various plant compounds have been identified as potential anticancer agents or modifiers of the multidrug resistance. Among these compounds are different carotenoids, and terpenoids. The effect of chlorophyll compounds isolated from the leaves of bean plants on MDR was studied.

The effect of chlorophyll *a* and *b* was studied on the drug accumulation in human MDR1 gene transfected mouse lymphoma cells. Chlorophyll *a* and *b* had similar dose dependent effect on cell membrane structure without altering the cell size measured by flow cytometry.

Chlorophyll *b* was able to elevate moderately Rhodamine 123 accumulation of tumor cells. The combination of chlorophyl *b* and capsorubin had a remarkable increase in the inhibition of Pgp 170 while the chlorophyll *a* reduced the effect of capsorubine.

MDR reversal effect of chorophyll *b* can be explained by energetically favorable electron charge transfer complex formation with the Pgp170. The energy gradient is in the optimum range from carotenoids to chlorophyll *b*, but low binding energy of chlorophyll *a* does not modify the functionally active conformation of the Pgp 170 membrane protein, In checkerboard experiment the combination of doxorubicine and chlorophyll *b* resulted in a synergistic interaction on inhibition of proliferation of MDR tumor cells in vitro.

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# *IN VITRO* SUSCEPTIBILITY OF DIFFERENT ZYGOMYCETES TO COMBINATIONS OF SURAMIN AND FLUVASTATIN

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**Abstract**

The number of zygomycotic infections (caused by member of Zygomycetes) has increased over the past years. Most of the antifungal agents are ineffective against these fungi; furthermore, treatments have serious side effects and could not be applied without a damage of the host. Therefore, there is a need to find novel substances having antifungal activity. Suramin is known as an agent for treatment of parasitic infections and an antitumor medicine. Fluvastatin is a fully synthetic compound, which is used as cholesterol lowering drug in human therapy.

The *in vitro* antifungal activity of suramin and its combinations with fluvastatin were investigated in this study against 15 Zygomycetes isolates representing 8 clinically important genera (*Absidia*, *Micromucor*, *Mortierella*, *Mucor*, *Rhizomucor*, *Rhizopus*, *Saksenaea* and *Syncephalastrum*). The growth inhibitory effects of various concentrations of fluvastatin, in the presence of suramin (100 μg $ml^{-1}$) were studied. The investigated compounds acted synergistically and additively on the growth when a strain was resistant to suramin and sensitive to fluvastatin, at the same time antagonistic interactions were detected when strains were sensitive to both agents. In these cases, the growth inhibitory effect of suramin was dominant.

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# NEWBORN SCREENING FOR METABOLIC DISORDERS WITH TANDEM MASS SPECTROMETRY IN METABOLIC SCREENING CENTER OF SZEGED

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Although individually rare, inborn errors of metabolism represent a potentially preventable cause of death and disability.

In Hungary, expanded newborn screening for rare inherited metabolic disorders by using tandem mass spectrometry (MS/MS) was introduced in October of 2007. Previously, four metabolic diseases were screened with different diagnostic methods: phenylketonuria (from 1975), galactosaemia (1975), congenital hypothyroidism (1985) and biotinidase deficiency (1990). MS/MS is adapted to quantitative measurement of amino acids and acyl-carnitines from dried blood spot and allows newborn screening for numerous biochemical genetic disorders with abnormal amino acid or acyl-carnitine profile, including aminoacidopathies, urea cycle defects, organic acidaemias, abnormalities of fatty acid oxidation and carnitine metabolism. Together with the formerly assayed diseases, now 26 inborn errors of metabolism are screened in all of Hungarian newborns, 23 of them with MS/MS. In the first year of expanded screening programme, approximately 45.000 newborn infants were investigated from the eastern part of Hungary. 16 patients with different metabolic disorders (phenylketonuria, n=5; 3-methylcrotonyl-CoA carboxylase deficiency, n=4; short- chain acyl-CoA dehydrogenase deficiency, n=3; medium-chain acyl-CoA dehydrogenase deficiency, n=2; propionic acidaemia, n=1; isovaleric acidaemia, n=1) were diagnosed by MS/MS and started to follow up and treat in Metabolic Screening Center of Szeged. Clinical characteristics of screened cases will be discussed in detail.

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# MIGRAINE HEADACHE AND COMORBID CONDITIONS IN WOMEN: RETROSPECTIVE ANALYSIS

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## ABSTRACT

Migraine is a frequent primary headache, especially in women. The migraine prevalence is between 6-18% and the gender ratio in women and men is 3:1. Two main forms of migraine type headache are migraine with aura and migraine without aura. Migraine without aura is more common. There are several comorbid diseases with migraine, such as ischemic stroke, depression, epilepsy, cardiovascular disorders and patent foramen ovale. Comorbidity means the occurance of two diseases in one individual beyond chance.

Self-made detailed (24 questions contained) questionnaire was used for retrospective analysis of migraine patients data. First part of the questions were applied to headache features (localisation, intensity, frequency, accompanying symptoms, aura symptoms, etc.), second part of the questions are about comorbid state, familiar medical history, hormonal profile in women and medication therapy.

Among our migraine patients (n=431) the major comorbid factor was depression and anxiety. There are cerebrovascular and cardiovascular patients between migraineurs, too. We have found that epilepsy and patent foramen ovale are quite rare in our patient group.

According to other international data from both retrospective and prospective studies, our results seem to be similar.

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# IMPLANT SUPPORTED OVERDENTURES

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**Abstract:**

For decades, natural teeth have been retained in the mouths of debilitated patients to support/retain overdentures and preserve bone. In a similar manner, root form implants have also been successfully used to enhance the support, retention and stability of overdentures.

**Keywords:**

Overdenture, edentulous, retention

## 1. THE DEVELOPMENT OF THE OVERDENTURE

The loss of the remaining teeth can be an emotional experience for many. The loss of teeth is associated with ageing and this can be a depressing factor for many. One should not underestimate the emotions related to the oral area and their effect on the patient's body image.

Preserving natural teeth or their roots (for example the two canines on an arch) should be considered as often as possible because of the advantages of this treatment choice:

1. Psychological benefits to the patient;
2. Preservation of the edentulous ridge;
3. Tactile discrimination;
4. Improved stability and retention of the denture.

In situations where extracting the remaining teeth is the only option left, patients may wear conventional dentures which give them a feeling of "floating plastic" in their mouth and a much lowered chewing capacity or choose implant supported restorations in order to restore their functional and esthetic status.

## 2. AVAILABLE BONE AND ANATOMICAL LIMITATIONS

Bone loss is a major issue regarding the treatment choice of edentulous patients. Available bone describes the amount of bone available in the area considered for implantation. It is measured in height, width, length and angulation.

The height of the available bone is measured from the bone crest to the closest anatomical landmark. As a general guideline, 2 mm is maintained between the implant and any adjacent landmark. In the posterior regions, the opposing landmarks are the maxillary sinus and the mandibular canal. The anterior regions are limited by the maxillary nares or the inferior border of the mandible. The problem in implant dentistry is that the posterior regions impose the greatest limits for placing dental implants. In these regions, implants will be shorter or none at all, but forces in the posterior areas are greater, since this is where mastication is done and where natural teeth have two or three roots. By not placing dental implants in this area, the clinician is often in the situation of choosing an overdenture instead of a fixed prosthesis.

The width of the bone is measured between the facial and lingual crests at the site where the implant will be placed. A 3.75 mm diameter implant requires a bone width of at least 5 mm in order to obtain a predictable result.

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The length of the bone is limited by the adjacent teeth or implants. For bone 5 mm wide or more, the minimum mesiodistal length for each implant is 5 mm. Lower bone widths require higher lengths for the available bone.

Bone angulation is another determinant for alveolar bone. It should be aligned with the oclusal forces and parallel to the clinical axis of the clinical crown of the prosthodonthic restoration.

## 3. SUCCESS, FAILURE AND COMPLICATION DATA

Implant overdentures are associated with more complications than any other type of implant prosthesis. However, the complications do not negate the benefits these prostheses provide for patients. Implant overdentures have been more successful in the mandible than maxilla.

## 4. IMPLANT LOSS

Several clinical studies provide data regarding implant loss in the maxilla. The mean loss of implants was found to be around 21%.

There are clinical studies that evaluate mandibular implant loss associated with overdentures. The mean loss of implants was found to be around 5%.

Studies also provide data regarding the time (preprosthetic or postprosthetic) when the implants were lost. Sixty percent of the implants were lost preprosthetically and forty percent were lost postprosthetically.

## 5. DESIGN PRINCIPLES

### Number of Implants

The number of implants used with overdentures has included one midline implant, two individual implants, two implants connected by a bar, and 3 or more implants connected by a bar. Placing several implants in the maxilla (because of the higher maxillary implant loss data) that are connected by bars permits the prosthesis to continue functioning should there be loss of an implant. It has been proposed that maxillary overdentures be supported by at least 4 implants, evenly distributed around the arch and connected by a bar.

In the mandible, the use of 4 implants and a bar was compared with 2 implants and a bar [1]. The authors evaluated plaque, calculus, and bleeding scores, probing depths, gingival recession, implant percussion, and made standardized radiographs. No differences were noted in the clinical or radiographic parameters and the authors suggest that 2 implants may be sufficient in the mandible. However, they did theorize that 4 implants might be beneficial for patients with sore, painful mandibular ridges since more force would be supported by the implants and bar rather than the edentulous mucosa.

### Individual versus connected (splinted) implants

Clinical studies have compared individual implants with implants connected by a bar. A study [2] of photoelastic stress patterns indicated that individual implants with ball/o-ring attachments transferred less stress to the implants than the design that used 2 implants connected by a bar. There were no biologic differences between the 2 designs but greater prosthesis retention was attained when the implants were connected by a bar.

Since no clear biologic advantages have been associated with the number of implants used in the mandible (individual or connected), the numerical decision should be based on retention requirements. For many patients, two individual implants with associated retentive mechanisms provide good patient satisfaction and the treatment is less costly than a bar overdenture. For patients where retention is a primary requirement (as evidenced by active oral musculature and functionally demanding eating expectations), the use of 3, 4, or more implants and interconnecting bars with multiple retentive mechanisms is recommended.

### Location of the Implants

The implants should be located so they are contained within the normal form of the denture base. Their form and location should ideally not produce substantial changes in the dimensions of the denture base. The canine areas often serve as appropriate locations for

implants. It is important to determine the location of the prosthetic teeth and the size and form of the denture base prior to implant placement. These characteristics are identified through development of a wax trial denture using conventional complete denture procedures. Implants that support/retain overdentures are commonly located in the anterior area of the mouth and they should be centered beneath the prosthetic teeth or slightly lingual to the center of the prosthetic teeth. When the implants are located anterior to the teeth or substantially posterior to the teeth, the denture base has to be enlarged to encompass the implant and retentive mechanism. The enlarged base dimensions prolong the time it takes for a patient to adapt to the new prosthesis and can make the adaptation challenging.

There is another negative aspect of placing implants too far facially or lingually. With malaligned implants, efforts are commonly made to reduce the amount of resin base overcontouring and this process frequently leaves only thin areas of resin over the retentive mechanisms. The thin resin is more prone to fracture. When implants are placed posteriorly, they should be centered beneath the prosthetic teeth.

A 5-year study [3] of 90 mandibular overdenture patients measured the parallelism of the virtual implant axis or bar with the transverse horizontal axis (hinge axis). There was parallelism in 7 patients. The study failed to show any highly significant advantages of achieving parallelism between the implant axis and the opening-closing axis of the mandible.

Implant Alignment

Implants that are parallel to each other or have their long axes nearly aligned with each other facilitate the prosthodontic phase of treatment by allowing the use of standardized components. When individual implants will be used with o-ring retention, malalignment can make prosthesis placement more difficult and the o-rings are pinched more often during placement and removal, producing o-ring wear and earlier loss of retention.

The master casts of 41 patients who had received 2 implants and ball abutment/o-ring overdentures were measured [4] to determine the effect of implant alignment on the number of adjustments/repairs. When a perpendicular relationship of the implant to the residual ridges was used as a reference angulation, implants that were inclined about 6 degrees to the facial or lingual were associated with a significantly higher number of repairs.

When an implant is placed substantially out of alignment with other sources of retention, the fabrication of custom components may be necessary. To facilitate axial loading of the implants, it has been recommended that implants be aligned so their long axes are perpendicular to the occlusal plane.

## 6. IMPLANT COMPONENT/RETENTIVE MECHANISM HEIGHT ABOVE THE SOFT TISSUE

After development of the wax trial denture, it is important to assess base dimensions to determine the amount of space available for implant components and retentive devices. The height of implant components and retentive mechanisms should be reduced as much as possible since they weaken the prosthesis base. However, the height should be sufficient to allow bars to be fabricated in such a manner that some space is present beneath the bar. It is recommended that a 1-2 millimeter space be present between the underside of metal bars and the edentulous ridge mucosa. It is felt that the potential for adverse soft tissue responses is related to minimal spaces underneath a bar. It has also been suggested in one publication that adverse responses under bars occur more often when unattached mucosa is present. In contrast, a study of 62 patients [5] found that attached mucosa was not a prerequisite for the maintenance of healthy function.

Peri-implant soft tissue complications were more frequently encountered with maxillary implant overdentures and it has been suggested that the reason may be related to the reduced vertical space available in the maxilla. Mandibular resorption frequently creates more vertical space than occurs in the maxilla causing retentive bars to be placed closer to the soft tissue in the maxilla. It has been stated that good oral hygiene is the main factor in preventing adverse soft tissue responses.

A 5-year longitudinal study [3] investigated the effect of the retentive mechanism on periimplant parameters (plaque index, bleeding index, probing depth, and clinical probing

attachment level). The retentive devices included round bars (both straight and curved to follow the arch form), U-shaped bars with and without distal extensions, and individual ball abutments. The authors concluded that the type of retentive mechanism appears to have little or no influence on peri-implant parameters. Some peri-implant soft tissue complications are severe enough to require surgery.

Retentive mechanisms vary in incisocervical and faciolingual dimensions. For example, ball attachments for o-rings can be as small as 2 millimeters in diameter or as large as 3.5 millimeters in diameter. The height of ball attachments (including the height of the ball abutment and the overlying o-ring is about 5-6 millimeters. The same height is occupied by ball abutments and metal caps that snap over the ball. Bars and clips are frequently 2-4 millimeters occlusocervically and 2-3 millimeters faciolingually. Bars that accept snap type attachments (Ceka) are about 1.5 millimeters in height with a faciolingual dimension of 2-4 millimeters. The overlying attachment that snaps into the recess in the bar is 1.5 to 2.5 millimeters in height for a total of up to 5 millimeters.

It is advantageous to have 2 or more millimeters of resin thickness surrounding the retentive mechanism when possible. Available base thickness will help determine the type of mechanism that can be used.

In summary, all retentive mechanisms require an occlusocervical space of about 8 millimeters (including retentive mechanism, overlying base material, and space under bars). When there is not sufficient space available, a change in the type of retentive mechanism may be necessary or the base may have to be thickened. For diagnostic purposes, the wax trial denture can be duplicated in clear acrylic resin and used in conjunction with a wax pattern of the proposed retentive mechanism to assess available space.

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# RETENTION FOR IMPLANT SUPPORTED OVERDENTURES

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**Abstract**

When placed in the mouth, a removable prosthesis is subjected to a number of forces which tend to withdrawal it along its axis of insertion. Retention is the force that opposes this tendency. In ideal situations, overdentures should have good stability and border seal to provide retention. Unfortunately, in practice, the ideal situation does not always apply. Anatomical variations and tissue loss related to aging dictate the type of overdenture to be used. Retention systems have been devised in order to achieve a better prosthetic result.

**Keywords**

Overdenture, attachment, friction

## 1. RETENTIVE MECHANISMS

There are several types of retentive mechanisms available, including the ball/o-ring, bar(s)/clip(s), magnet, and other types of mechanical attachments.

The choice has largely been determined by practitioner preference with bars/clips being one of the mechanisms frequently selected to support/retain overdentures. When bars are used, it has been proposed that the bar be fabricated so it is parallel to the plane of occlusion [1].

Ideally, the retentive mechanism should be positioned so it cannot be seen through the visible portion of the denture base, does not interfere with proper positioning of prosthetic teeth, and does not excessively enlarge the denture base.

## 2. BAR ATTACHMENTS

Bar attachments (Fig. 1, Fig. 2) have been used for most of the twentieth century They can be divided into two groups, those allowing slight movement between the components, the bar joins and the comparatively rigid bar units. Bar attachments lend themselves to implant prosthodontics. The retention characteristics are favourable and they are robust and effective retainers.

This type of rehabilitation usually requires a minimum number of two implants. In the case of mandibular overdentures, the bar and clip retention system is frequently used. This system ensures the fixation and support of the prosthesis in the anterior area, but also allows protection from oclusal forces when chewing forces are applied on the posterior part of the prosthesis.

The bar, as a mesostructure is cemented or screw retained to the implants in order to join them and provide retention to the overdenture.

The Dolder bar or the round bars are used mostly in cases where implants are interforaminal because they allow the prosthesis to rotate around the axis of the bar.

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Fig. 1



Fig. 2

### 3. BAR JOINTS

Bar joints allow some movement between the two components. They can be subdivided into two types:

- Single sleeve bar joints:

The Dolder bar joint is an excellent example of this type of attachment. This well-tried bar is produced from wrought wire, pear shaped in cross-section and running just in contact with the oral mucosa between the abutments. An open-sided sleeve is built into the impression surface of the denture and engages the bar when the denture is inserted. A spacer is provided with this bar joint to allow a degree of movemet potential.

- Multiple sleeve bar joints

The retaining sleeves are relatively short. This allows the bar to follow the curvature of the ridge as well as to be adapted to its vertical contours. This type of approach has proved to be very versatile and has become very popular with implant supported overdentures.

Although friction between the sleeves and the bars may be improved by activating the sleeve, there are many possibilities of combining this system with others like Ceka attachments, Presso-matic, Isoclip and 3-D-O-Ring.

### 4. STUD ATTACHMENTS AND MAGNETS

Stud shaped attachments have served as overdenture abutments for several decades. Most are straight-forward to use and possess favourable retention characteristics. Nowadays, they have applications to both root and implant supported prostheses.

For the purpose of description, stud attachments are divided into two groups:

- Extraradicular, in which the male element projects from the root surface of the preparation or implant.
- Intraradicular, in which the male element forms part of the denture base and engages a specially produced depression within the implant.

In selecting an attachment, it should be appreciated that space must exist for these units to be surrounded by a reasonable thickness of acrylic resin, otherwise the denture will be weakened.

Examples of stud attachments:

The Ceka system (Fig3, Fig.4):

The basic idea is simple: a spring pin which snaps exactly into a conical female. Together, they make up the Ceka Attachment. It was developed 35 years ago as an esthetic alternative to the traditional clasp, and ensures stable retention. Once the spring pin "clicks" into the female, the patient knows that the prosthesis is properly seated.

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Fig.3

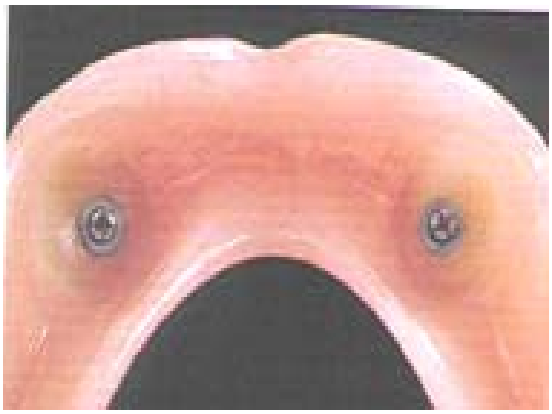


Fig. 4

Overdenture using O-Ring:

The o-ring abutment is fabricated from titanium alloy and available in variable cuff heights that incorporates a coronal spherical geometry which snaps into a rubber o-ring in the denture or partial denture acrylic base.

The Rothermann system:

It consists of a short stud with a retaining groove. Retention provided by a C-shaped ring designed so that the free ends of the clip engage the deepest portion of the retaining groove. The stud comes with a central core of solder for easy attachment to the coping

The Gerber system:

Stud type, matrix, patrix, resilient and non-resilient designs

Magnets:

Magnetic retention systems have been used in prosthodontics for some 60 years. The early types of magnets could not be reduced in size in order to allow their application for overdentures. The introduction of rare earth alloys with a high field strength and an intrinsic coercivity many times that of earlier alloys allowed the production of magnets that were not much larger than stud retainers. Space was always a problem with magnet retainers and this lead to several designs in order to fit all the necessary components. The magnets are placed in the denture and the flat keeper on the abutment root. A disadvantage of this system is the corrosion of the ferromagnetic alloys.

## 5. TELESCOPIC OVERDENTURES

The implant abutments are covered with occlusally converging primary cast copings. Support and frictional retention for the prosthesis is provided either by secondary cast copings fitting over the primary copings and incorporated as an integral part of the denture base.

The retention and stability of the overdenture is achieved trough the friction between the primary coping and the secondary coping in the overdenture.

## 6. BASE REINFORCEMENT

When the denture base will be thin or there are heavy occlusal forces present, it may be prudent to reinforce the denture base with a metal mesh/framework incorporated into the denture base or use a metal base.

Evaluating prosthetic tooth wear on an existing prosthesis provides an indication of the magnitude of forces present. When aggressive wear facets are noted on the prosthetic teeth of an existing denture, a hostile environment is likely to be present and the use of reinforcement may be advisable.

It is also important to remember that patients who have implants can place greater occlusal force on the prosthesis than they could with their conventional complete denture. However, the maximal occlusal force applied by patients with mandibular implant

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overdentures was found to be less than the force developed by patients with teeth and patients who have fixed complete dentures.

## 7. COMPARISON OF RETENTIVE MECHANISMS

When bars are used, a casting is required which increases cost and complexity. Bars have been found to provide greater retention than balls/o-rings which may be important with patients exhibiting high functional activity and the need for maximal retention. One study [2] indicated that o-rings provided significantly better retention and stability than magnets.

Bars and associated retentive devices require more space within the denture base than do o-rings. When implants will be used separately (not connected), the ball/o-ring mechanism or metal cap/stud type of design has frequently been used.

All mechanisms are subject to retention deterioration over time and the need for regular adjustment/replacement.

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# QUO VADIS, SEXUALITY?

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**ABSTRACT**

Noticing the profound everyday changes in social structure and dynamics, changes that ask for an individual's adaptation and integration, we come to ask ourselves: "Where is sexuality repositioning itself, on which step of life's everyday ladder?"

The peaceful and pleasant silence is suddenly disturbed by an irritating noise that does not seem to quiet down. Another day begins; a day of work, running around, stress, contradictory conversations, sensational news that relate troubled times are approaching. It is what Fanus Neagu called "the thirst for others' misery". We continue on with our children returning from school with teacher complaints and then, when we finally await the time to close the blinds for the night, our television sets draw us in and keep us glued watching channels that portray immorality, catastrophy and that encourage the most inhumane behavior possible.

Finally, you gaze towards your wife and watch her sleep; the hour is late, what have you forgotten? It has been a very busy day, another one inevitably follows. Something's missing; but what? You fall asleep asking yourself: "What else?" and your unconscious pampers you with nervous discharges, offering you hallucinogenic moments of eroticism.

In situations as described above, we wonder: "Where does sexuality stand, on which step or level of our everyday life?" Green said: "Make everyday as complete as possible". But is it possible?

Birthrates worldwide have plummeted, the average age at which young folk decide to build a family has increased, pushing the time of conception towards an age at which having a second child is a physiological and "logistic" impossibility.

We face a daily change in social structure and dynamics, a change that requires adaptation and integration skills for all individuals, a change that is simply the depreciation of traditional values and a depersonalization of the individual that manifests itself in new attitudes, mentalities and behavior.

This "new social order" also deals directly with sexual and erotic concepts and behaviors.

The brief description from our introduction, which relates to a couple's normal day, prompts us to speak about the psychological sexuality of the couple and its ups and downs. We may also say that the crises a couple faces are comparable –in a microscopic way of speaking- to the global crisis in this matter.

In our contemporary society, the couple is based more and more on interest rather than love. Do you think that the global crisis is affecting an individual's sexuality? Is that individual interested in sexuality or is he/she more focused on their survival, along with their family's well-being?

Sexuality is a fundamental part of human behavior. Practice has proven that without taking into consideration the biological or mental health of an individual or their professional training, they are not satisfied on an intimate level unless they have a normal and regular sexual function, the negation of which translates into a feeling of frustration that reflects onto their entire personality.

To achieve this normality, an individual –and indirectly, society- needs a moral, material, spiritual and social balance. They need certainty and not doubt, be it material, professional, or interpersonal. But "doubt" is now happening. Rising unemployment rates –no matter top or bottom in professional development- in all sectors tend to add to this feeling nowadays, hence the interest for affection and sexuality is harder and harder to find.

If pills such as Viagra, Cialis and Levitra, that were very sought after in pharmacies, were the answer –momentarily, of course- for the man, who still valued his personal potency and eroticism, now their sales have dropped by nearly a half.

Has the man become more potent, liberated from all his inhibitions or his need of decent sexual performance or is it something else? Has he become less interested in sex, his libido nearly gone, putting more emphasis on his survival rather than his sexuality?

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Freud's psychoanalytic theory describes the existence of the primary sexual instincts, emotions that if bottled up, at a certain point need to manifest themselves. It is in such a way that sexual conduit, further regulated by cultural, moral and religious norms has degenerated in purely instinctual, going towards exhibitionist and perverse behavior.

At some point during the stages of human evolution -from barbaric to civilized-, B. Malinowski said that "culture begins with the control of instincts". Today we might say that "the manifestation of instinctual behavior is given by the absence of cultural, moral and religious values in the development of individuals", together with the crisis modern society finds itself in.

The idea of a democratic society is interpreted in a wrong way – freedom is replaced by liberation, responsibility is thought of as a barrier which must be eliminated.

The rapport between the members of a conjugal couple is today based on individual freedoms, as opposed to the traditional couples' feelings of trust and responsibility.

Psychologically, sexually, but also morally, youth who want to start a family are completely unprepared. They are much too immature and primitive -behaviorally, of course- to take over the responsibility of building and maintaining a family.

A life of freedom and no responsibility is preffered over a family life that imposes some norms. It is perceived in such a way that the sexual liberation one faces when in a couple is skewed towards an open, libertine, degraded sexuality. "Degraded in what way?" one may ask. An entire erotic industry has spawned in very different ways that maintains a sort of sexual-erotic tension present, provocative and with unconscious negative effects on one's sexual attitude, mentality and behavior.

Present society cultivates and puts forth the sexual "image" instead of sexual affection. Hence, the new "sexual revolution" associates itself with drug use, violence, prostitution, disrespect for work, all leading to a loss in the purpose of life.

The sexual education of youth today is manipulated by the evermore cunning media: many television programs, specialized magazines, chatlines, CDs, and of course, the Internet. Next to the column in the paper that informs us of prices increasing and the current economic situation, we find the provocative and sensual profile of a young girl. Page X. Or the girl giving us the weather info for this week, dressed in very skimpy clothing –although there may be a blizzard outside-.

By stimulating -on a daily basis- one's visual sense with such images, the very mystery fades and masculine curiosity deteriorates. Sexual desire is more present in the brain than anywhere else and can turn into sexual arousal without any other physical or mental stimulus. This explicit erotic material, be it written or in image form represents a source of erotic stimulation, but prolonged exposure to it can create saturation, which in turn reduces the desire for it.

Sexual conduit becomes, in these conditions, a form of collective manifestation, directly represented by symbolic sexual behavior, such as rythmic music festivals / parties (these favoring the pulsional release), association with isolated groups that have as a basis the sexual component or other instinctual behavior –junkies, satanists, delinquents-. Also, we may note group violent sexual behavior, perversions which are "trendy", such as homosexuality and swinger clubs.

The psychological mechanism that collective sexual conduit bases itself on is imitation, negative suggestion and peer pressure further enhanced by a lack of information and education; these types of behavior are very fertile on immature psychological ground, Oedip-based insecurities maybe.

The consequences of these manifestations that come from the "sexual revolution" will be seen in the future. They will affect all aspects of society, way of thought, human relationships and futures of families and individuals in a negative way.

I did not want to debate this subject by making pesimistic, negative and erotic-depressive assumptions, but I asked myself: "Where to, sexuality?", because not the liberation but the reprimation of instincts represent the advancement of a human being and keep him/her from going back to primal behavior.

Relating back to positive models of thinking will save man and invigorate society. It will bring back affection in our erotic interactions, self-trust, respect for one another and for ourselves, sex as a result of love, in other words: a healthy bio-psycho-social sexuality.

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# SHORT-TERM URETERAL STENTING IN URETEROLITHOTRIPSY

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**Abstract**

The aim of our study was to evaluate for one week the ureteral stenting in patients who have undergone ureteroscopy for ureteral lithiasis.

## 1. INTRODUCTION

Ureteral stenting has some advantage: for ureteral obstruction is a common procedure because it can mentain his position, also it can be used in thi treatment of ureteral stones under 5mm and for urinary drainage in patients who needed endoscopic or classical surgery.

## 2. MATERIAL AND METHODS

The study included a cohort of 140 patients with ureteral lithiasis who underwent ureteroscopy followed by ureterolithotripsy. The stone sizes were between 5-10 mm and the chemical composition of lithiasis is: oxalate dihidrat, oxalate monohidrat or uric acid. The operation was performed in rachidian anesthesia with an rigid ureteroscope STORZ 14 Ch and the stones were fragmented with a pneumatic lithotritor STORZ.After the operation we have 109 uncomplicated cases which was randomized into stented A groups 54 patients and nonstented B groups 55 patients. In A groups a 5 Ch polyurethane stent was passed through ureter after lithotripsy. Postoperatively all patients were evaluated for flank and suprapubic pain, clinical renal colic, irritative urinary symptoms, analgesis usage, urinary analysis and culture. During the operation 31 patients suffered complications: ureteral perforations (23 patients), that was successfully treated with temporary stenting for 4 weeks,or failure of lithotripsy in 8 cases which needed ureterolithotomia.Ureteral stents removal is usually performed with the cystoscop without anesthesia at women and with i.v. analgesia at man.

## 3. RESULTS

In the first postoperative day in group A 11 patients (20,4%) patients had flank pain while it was present in 42 patient in group B (76,4%).In group A one patient (1,9%) complicated of clinical renal colic comparing to 25 patients (22%) in group B. During hospital stay 11 patients in group A (20,4%) needed analgesic administration compared with 37 in group B (67,3%).Suprapubic pain was reported by 3 patients in group A (5,5%) compared With 7 patients in group B (13%). Ureteral irritation was also more frequently reported in patients who had stent 20 patients (A group 37%) and 3 patients(B group 5%).Urinary tract infection was developedin 4 cases from group A(7,5%) and 2 cases from B group(3,6%).There was no difference in duration of hospitalization between both groups. In this 7 postoperative day only 3 patients in A group (5,5%) complained of renal colic comparing to 11 patients in B group (20%) .No residual stone was discovered on week follow-up radiographics in both groups.

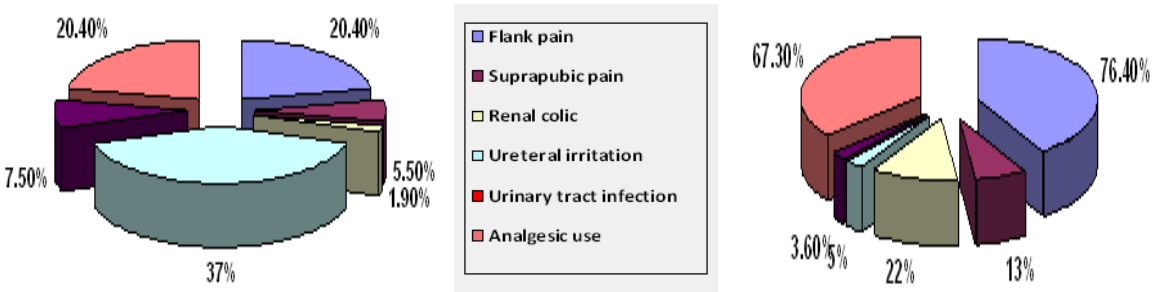
I.Patients simptomatology first postoperative day

| | A group | B group |
|---|---|---|
| Flank pain | 11 patients (20,4%) | 42 patients (76,4%) |
| Suprapubic pain | 3 patients (5,5%) | 17 patients (13%) |
| Renal colic | 1 patient (1,9) | 25 patients (22%) |
| Ureteral irritation | 20 patients (37%) | 3 patients (5%) |
| Urinary tract infection | 14 patients (7,5) | 2 patients (3,6%) |
| Analgesic use | 11 patients (20,4%) | 37 patients (67,3%) |

II. Evaluation symptoms in first week after stent-removal

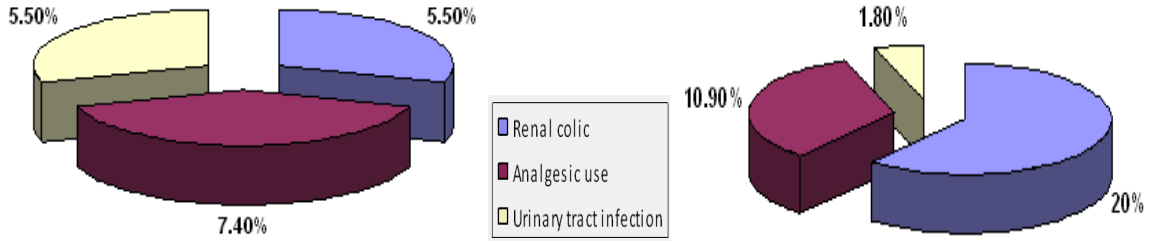
| | A group | B group |
|---|---|---|
| Renal colic | 3 patients (5,5%) | 11 patients (20%) |
| Analgesic use | 4 patients (7,4%) | 6 patients (10,9%) |
| Urinary tract infection | 3 patients (5,5%) | 1 patient (1,8%) |

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A Group B Group

I.Patients simptomatology first postoperative day




A Group B Group

II. Evaluation symptoms in first week after stent-removal

We have to mention the statistically significant decrease of the symptoms during a week after surgery comparing table I with table II.

## 4. CONCLUSION

Even if patients with stent developed urinary tract infection or ureteral irritation, ureteral stenting in uncomplicated ureteroscopy and lithotripsy has a considerable role in reducing postoperative morbidity like renal colics flank paine and analgetic usage.

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# STANDARDIZATION OF THE EXPERIMENTAL MODEL OF ISOLATED PERFUSED RAT HEART ACCORDING TO LANGENDORFF

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**ABSTRACT**

The isolated mammalian heart preparation established more than one century ago by Oscar Langendorff was critical for the current understanding of heart physiology during the last century. The model is still extensively used nowadays as the most reliable model of acute ex vivo global ischemia. The aim of this paper was to describe the standardization of the experimental model of Langendorff perfused rat heart that will be further used to:

i) study the contractile function in the setting of ischemia-reperfusion injury and
ii) to test novel cardioprotective strategies.

The setup consists of a heart whose coronary arteries are retrogradely perfused with heated and oxygenated buffer solutions through a cannula fixed in the ascending aorta, either at constant hydrostatic pressure or at constant flow rate. The ventricles contract isovolumetrically after the insertion of an intraventricular latex balloon. Global ischemia is achieved by completely stopping the coronary flow followed by different reperfusion times. Normothermic ischemia of different durations was applied and the post-ischemic recovery of contractile function was assessed in order to characterize the ischemic transition from reversible to irreversible injury. The isolated perfused rat heart represents a highly reproducible model and an important tool in modern cardiovascular and pharmacological research.

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# COMPARATIVE STUDY OF THE RAPID DELAYED RECTIFIER POTASSIUM CURRENT (IKR) IN DOG, RABBIT AND GUINEA PIG CARDIAC VENTRICULAR PREPARATIONS

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**ABSTRACT**

The purpose of the present work was to understand the large inter-species variation in the drug effect on repolarization in isolated cardiomyocytes. To this aim the properties of the rapid component of the delayed rectifier potassium current ($I_{Kr}$) were compared in myocytes isolated from dog (DM), rabbit (RM) and guinea pig (GM) ventricles by applying the patch-clamp a techniques at 37°C. The amplitude of the E-4031 sensitive $I_{Kr}$ tail current measured at -40 mV after, a 1 s long test pulse to 20 mV, in DM was 0.38±0.02 pA/pF, n=12-15) but larger in RM and GM (0.66±0.05 pA/pF and 1.0±0.08 pA/pF, respectively, n=10). $I_{Kr}$ activated rapidly and monoexponentially in each studied species. The corresponding activation time constants measured at 30 mV were: 53±6 ms in DM, 35±3 ms in RM and 30±2 ms in GM, respectively (n=6-26). The deactivation of $I_{Kr}$ in DM and RM measured at -40 mV, after a pulse to 30 mV was slow and biexponential $\tau_1$=0.4±0.02 s and $\tau_2$=3.3±0.3 s in DM ; $\tau_1$=0.6±0.03 s and $v_2$=6.5±0.3 in RM, respectively, n=8-26), while in GM the $I_{Kr}$ tail current was best fitted triexponentially ($\tau_1$=0.14±0.01 s, $\tau_2$=0.8±0.01 s and $\tau_3$=6.6±.06 s, n=10). These results suggest that $I_K$ in DM and RM resemble with those reported in human by others, and considerably differ from that observed in GM. These findings suggest that the dog and rabbit are more appropriate species than the guinea pig for preclinical evaluation of new potential drugs expected to affect cardiac repolarization.

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# METHODOLOGICAL SUPERVISING OF THE MOTOR CAPACITY DEVELOPMENT

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**Abstract**

Specialized literatures consider the psychomotor capacity as a complex function, an ability that integrates both the aspects of the motor activity and manifestations of the perceptive functions. During the volleyball players training, they make many mistakes because some inaccurate methodological extrapolations and, specially, because of the lack of knowledge of the real dimensions of the original (game model) that must be transposed into the training process by analogy and modeling. The authors fructify and combine their own scientific investigation with the investigations of some international experts, offering a valuable methodological material.

The information obtained by new record or by the specialty literature must scrupulously studied and turned to good account during the training process by the people interested in ensure the quality and the efficiency of the training process.

## 1. METHODOLOGICAL SUPERVISING OF PSYCHOMOTOR CAPACITY DEVELOPMENT OF A VOLLEYBALL TEAM FROM THE SECOND ECHELON

The psychomotor behavior of every individual evolves based on his abilities, on his physical and intellectual development and on the educational influences that he submitted during his childhood. As a complex function that determines the human behavior's adjustment, the psychomotor capacity includes the participation of different psychical process and functions that assure both the information's reception and the accurate execution of the answering acts. Thru its fundamental components the psychomotor capacity makes possible the pragmatically, esthetical, educational adaptation. Related on the psychomotor capacity, DeMeur underlined some relations that exist between motor capacity, intellect and affectivity. Although, Lapierre considered that the notion of psychomotor capacity is too large to have a precise, categorical and indisputable definition, C. Paunescu underlined that the psychology proves that the motor act represents the foundation of the knowledge and learning organization, so it considerably leads the mental organization of the individual.

Rene Zazzo considers that the psychomotor education represents a fundamental education during the elementary school, because it conditions the entire learning process. The learning process cannot be efficient if the child has not the conscience of his body or he does not know his laterality, he cannot place himself into the space, he does not control the time and he has not enough coordination and stability of his gests and movements. One of the essential life manifestations is the movement; realized by the muscles bound up with the CNS and PNS; the muscles effectively realize the body's accommodation with the permanent modifications of the exterior environment. Based on the information received, NS absorbs and gives orders that, thru the efferent nervous fibres reach to the muscles and connect them by the motor plates; the result is the muscular contractions, translated by the multiple movements made by the human body.

During the volleyball players training, they make many mistakes because some inaccurate methodological extrapolations and, specially, because of the lack of knowledge of the real dimensions of the original (game model) that must be transposed into the training process by analogy and modelling. The authors fructify and combine their own scientific investigation with the investigations of some international experts, offering a valuable methodological material

Many errors made during the players and teams training could be avoided if the technical manager (inclusive teamwork) would have the competence to give correct answers to some distinct questions, as follow:

- Which is the motor structure of the game (the original) or the causes that lead to the specific energetic solicitations and consumption?
- Which are the structural elements of the game or the technical-tactical actions that request foreground improvements of the motor, functional and psychical indicators?
- Which are the energy sources that support the effort?

- Which are the evaluation tests of the parameters and indicators that allow us to lead the training process?
- How, when and with what must begin the training? etc.

The correct answers of these questions are, mostly, depending on knowledge of the principal dimensions of the game's model (of the original or the properly game). Many specialists (foreign or Romanian) as: W. Baleserro (1990), J.O. Betran & J. Tico (1992), R. Colli & M. Faina (1985), D.E. Colibaba (1975, 2001, 2004), G. Cometti (2002), E. Generale & J. Zaragoza (1992), J. Jole (1990), M. Mandoni (1984), A. Predescu (1973, 1975), T. Predescu, G. Ghitescu (2001, 2003), L. Teodorescu, I. Portnah (1986) s.a., studied them.

Mostly of the above said authors agree that the volleyball game (the original) must be analyzed and knew thru some systemically dimensions that, under analogical conditions, can be improved during the training process. Taking into account the above said authors' opinion, but also according to our experience about solving this problem, we agree that the volleyball game model could be represented accordingly to the next dimensions that accept deductive systemically arguments:

- **Motor structure of the game** – that determines three types of functional solicitations:
  - anaerobic alactacid
  - anaerobic lactacid
  - aerobic, with alternative manifestation regime or preponderant mixed, joined by psychological (mental) solicitations and some psychological-social relations between team members.
- **Energetically systems capacity and power**

All these, together, flexibly integrate into the **Cycle of the game's phases.**

Next, we present (as far as spatially possible) the essential aspects of these dimensions and some methodological specifications of development during the training process.

**Motor structure of the game** represents "the dimension cause that provokes the phenomenon effect, namely it determines and, ulterior, it is determined by the physiological, energetically, psychological solicitations etc.

Motor structure of the game, specific to the volleyball game is identified by the follows distinct elements:

**1. Natural" skeleton" of the game** constituted by:

- fundamental motor capacities and skills (running, walking, jump, volley) mixed and adapted to the game's specific.
- motor abilities adjacent to the motor capacities and skills, hereditary or/and anterior obtained (power, speed, resistance, coordination etc);
- favorable physical development (anthropometric sizes and body constitution);
- psychomotor and psychosocial capacities, hereditary or socially learned (family, entourage, friends)

This natural motor construction (hereditary) is precious and, in the same time, very important, especially during the initial selection process. Ulterior, it is improved and consolidated by a permanent athletic training.

**2.Technical motor capacity, specific to volleyball** (the elements and the specific technical methods) represent an ensemble of movements (simple, complex, partial, integral, interdependent, cyclic and acyclic, symmetric and asymmetric), different as shape and amplitude and variably or flexibly mixed, depending on the game situation or on the adversary performance.

The most important groups of elements and technical methods are:

2.1. Ball elements and technical methods (heavy of 657 group M and 600 group F) that request a high virtuosity to control, handle and send the game object. They include:

- Diversity of the ball striking methods, when the ball is in the air - flexible, depending on the diversity of the ball catching, keeping, controlling, handling, feint, protection methods etc, and all these under the adversity and physical and psychical solicitations conditions.
- Diversity of the ball striking methods in offensive or in defence - flexible, depending on the spatial and temporal variability, on the position and reactions of the adversary, on the triple threatening feint effects, on the physical and psychical solicitation regime, on the tiredness etc.

2.2. The elements and technical methods without ball or the movement elements on the field:

- Offensive: necessary to make the individual and collective tactical actions, related to the offensive phases.
- Defense: necessary to make the individual and collective tactical actions, related to the defense phases.

**3.Team individual and collective tactical actions (offensive and defence):**

The technical structure stereotypically executed, without obstacles or opposition (adversaries, partners, referees). If they appear (lxl, 2x2, 3x3, 2x1, 3x2 etc.) then, they are consciously executed and tactically thought-out.

All the tactical actions (individual, collective, of team) contain interdependent technical elements under the form of operational schemes of game situations' resolution.

**4.Specific motor qualities** related with the technical methods and the tactical actions:

- speed, differently manifested (reaction, execution, repetition, movement) involved in the technical methods with and without ball, in the tactical actions, in the game phases, in combat on the net etc.
- speed is aided by power (0-5 sec) and capacity (5-20 sec) anaerobic alactacid. The player uses ATP and PC to make maxim efforts: short and rapid sprints, maxim repeated jumps, changing direction, acceleration - deceleration etc.
  The next forms of speed manifestation are involved:
  - reaction speed of visual, acoustic and tactile stimulus;
  - execution speed (rapidity of motor gesture);
  - repetition speed (rapidity of a motor gesture repetition);
  - movement speed - frontal, back, lateral oblique - in fundamental offensive and defence
  - position.

The force is the quality that fundaments the specific physical training of the volleyball players. According to the modern concept of training, to train for force does not necessary mean to develop the force indicators. It means, firstly, to prepare the muscular and functional system involved into the specific instruction regime, concretized by morphofunctional improvement, namely by increasing the contraction capacity, oxidation capacity, muscular flexibility, inter and intramuscular coordination, perfecting of energetically mechanism and, of course, of the force indicators. During the training of volleyball players, the next types of power manifestations have priority:

- Dynamic power that presumes the improvement of all muscular groups (m) geared by the locomotory system in the motor structure of the game, it means:
  - musculature of feet, back, arms for displacement, throwing and pass;
  - abdominal, dorsal, lumbar musculature in order to maintain the equilibrium;
  - musculature of thighs and shanks for jumps, changing the direction and defence game.
- Maximum force - realized by maximal and under-maximal charges (also named by some authors the slow force).
- Force as resistance regime (power) - to use lightly the dexterities with high frequency during the game.
- Rapid force - detente or speed as force (V+F) necessary to jump, to sprint, to strip off shortly, acceleration, change of direction.
- Explosive force (F+V) - placed at the arms' level and necessary to send the ball (pass, throwing).
- Static force and robustness – particularly necessary to the central players (pivots) in the net struggle (blocking plan's occupation, placement, body struggle, stability in field, etc.)

General aerobic resistance (aerobic capacity and power) sustains the development of the other capacities and abilities. They improve it by solicitations of medium intensity and for long time, respectively for more than three minutes the body can adapts the big effort functions, becoming stable. Anaerobic resistance or anaerobic capacity lactacid and alactacid are the quality educated by high intensity solicitations and for almost short time (20-120 sec). FOR VOLLEYBALL GAME, these solicitations time are majority. The appearance and the accumulation of the lactic acid limit the work time. The consumed energy is produced without oxygen, a very important thing for the technical dexterity under the tiredness regime or at the end of the game.

The articular mobility and the muscular flexibility assure the elasticity and the amplitude of the movements.

The skill is a complex psychomotor ability characterized by perspicacity and promptness of finding some motor solution to solve efficiently some game difficulties, anticipated or unanticipated. This ability optimally integrates or combines the next dimensions of motility:

- capacities perceptive - sensitive - representative (visual acuity, peripheral sight, kinaesthesia and spatial-temporal difference, coincidence time, ball sense, placement sense, operational schemes of action, image - body scheme, idiomatic - motor representations),
- neuromuscular coordinative capacity (general, segmental and intersegmental, eyepiece segmental), a movements precision and address,
- mobility and flexibility,
- static and dynamic equilibrium,
- agility and implementation capacity of the indicators of other motor qualities.

Some of these components of ability obtained the status of relative independent abilities, being educated by some special programs of training. Examples: education of taking precision, agility education, ball sense education etc. In volleyball game, in fact, in all sport games, we cannot solve the tactical game situations only by the coordinative capacity, therefore we plead for the concept of ability,

in the meaning of above definition.

It is important to know and to model in training: distances covered, types of displacements, displacement speed, frequency of jumps, stops, change of direction, pirouettes etc, solitarily made by each player, on the posts or integrated into the tactical actions, individual, collective and of team.

In the next tables, we mention the principal dimensions of the motor structure of game and of the specific effort of volleyball game:

Table 1. Types of important actions (according to R.Colli, M. Faina)

| No. | PARAMETERS | INDICATORS |
|---|---|---|
| 1. | Standard length of game (SLG) | SLG = 4x10 min (or 2x20) = 40 min. timed plus "n" in overtime of 5 min for finishing tied |
| 2. | Number and total length of interruptions (TLI) | Number of interruptions = about 150/match<br>TLI - about 23-30 min. without interval between quarters and reprises |
| 3. | Effective length of match (ELM) | ELM = SLG + TLI = 40 + 23 = 63 min (to 70 min) * at 63 min (100%) from which:<br>- 37% action: 10% rapid action and<br>- 27% slow action<br>- 63% interruptions 27%<br>- displacements 36% |
| 4. | Percentage weight of effort period and the interval | Effort% Interval%<br>1-10 sec 5.4% 5.1% 11-40 sec 52.0%<br>41-60 sec 14.0% 20.1% 61-90 sec 14.7% 13.8%<br>91-120 sec 8.7% 4.3% more than 120 sec: 2-3 time/match |
| 5. | Number of consecutive team action (without interruptions) | No. act. No./match x average Length%<br>1 act 16.33x19 sec 310 sec 13.0%<br>2 act 10.33x34 sec 350 sec 14.0% 41.8%<br>3 act 7.00x49 sec 343sec 14.4%<br>4 act 5.33x58 sec 307 sec 12.9%<br>5 act 5.00x85 sec 425 sec 17.8% 30.7%<br>6 act 2.33x90 sec 207 sec 8.7%<br>7 act 4.00x110 sec 444 sec 18.6% 27.3% |
| 6. | Length and causes of interruptions | 11-40 sec (52% of total interruptions) resulted from: ball out, personal mistakes, referees, technical mistakes, regulation infringement, engaging between two players<br>20 sec - free throwing after basket, player change<br>41-60 sec: free throwing, accidents, elimination for 5 faults;<br>60 sec: time-out (8x60sec) + 2x150 sec (2.3 min) in the fourth quarter for TV;<br>61-80 sec: repeated free throwing; 3 free throwing, timeout + free throwing;<br>> 120 sec: at 2/3 matches for conflicts between players, technical installations reparations |
| 7. | Solicitations density (SD) reported to the standard length of game, namely SD = SLG/TLI | SD = 40 min = 240 sec; TLI = 63 min = 3780 sec<br>70 min = 4200 sec<br>SD = 2400/3700 = 0.65% or 65%<br>SD = 2400/4200 = 0.57% or 57% |
| 8. | Modelling of sequential density of training effort (SDTE) | Length of exercise (LE) = 5 min = 300 sec from which 200 sec effective work (EWL)<br>SDTE = EWL/LE = 200/300=0.67 or 67% |
| 9. | Training density (TD) | Training length 120 min = 7200 sec Length of effective work 55 min = 3300 sec TD = 3300/7200 = 0.45 or 45% |

Table 2. Intensity of solicitations for each post

| ACTIONS/QUARTERS | I | II | III | IV | TOTAL |
|---|---|---|---|---|---|
| Sprints | 3 | 3 | 2 | 2 | 10 |
| Sprints with ball | 1 | 1 | 0 | 0 | 2 |
| Accelerations - offensive | 12 | 18 | 19 | 6 | 55 |
| Slow running | 29 | 28 | 40 | 22 | 119 |
| Slow running with ball | 4 | 2 | 3 | 4 | 10 |
| Normal defence | 12 | 9 | 12 | 11 | 44 |

Table 3. Types of actions

| TYPES OF ACTIONS | PERCENTAGE |
|---|---|
| Reserves' bench | 3% |
| Running with or without ball | 36% |
| Acceleration with or without ball | 6% |
| Sprints | 2% |
| Rapid actions - offensive | 10% |
| Defence | 10% |
| Interruptions (intervals) | 14% |
| TOTAL | 100% |

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Table 4 Types of actions

| TYPES OF ACTIONS (cardiac frequency/min.) | BACK | EXTREME | CENTER |
|---|---|---|---|
| Defence of player with ball | 172 | 171 | 169 |
| Defence without ball | 167 | 166 | 164 |
| Defence of weak part | 164 | 154 | 154 |
| Slow attack passing | 167 | 162 | 161 |
| Average speed passing | 174 | 171 | 170 |
| Rapid passing | 175 | 175 | 177 |
| Rapid passing by dribbling | 195 | rarely | no |
| Throwing (jump, running) | 208 | 207 | 204 |
| Jumps tracking (offensive/defensive) | 178 | 174 | 180 |
| lxl without ball | 169 | 166 | 167 |
| lxl with ball | 183 | 178 | 178 |
| Ball blockage (stop) | rarely | rarely | 175 |
| Game interruptions | 150 | 158 | 153 |
| AVERAGE SOLICITATIONS ± S | 175.2 ±15 | 171 ±14 | 171 ±14 |

Table 5 Anaerobic alactacid system

| TYPE OF EFFORT dimensions | ANAEROBIC ALACTACID | |
|---|---|---|
| | CAPACITY | POWER |
| Optimal work time | 5-20 seconds | 1-5 seconds |
| Optimal work intensity | 95-100% of maximum intensity during the entire work time | 90-100% of maximum intensity or of individual possibility |
| Cardiac frequency (control) | Over 210 beating/min. | Over 200 beating/min. |
| Restoration (necessary pause) | 60-180 sec between repetitions<br>6-8 min between series, 70% of energetically reserves recovery in one minute 100% of energetically reserves recovery in 3 minute | 120-180 sec between repetitions<br>6-8 min between series |
| What we educate, develop, coach | - speed resistance, force<br>- speed + force, force + speed<br>- technical abilities < 10 sec<br>- tactical abilities < 10 sec<br>- power, agility < 10 sec | Maximum force<br>- speed + force<br>- force + speed |
| Examples of means and methods | 4-5 x 100m at maximum speed<br>4-5 repetitions at 95-100% of maximum force<br>10-15 maximum jumps with a heavier belt (3-10 kg) | 4 series x 4 x 30m maximum speed<br>-1-2 heaving weights 100-110% of maximum force<br>- 1-2 maximum jumps with |
| Verification tests | pushing of bells from dorsal lying position | weight of 10-20 kg sprint with medium time on 10,20 and 30m<br>- detente - Bosco jumping board |
| Influence factors | ATP and PC muscular reserves - enzymatic activity | |
| Other recommendations | - Every series must work for power maximum 1 minute before resting.<br>- Total volume of rest of real work time must vary between 3 and 6 min. | |

Table 6 Anaerobic lactacid system

| TYPE OF EFFORT dimensions | ANAEROBIC LACTACID | |
|---|---|---|
| | CAPACITY | POWER |
| Optimal work time | 1-3 min 60-90-180 sec | 20-60-90 seconds |
| Optimal work intensity | 90-95% of maximum intensity | 90-100% of maximum intensity |
| Cardiac frequency (control) | 180-220 - young people 160-200-adults | 180-210 beating/min. |
| | UNDERMAXIMU | M |
| Restoration (necessary pause) | 2-5 min between repetitions<br>8-15 min between work series | 5-15 min for 60-90 sec solicitation<br>2-5 min for 20 sec solicitation |
| What we educate, develop, coach | - speed resistance<br>- effort resistance<br>- musculature | - muscular force<br>- detente |
| Examples of means and methods | - 3 series 2x600m<br>- technical-tactical exercises of intensity 90-95%<br>- modelling practical exercises<br>- relation 3x3, 4x4, 2x2 on the entire field | -4 series x 4 x 300m with 3 min interval between the repetitions and about 10 min between series<br>- active pause: respiration exercises, stretching, basket throwing etc. |
| Verification tests | - how much they run in 3 min, maximum speed | - little marathon<br>- big marathon |
| Influence factors | Lactacid concentration allows to continue the effort | |
| Other recommendations | - Real work volume for every series 2-4 min<br>- Real work volume on 10-12 min interval | |

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Table 7 Anaerobic energetically system

| TYPE OF EFFORT dimensions | AEROBIC | |
|---|---|---|
| | CAPACITY | POWER |
| Optimal work time | Over 15 min | 3-5 (6) min 180-300-360 sec |
| Optimal work intensity | 70% of maximum intensity | 80-85% of maximum possible, even 95% of possibilities |
| Cardiac frequency (control) | X=120±20 | - young people - 220 ± beating/min.<br>- adults = 160 ± beating/min.<br>- for under maximum intensity<br>CF max - minus 5-10 beating/min. |
| Restoration (necessary pause) | It is not necessary. Tiredness does not appear | - for effort of 5 (6) min<br>- recovery = *Vi* + *lA* of effort length<br>- or CF diminishes to 90-110 beating/min.<br>- for 10 min solicitation, active recovery of 5 min |
| What we educate, develop, coach | - general resistance - ability<br>- learning of technical methods | - endurance<br>- substantiation of speed resistance -force<br>- speed technique and tactics |
| Examples of means and methods | - running on the flat field, varied with average tempo, uniform | - 3x400m<br>- 3x500m<br>- 3x800m<br>- 3x100m; - 3x1500m, technical-tactical exercises during 3-5 min, under maximum intensity |
| Verification tests | - Jogging; Speed - Talck; Fartlek<br>- cross 5-15 km (M), 3-5 km(F)<br>- Cooper = 12 min<br>Long technical-tactical complex<br>- Cooper, Karvonen tests etc | - 400,800,1000 m<br>- Brue-Gacon bicycle<br>- Leger - Bouchet shuttle |
| Influence factors | | - Oxygenation capacity of the body<br>- Energetically and endocrine system<br>- Cardiovascular and respiratory system<br>- Respiratory frequency and vital capacity<br>- Diaphragm - costal respiration |
| Other recommendations | - Global work volume about 20-60 min during preparation time | 10-20 min during before competition time;<br>10-15 min during competition time |

## 2. Comments

### a)Getting the energetically resources

The secret of fructifying these effort dimensions is revealed by the three sources of energy, supplied to the muscle, that is to say:

First anaerobic alactacid system: muscular fibres use ATP molecules adenosine-triphosphoric and PC (phosphocreatine), directly from their content. This delivering of energy phenomenon lasts 10 sec when we work at maximum intensity; Second anaerobic lactacid system: production of ATP made by aerobic glycolysis of blood, where the muscular glycogen and blood glucose (both carbohydrates substances) are separated (metabolized), producing high coefficient ATP. ATP + PC and the glycolysis systems are anaerobic (they do not need oxygen). Glycolysis allows to muscle to work at very high intensity, but it leads to the formation of lactic acid in muscles and blood. Accumulation of the lactic acid leads to a slow anaerobic glycolysis and to the installation of tiredness after about 3 min of intense work. Therefore, to reduce the lactic acid of muscles and blood, we have to interrupt the effort or to continue it but at a diminished intensity. Consequently, we find the third energy source, namely aerobic way; The third aerobic way: supplying energy for efforts longer than 2-3 min, when all the three systems are involved (ATP+PC; glycolysis - aerobic system). Energy sources contribution is very important to establish the length, intensity and methods of work.

### b)Capacity and power of energetically systems

In volleyball, the aerobic efforts alternate with the anaerobic efforts (especially, lactacid and, more rare, alactacid). Episodically, there are phases or short moments (10-20 sec) of time when the players solicit their bodies at maximum (220 beatings/min). It supposes to pass in anaerobic alactacid status and to reach the functional anaerobic lactacid status underlined by apparition of lactic acid in muscles (example: continue pressing all over the field with contra attack, throwing, body struggle under the panel, repeated jumps about 10-20 sec + continue other actions 90-100 sec).

During the game, all the three types of solicitations, above mentioned, appear, it means anaerobic alactacid, anaerobic lactacid and aerobic. In all mentioned energetically systems, we have to make the difference between capacity and power, namely:

- Capacity represents the total energy that the player disposes to accomplish the requested solicitations or the energetically availability for a large work volume - work resistance under anaerobic alactacid regime, anaerobic lactacid regime and aerobic.
- Power (potentiality) represents the intensity of respective solicitations manifestation - body reaction speed or vitality.

Therefore, it is very good to know exactly the optimal stimulus of the capacity (anaerobic alactacid, anaerobic lactacid and aerobic) and the optimal stimulus of the power of these energetically systems. This is a very important aspect of training process, especially, when the subject is the development of the motor abilities that, without some optimal stimulus, do not lead to the expected progress.

In the same time, it is recommendable to begin by education of the energetically capacity and ulterior, of the energetically power.

**c) Energetically resources recovery**

The relation between the consumed energetically process and the resources recovery was studied and it is, generally, known. In this way, T. Bompa (2003, p.209) offers us the next table of the three energetically systems restoring:

Table 8. Restoring time of the three energetically systems

| ENERGETICALLY PROCESS | MINIMUM | MAXIMUM |
|---|---|---|
| Restoring of muscle phosphagen (ATP and CP) | 2 min | 3-5 min |
| Length of lactic acid 02 elimination | 3 min | 5 min |
| Myoglobin restoring | 1 min | 2 min |
| Length of lactic acid 02 elimination | 30 min | 60 min |
| Resistance of muscular glycogen:<br>a) after intermittent activities<br>b) after a long, continue activity | - 2hours to recover 40%<br>- 5hours to recover 55%<br>- 25hours to recover 100%<br>- lOhours to recover 60%<br>- 48hours to recover 100% | |
| Lactic acid elimination from muscles and blood | - 10 min to eliminate 25%<br>- 25-30 min to eliminate 50%<br>- 60-75 min to eliminate 95% | |
| Resistance of hepatic glycogen | unknown | 12-24 hours |

To know the lactic acid accumulations and its elimination time is very important for a coach (table 8).

**c) Methodological development**

The information presented in the previous tables must turn to good account during the training process:

| Firstly, define these lengt | ı steps in order to identify the work system: | |
|---|---|---|
| ANAEROBIC ALACTACID | ANAEROBIC LACTACID | AEROBIC |
| ATP + PC | Aerobic glycolysis | aerobic |
| 1 - 10 sec | 10 sec-3 min | Over 3 min |
| Sprints, change of direction, jumps etc | Continue effort | Game length |

This bio-energetically scheme is very important so that the player could endure the effort of this kind: defensive pursuit + contra-attack sprint + throwing and offensive pursuit with the defender opposition. This kind of action of high solicitation leads to the exhaustion of all energetically resources in 7 - 10 sec, from which only the contra-attack last 4-5 sec; the recovery of this energy last 20 sec 9if the player interrupts the effort) or he "moves down" on the aerobic recovery fund of some lower intensity exercises.

During the match, a low concentration of lactic acid accumulates in blood and there is a small recovery of this energetically metabolism. A training program must content the next elements:

- Number of sprints: minimum 3 sprints
- Cover distance begins, for example, with 800 m, and then the running distances become shorter to maintain a high intensity: 2x400; 4x200; 8x100; 4x100 and 8x50m etc.
- Effective work time (example, 30 sec)
- Rest interval: at the beginning 90 sec and then, according to the covering distance time.
- Solicitation/repose relation: 1:3; 1:2; 1:1.
- Total covered distanc4e during a training (it must be more than 3200 m; 2 - 2.5 miles, according to S. Brown, 1993).

Number of training on week

- medium and long running: 2-4 x/week;
- short sprints: 3-5 x/week.

Other methods of anaerobic functional capacity development:

- accelerated running alternated with walking or jogging;
- fartlek adapted to high intensity efforts.

Examples: 400 jogging + 200m walking + sprints alternated by 100m walking (10 min) + running on the hill 100m and 100m walking (6 min) + sprint of 50 m alternated by 50m walking (3m). Under the limits of anaerobic solicitations, appears also the development strategy of speed, detente, agility, maximum force and power. For develop the named qualities they use the so-called

neuromuscular training, with the follows amendatory: a more efficient sending of the nervous impulses to the effectors muscles, a more efficient coordination inter and intramuscular, collection of more rapid muscular fibres that act stronger in order\r to make the movements.

Neuromuscular strategy belongs to the next methodological way (conf. T. Bompa, 2003; Colibaba, 2004, G. Cometti, 2002 etc):

1. Adaptation period of the body or the period of morphofunctional substratum preparation and of the cardio respiratory system for the next neuromuscular solicitations. This step lasts about 3-6 weeks, depending on the age, experience, training level, training time etc. They work especially for the entire musculature (global or selective for the stabilizer musculature), for the resistance, skills, technique etc. (conformable with the training time - phase I).
2. Maximum force development (Fmax) high charged (70-110%) and few repetitions (1-2). Fmax development means the development of the recruited rapid fibres (FT - fast twitch = fibres). This result appears only by rising heavy dumb bell. Work time for Fmax is about 4-6 weeks. They use different weighting exercises as the genuflections, abdomens, rising on the toes etc. (training, phase II).
3. Power development or the improvement of the coefficient of engagement or discharging the rapid muscular fibres. On this purpose, they use some charges lower than 70% of maximum possibilities, but made with maximum rapidity. They use explosive, rapid and strong movements as jumps, sprints, throwing etc. On this purpose, they use plyometric exercises, with medicinal balls, agility exercises, jumps with genuflections, acceleration-deceleration with the medicinal ball etc. They work 4-5 weeks (2 training x 30 min) necessary recovery 1-4 min after each exercise; (it corresponds with training phase III or before competition).
4. Maintenance of Fmax and power index during the competition time for keeping the neuromuscular adaptations anterior realized (detente, speed, agility etc.). Therefore, they work also during the competition time, for force and power 2 times every week (it corresponds with the competition time).
5. During the transition time, we try to maintain the force anterior obtained. Generally, they work, 2 times every week of 40-60 min, low charge for the antagonistic and stabilizer muscles.

Aerobic energetically system (oxidative)

- It needs at least 3 min effort to install the real stable condition (stady sted); it means equilibrium between the oxygen contribution and the oxygen necessity of the body. Generally, they work for the aerobic system minimum 10-20 min during the competition time and depending on the training level presented during the training time.
- We must distinguish the differences between the aerobic capacity and the aerobic power;
- Aerobic capacity is educated by appliance of low and medium intensity efforts that last more than 15 min. In volleyball, they use long running (until 60 min), uniform rhythm, 70% maximum intensity, cardiac frequency of 120-164 beating/min;
- Methods: continue effort, Fartlek, Talk-Speed etc.
- Aerobic power needs efforts of 3-5 min, 80-95% maximum intensity; lot of energy consumption; it ensures the foundation of the physical condition in volleyball; it is recommendable to work at under maximum intensity and with pauses of 1/3 and ¼ of effective work time. Example - a 3 min effort = 3x60 sec = 180 sec; 1/3 and ¼ of 180 = 90 and 45 sec; in pause, FC recoveries about 120 ± beating/min.
- Aerobic training is considered one of the most efficient recovery means. In this way, after a very hard period, when we are very tired, we can use the aerobic training to oxygenate the body, to eliminate the toxins by perspiration and the lactic acid by its decompositions in contact with $O_2$.

**Cycle of the game's phases**

The game is permanently animated by the battle between the two teams in order to win the ball. This dispute is limited by a series of moments that indicate the game's phases for the both teams. Figure 1 surprise very well these game's moments and phases which, joined by records (numbers) permit us to make a close analyze of the game performed by team and by every player apart. From presented photo, it is important to remember:

a. when the team A get the ball, it begins a five moments cycle (I-V) who, ideally, should finish by success (V);
b. team B simultaneously goes through the same moments and phases in reverse order (V-I), it means in defence. It is ideal that the team B gets as rapid as possible the ball, before the team A reaches the final phase;
c. the number of ball possessions cannot be equal for the both teams. Difference appears when the ball does not belong to any team, respective: at the beginning of the match, during the engaging between two and, especially, during the offensive and defensive followings, when the ball does not belong to anyone (consequently appears the rule "who dominate the net wins the game"!);

d. calculate the length of the attack and defence phases in order to appreciate the game tempo; find the optimal rhythm and tempo for your own team.

To improve the game performed by the personal team and to settle some real instructional objectives, it is recommendable to proceed as follow:

- Analyze very carefully the ball winning moments (I) and the ball loss moments (V).
- Analyze the other game's moments and phases to identify the strong and the weak points of the game performed by your team.
- Systematize the conclusions on three game components: attack, defence and panel follow (offensive and defensive). In this way, it will be much easier to make the algorithm of the objectives based on the training periods.
- All the game sequences (moments, phases, relations, game tempo etc.) are trainable.
- You can analytically approach them, in cyclic succession, in antagonistic relation, under physical and psychical solicitation or under analogical conditions.
- Try to identify any relations between the effort's dimensions and the cycle of game's phases.

## 3. Conclusions

The information obtained by new record or by the specialty literature must scrupulously studied and turned to good account during the training process by the people interested in ensure the quality and the efficiency of the training process. Nevertheless, we underline the next significant conclusions:

- it is the principal dimension of the original that must be scrupulously analyzed for avoid the incorrect extrapolations from other disciplines (athletics, dumb bell etc) and the methodological confusions committed in solving the training objectives. Essentially, this motor structure specific to volleyball supposes the transfer and the modelling of the work regime of the locomotory system, by training; it includes the adjacent anticipated improvement (morphological, functional, energetically and psychological).
- Volleyball is a sport game with a great motor diversity and complexity that alternatively implicates the three mentioned energetically mechanisms: anaerobic alactacid, anaerobic lactacid and aerobic. Alternation or combination of the solicitation is limited by the next relative values:
  - 10-30 sec - anaerobic alactacid + anaerobic lactacid
  - 30-90 sec - anaerobic lactacid + anaerobic alactacid
  - 90-120 sec - anaerobic lactacid + aerobic
  - identify the optimal relation between solicitation regime and the length of the optimal rest intervals;
  - limit the instructional objectives directed to the capacity and power of energetically systems.

From the specific motor qualities, much confusion appears during the training for force development. In this view, we specify the follows:

- in present, they use the force training as principal mean of muscular system preparation, of contraction capacity, of inter and intramuscular coordination, of oxidation, of muscular flexibility, of energetically mechanisms improvement, of force indicators etc. that, together, contribute to the permanent increase of physical specific training level;
- during the traditional training, they worked according to the Russian pyramid model, it means with small charges (8 x 70-75%) and it ended with big charges and small number of repetitions (1x100%). consequently, they worked for resistance, for slow fibres (slow-twitch =ST - red). Today, after a period of muscular system global training, they begin by very big charges (1-2 x 85-110%) and, gradually, they pass to lower charges and more repetition. As a second variant, they work for rapid muscular fibres (fast-twitch = FT-white) and they consider that the neuromuscular system is relaxed and prepared for increasing the maximum force;
- attention when they pass from the specific training for maximum force development to the power development and resistance training;
- use alternatively and/or in combination the muscular contraction types (concentric, eccentric, plyometric, isometric and by electro-stimulation).

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# INFORMATION TECHNOLOGY SYSTEM FOR THE EVALUATION OF PHYSICAL EDUCATION TESTS

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**Abstract**:
This work presents an IT system made in order to eliminate subjectivity during the assessment of the baccalaureate candidates at the physical education and sport test, and at the same time to grade them in real time. The IT system also has the capacity to offer the specialists in the field information regarding the strong and weak points of the candidates' training for taking this test, through different statistic data.

**Keywords**:
Baccalaureate, evaluation, methodology, databases

## 1. THEORETICAL CONSIDERATIONS

During the 2009 baccalaureate examination, the education discipline comprised in the Physical Education and Sport curricular area is an optional discipline within the F test, for the students of high schools with profiles different from the ones with sports program.

At the practical test Physical education and Sport all candidates from high schools belonging to all profiles and specializations can register, irrespective of the number of specialty classes allotted according to the curricula of the education system.

The candidates that opt for this test take full responsibility regarding the compatibility of their own level of sport preparation with the level of exigency imposed by the Baccalaureate Examination.

Competences that evaluate the level of general and specific motive capacity of practicing 4 sport disciplines/tests.

Each candidate will be evaluated at 4 tests:

*Test I*: One test chosen from the following:

1. 50 m speed running, start from the ground;
2. Distance weight throwing from the spot;
3. Length jump at the sand pool with take-off.

*Test II*: One test chosen from the following:

1. Jump over the buck in wide hold;
2. Imposed exercise from acrobatic gymnastics.

*Test III*: One test chosen from the following:

1. Push-ups
2. Torso lifts from lying down on the back;
3. Length jump from the spot.

*Test IV*: One test chosen from the following:

1. Technical structure from basketball;
2. Technical structure from volleyball;
3. Technical structure from handball.

All the 4 tests are compulsory for the candidates and they are marked individually for the performance obtained at each test.

After each test, a member of the Examination Board reads out loud to each candidate the performance, the mark received and its effect.

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For the optional acrobatic gymnastics and sport game tests the marking takes place based on observing the performance. The examiners appreciate the candidates' performance individually, with integer grades; the difference between the grades must not be bigger than one. The grade given by each of the two examiners reflects the structures' correctness, fluency, expressiveness and/or efficiency. The final grade at these tests is the arithmetic means of the grades given by the two examiners.

For the 2 tests, the grading takes place by transforming performances into grades, according to table 1. The grading is done only using integer grades.

Tab. 1. Transforming performances into grades

| Measurable sport tests | Grade 5 | | Grade 6 | | Grade 7 | | Grade 8 | | Grade 9 | | Grade 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Boys | Girls | Boys | Girls | Boys | Girls | Boys | Girls | Boys | Girls | Boys | Girls |
| 50 m speed running, start from the ground (sec.) | 7.5 | 8.5 | 7.4 | 8.4 | 7.3 | 8.3 | 7.2 | 8.2 | 7.1 | 8.1 | 7.0 | 8.0 |
| Length jump from the spot (m) | 2.15 | 1.65 | 2.20 | 1.70 | 2.25 | 1.75 | 2.30 | 1.80 | 2.35 | 1.85 | 2.40 | 1.90 |
| Push-ups (no. of repetitions) | 19 | 9 | 20 | 10 | 21/22 | 11/12 | 23/24 | 13/14 | 25/26 | 15/16 | 27 | 17 |
| Torso lifts from lying down on the back | 17 | 15 | 18 | 16 | 19/20 | 17/18 | 21/22 | 19/20 | 23/24 | 21/22 | 25 | 23 |
| Distance weight throwing from the spot (m) | 5.40 | 3.80 | 5.65 | 4.15 | 5.90 | 4.40 | 6.10 | 4.60 | 6.30 | 4.80 | 6.50 | 5 |
| Length jump at the sand pool with take-off (m) | 4.0 | 3.00 | 4.10 | 3.10 | 4.20 | 3.20 | 4.40 | 3.40 | 4.60 | 3.60 | 4.80 | 3.80 |

For all the tests the candidates have only one trial, except for the length jump from the spot. For the sport games:

- The board appoints the person who will pass the ball to the candidate;
- If the performance is encumbered or interrupted due to the passer's fault, the board can rule its repetition without disqualifying the candidate.

The passer will be placed in a 1-meter radius circle drawn as follows:

- At the intersection of the centre line with the lateral line of the field (basketball, handball, football);
- In the center of area 2 (volleyball).

The candidates will start their performance:

- From the free throwing line of the field (basketball);
- From the centre of the 6m semicircle line of the field (handball);
- From the back line of the field anywhere on its length (volleyball);
- From the back line of the handball ground (football).

The tests will be held:

- For basketball: with rings situated at the proper height;
- For handball: with balls of specific sizes, different for boys and girls;
- For volleyball: with the network situated at proper heights, different for boys and girls;
- For football: on the handball ground.

## 2. APPLICATION PRESENTATION

The students' option for sustaining the practical test at the Physical Education and Sport school subject within the Baccalaureate Examination is done on individual cards in due time, as foreseen in the Regulation, cards that must be registered at the secretariat of the school they belong to.

According to the material equipment of the school mixed or unisex candidate groups are created so as to ensure their proper examination.

The compulsory order of the Baccalaureate practical test performance is the following:

1. The chosen test of the 1st test group;
2. The chosen test of the 2nd test group;
3. The chosen test of the 3rd test group;
4. The chosen test of the 4th test group;

The candidates that opt for the sport tests of Physical education and Sport have to show the medical approval "CAPABLE OF PERFORMING THE SPORT TESTS AT THE 2009 BACCALAUREATE EXAMINATION", which is a compulsory condition for examination enlisting.




Fig.1 The interface of the IT system

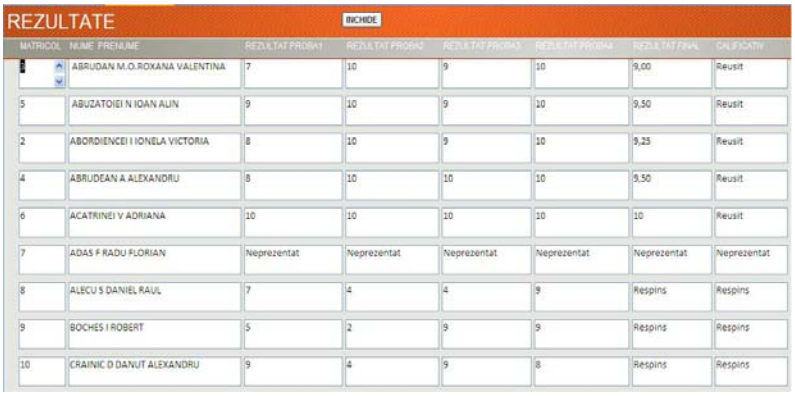
This IT system can centralize the data at the county level, which will allow the specialty inspector the possibility to perform a SWOT analysis with a view to reconciling the analytical programs with the result reality.




Fig.2. The enlistment card

Thus a database has been made which offers the examiner the possibility to evaluate in real time the candidates enlisted for this test. The interface allows the effortless identification of the following elements, namely:

- The candidates' enlistment cards;
- The candidates' last and first names;
- The tests chosen by the candidates;
- The list with the candidates enlisted for this test;
- The results and statistics.


REZULTATE

INCHIDE

| MATRICOL | NUME PRENUME | REZULTAT PROBA1 | REZULTAT PROBA2 | REZULTAT PROBA3 | REZULTAT PROBA4 | REZULTAT FINAL | CALIFICATIV |
|---|---|---|---|---|---|---|---|
| 1 | ABRUDAN M.O.ROXANA VALENTINA | 7 | 10 | 9 | 10 | 9,00 | Reusit |
| 5 | ABUZATOIEI N IOAN ALIN | 9 | 10 | 9 | 10 | 9,50 | Reusit |
| 2 | ABORDINCEI I IONELA VICTORIA | 8 | 10 | 9 | 10 | 9,25 | Reusit |
| 4 | ABRUDEAN A ALEXANDRU | 8 | 10 | 10 | 10 | 9,50 | Reusit |
| 6 | ACATRINEI V ADRIANA | 10 | 10 | 10 | 10 | 10 | Reusit |
| 7 | ADAS F RADU FLORIAN | Neprezentat | Neprezentat | Neprezentat | Neprezentat | Neprezentat | Neprezentat |
| 8 | ALECU S DANIEL RAUL | 7 | 4 | 4 | 9 | Respins | Respins |
| 9 | BOCHES I ROBERT | 5 | 2 | 9 | 9 | Respins | Respins |
| 10 | CRAINIC D DANUT ALEXANDRU | 9 | 4 | 9 | 8 | Respins | Respins |




Fig.3. The enlistment card and result registration




## 3. CONCLUSIONS

By using this database the following will be achieved:

- identification and checking of candidate data;
- correct assessment (not subjective) and in real time of all the candidates;
- data centralization for all test types;
- listing the candidates' performances and grades for each test;
- statistic reporting of the grades received by the candidates for each test.

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# USING TAMSULOSIN FOR DISTAL URETERAL STONE CLEARANCE WITH OR WITHOUT SHOCK WAVE LITHOTRIPSY

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**OBJECTIVES:**

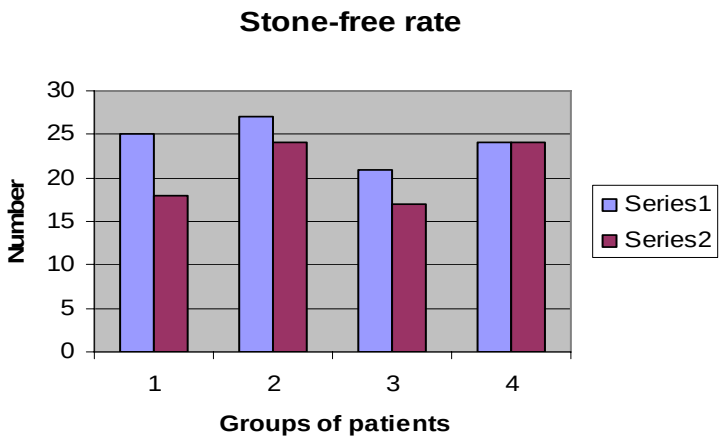
The aim of the present study is to evaluate whether there is a significance of using alpha-1-blocker (Tamsulosin) on stone clearance in patients with ureteral stones who underwent either shock wave lithotripsy (SWL), or were followed up with standard hydratation and anti-inflammatory treatment. The Alpha-1 blocker action to the alpha-1 receptor that is located in muscular cell in ureteral wall bladder wall and uretral wall that are relaxing effect and favorised to expulsion the stones. Ultrasound wave litotripsy using the high energy wave focused for disintegrated the urinary calculi without tisular lesion. In this study I use Siemens Lithostat lithotritor with two focalizer system-radiologic and ultrasonic.

**Key words:**

alpha-1-blocker, Tamsulosin, ureteral calculi,shock wave lithotripsy

## 1. MATERIAL and METHODS

In the present study, I investigated 97 patients-61 men and 36 women-who had distal ureteral stones. Patients were divided into the following groups: the first group consisted of 52 patients with stone less than 6 mm (range 2-6mm,on averge 4,1+/-0,06mm) and the second group consisted of 45 patients with stone greater than 6mm (range 6-15mm,on averge 8,9+/-0,14mm) who underwent SWL. The first group were randomly divided into two subgroups: patients of subgroup A(n=25) were followed up with standard regime of management: oral hydratatin and anti-inflammatory treatment; patients of subgroup B (n=27) were received Tamsulosin 0,4mg daily in addition to the standard gegime. The second group consisted of 45 patients with stones greater than 6mm who underwent SWL were randomly divided into two subgroups: those who did not-C subgroups(n=21)-and those who did receive Tamsulosin 0,4mg daily-subgroup D (n=24).Weekly all patients were reevaluated with plain abdominal X-rays and renal ultrasonography. Duration of investigation was 28 day or until expulsion of the stones.




## 2. RESULTS

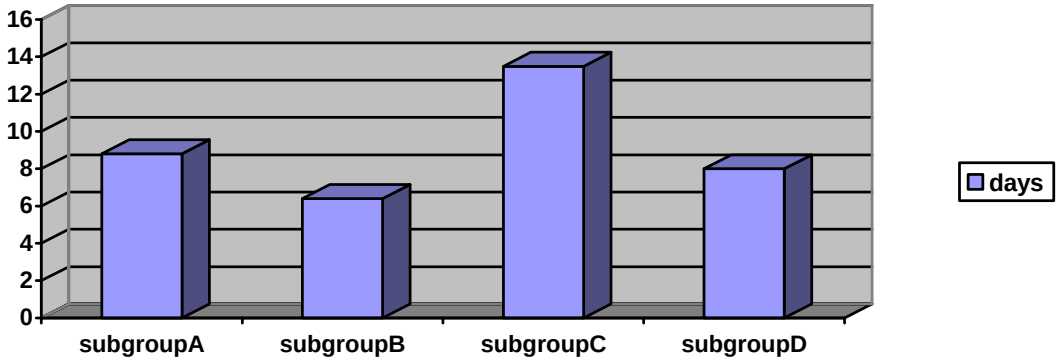
Of the 97 patients 83 (85,5%) become stone -free. The stone –free rate was: subgroup A 18 patients (72%), B 24 patients (88,9%), C 17 patients (80,9%) and D 24 patients (100%).

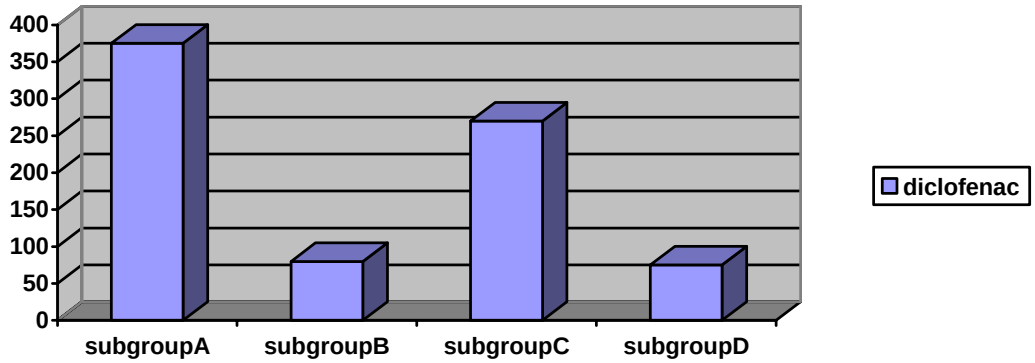
The best results were archieved in those who underwent SWL and additionally took Tamsulosin (subgroup D). The differences between the stone-free rates for subgroup C versus D (p=0,008) were statistically significant but subgroup B versus A (p=0,23) were statistically insignificant. The duration of expulsion of stones was on averge: 8,8 days subgroup A,6,4 days B,13,5 days C and 8 days D.

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### 3. MEDIUM TIME IN DAY UNTIL EXPUSION OF STONES

Differences between subgroup A and B(p<o,oo1),were statistically significant, but C and D (p>0,05) were statistically insignificant. The mean anti-inflammatory consumption (diclofenac 50mg) during the treatment period was:375mg subgroup A, 80mg B, 270mg C and 75mg D.Difference between subgroup A and B(p<0,05),C and D(p<0,05) were statistically significant.




### 4. CONCLUSIONS

The results of the present study demonstrate a positive effect of using Tamsulosin in addition to the standard regime in shortening the time necessary for expulsion of the ureteral calculi also when combined with SWL. Also it was evident that using of Tamsulosin accompanied with less painful condition and reduced the consumption of anti-inflammatory.

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# PRODUCTION OF CELLULOLYTIC ENZYMES ON AGRICULTURAL WASTE BY DIFFERENT ZYGOMYCETES

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**Abstract**:
Filamentous fungi are good producers of different extracellular enzymes. Due to this feature, some of them assumed to play an important role in the decomposition of plant and other organic materials. Several members of the class Zygomycetes are involved in different biotechnological applications, in consequence of their efficient extracellular enzyme production. Because of the increasing interest in the microbial biodegradation, isolates of *Mucor corticolus* (syn.: *M. circinelloides* f. *corticolus*) and *Gilbertella persicaria* were screened for their secreted cellobiohydrolase (1,4-β-D-glucan cellobiohydrolase) and beta-glucosidase activities. These enzymes are key-players in the microbiological degradation of cellulose biomass. The aim of the present study was to evaluate the production of these cellulolytic enzymes on a cheap, exploitable agricultural waste. To investigate the production of cellobiohydrolase and beta-glucosidase, solid-state fermentations were performed on chopped corn-stalks and corn leaves as carbon source. Cultures incubated at 25°C for 12 days were repeatedly sampled to monitor changes in the enzyme activities. Results show that isolates of both species showed intensive growth on these substrates, and high activities of the investigated enzymes were observed during the fermentation period. The potential application of these fungi for biodegradation and enzyme production is discussed.

**Keywords**:
*Gilbertella*, *Mucor corticolus*, solid-state fermentation (SSF), cellobiohydrolase, beta-glucosidase

## 1. INTRODUCTION

Corn is a major crop in the eastern European countries and therefore large amount of corn stalk arise as agricultural waste. Bioconversion may convert corn stalk to ethanol, which is a clean burning fuel and chemical feedstock. Utilization of this resource requires hydrolyzes of cellulose to fermentable reducing sugars in the first step. Cellulases, responsible for the hydrolysis of cellulose, are complex mixture of enzyme proteins with different specificities to hydrolyze the β-1,4-glycosidic linkages bonds. Three major enzyme activity classes are found in the cellulose enzyme complex [5]: endoglucanases (EC 3.2.1.4), cellobiohydrolases (1,4-β-D-glucan cellobiohydrolase; EC 3.2.1.91) and beta-glucosidases (β-D-glucoside glucohydrolase; EC 3.2.1.21). Cellobiohydrolase is the major component of the fungal cellulase systems accounting for 40–70% of the total cellulase proteins [4]. Cellobiohydrolases remove monomers and dimers from the end of the glucan chain. Beta-glucosidase hydrolyzes glucose dimers and in some cases cellulose oligosaccharides to glucose [2].

Zygomycetes fungi are widely distributed in soil and plant debris, on dung and other moist organic matter in contact with soil. Some species cause fungal rots, especially in fruits and vegetables, while others are important as spoilage microorganisms of certain foods. Several members of this fungal group are well known from biotechnological applications in consequence of its effective extracellular enzyme production [13-16]., e.g. mainly proteases

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and lipases [12, 1]. Solid-state fermentation (SSF) is a process carried out in the absence or near absence of any fluid in the space between particles [9]. In comparison with other processes used for enzyme production, SSF has the advantage that it allows the usage of solid agricultural and agro-industrial residues as a substrate for microbial growth [10, 11]. Such residues have yielded good results in the production of cellulases and xylanases [3, 8]. Currently, the rapidly evolving biotechnological applications require the isolation and characterization of new cellulose-degrading microorganisms. The aim of the present study was to investigate the production of cellulolytic enzymes by *Gilbertella persicaria* and *Mucor corticolus* on corn stalks and corn leaves as sole carbon source.

## 2. THE STUDY

*Strains and culture conditions.* In this study, *Gilbertella persicaria* (G1) and *Mucor corticolus* (M21; syn.: *M. circinelloides* f. *corticolus*) strains were used. Isolates were maintained on malt extract agar slants (0.5% malt extract, 0.5% yeast extract, 0.5% glucose, 1% $KH_2PO_4$, 1.5% agar) at 4 °C. For the solid-state fermentation, Cultivation of fungi was performed in 250 ml Erlenmeyer flasks; the culture medium contained 5 grams of chopped corn stalks and corn leaves moistened with 5 ml distilled water. Autoclaved media were inoculated with $10^6$ spores and incubated at 25 °C for 12 days.

*Sample preparation:* Fungal cultures were extracted with 50 ml distilled water at 4 °C for 3 h. After filtration, extracts were centrifuged (10.000 x g, 20 min, 4 °C) and the supernatant was assayed for enzymatic activities.

*Enzyme assay:* Beta-glucosidase and cellobiohydrolase activities were measured using the appropriate *p*-nitrophenyl-β-D-glucopyranoside (pNPG, Sigma) and *p*-nitrophenyl-β-D-cellobioside (pNPC, Sigma) as substrates. Reaction mixture consisted of 0.1 ml of 7 mM substrate, 0.8 ml of sodium acetate buffer (pH 5.0) and 0.1 ml of crude extract. After incubation at 50 °C for 30 min, the reaction was stopped with 2 ml of 0.1 M sodium carbonate. The released *p*-nitrophenol was measured spectrophotometrically (DU®-65, BECKMAN) at 405 nm. One unit of enzyme activity was defined as the amount of enzyme that liberated 1 μmol of *p*-nitrophenol per min under the described assay conditions.

## 3. ANALYSIS AND DISCUSSION

The fungal isolates used in this study were selected in previous experiments in which wheat bran was used as substrate. The present assay used corn stalks, corn leaves as carbon source, and strains were grown for 12 days at 25 °C: enzyme activities were determined from the crude water extracts obtained every second day. Both isolates showed intensive growth on these substrates, but they revealed high differences in the production of the cellulolytic enzymes. Extracellular beta-glucosidase activities of these fungi were found to be higher than their cellobiohydrolase activities; similar observation was recorded for mixed cultures of *Aspergillus ellipticus* and *A. fumigatus* in solid-state fermentation [6].

Cellulolytic enzyme production of *M. corticolus* are shown in Fig. 1. The highest beta-glucosidase and cellobiohydrolase activities were reached on the twelfth day after the inoculation (10.4 U/ml and 2.5 U/ml, respectively). Amounts of both enzymes were permanently increased during the fermentation period, and remarkable rises in the activities were detected at the tenth and twelfth culturing day. It is worth to mention that beta-glucosidase activity of *M. corticolus* used in the present analysis is comparable to those of a *Trichoderma viride* wild type and a mutant strain reported by a recent study [7]. These isolates produced the enzyme within a range of 4-15 U/ml on wheat bran.

In contrast to *M. corticolus*, *G. persicaria* had the maximum yield of both enzymes on the eighth day of the cultivation (Fig. 2). In this fermentation, the highest value for beta-glucosidase and cellobiohydrolase activity was 3.1 U/ml and 1 U/ml, respectively. Further increase of the incubation period resulted in decreased enzyme production. It is supposed that the lower extracellular enzyme production led to the reduction in the enzyme activities at *G. persicaria*, and longer fermentation period is required to produce higher amounts of cellulolytic enzymes in case of *M. corticolus* on corn-stalks as substrate.

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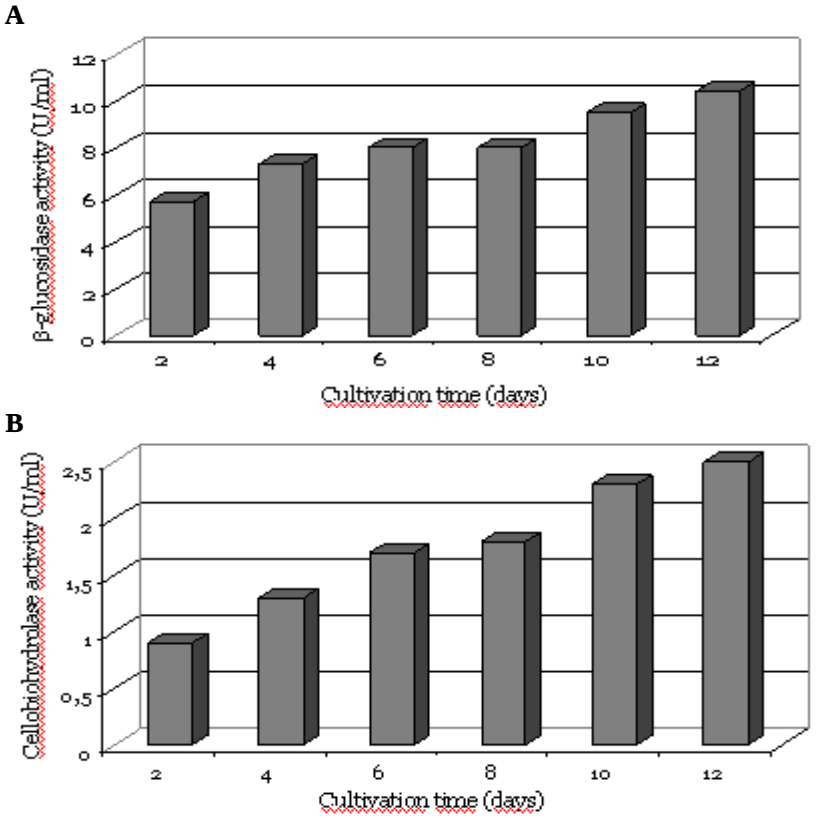



Figure 1. Time course profiles of beta-glucosidase (A) and cellobiohydrolase (B) production by *M. corticolus* by using corn-stalks and corn leaves alone as substrate.

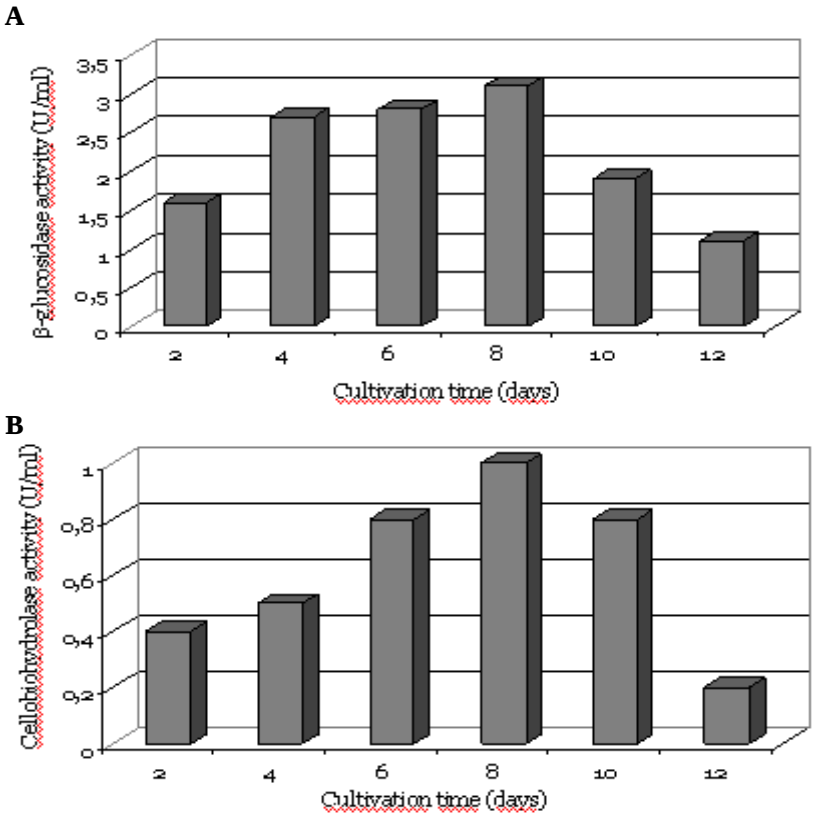



Figure 2. Time course profiles of beta-glucosidase (A) and cellobiohydrolase (B) production by *G. persicaria* by using corn-stalks and corn leaves alone as substrate.

**ACKNOWLEDGEMENTS**

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# BETA-CAROTENE PRODUCTION BY MUCORALEAN FUNGI

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**Abstract**

Although some fungi belonging to the order Mucorales (Zygomycetes), such as *Phycomyces blakesleeanus*, *Blakeslea trispora* and *Mucor circinelloides*, have been traditionally involved in the study of the fungal carotenoid biosynthesis, the majority of the related species have not been studied from this aspect. As morphological observations indicates that a number of other species also seems to be promising producers, the main objective of the present study was to investigate the beta-carotene production ability of several Mucoralean fungi belonging to the genera *Mucor*, *Backusella* and *Gilbertella*. After cultivation under different conditions, the total carotenoid level and the beta-carotene content in the mycelia were measured by an HPLC method. Pigment production of *Gilbertella persicaria* was worth to mention only if it was cultured as a mixture of isolates with opposite mating types. Some *Mucor* and *Backusella* strains produced beta-carotene in significantly higher amounts than the *M. circinelloides* reference strain or the wild-type *B. trispora*, a model organism of the carotenogenic studies. Effects of the illumination, the carbon source and the growth temperature on the carotene production were examined.

**Keywords**

pigment production, carotenoid, Zygomycetes, *Mucor*

## 1. INTRODUCTION

Carotenoids are one of the most important groups of natural pigments. They are used in the food, pharmaceutical and cosmetic industry and as feed colour additives. Carotenoids recently attracted great attention, due to their beneficial effects on human and animal health; for example, their antioxidant property linked with a preventive action on different types of cancer [5] and the enhancement of the immune system [2]. Most of the carotenoid production is performed by chemical synthesis and only a few natural compounds can be obtained from cheap plant sources [1]. Currently there is an increasing interest in sources of carotenoids from microbial origin, especially in cases of the β-carotene and its oxygenated derivatives.

In Zygomycetes fungi β-carotene is the predominant carotenoid species. Traditionally three Zygomycetes, e.g. *Blakeslea trispora*, *Phycomyces blakesleeanus* and *Mucor circinelloides*, have been involved in the study of the carotene biosynthesis.

The aim of the present study was to obtain information on the carotenoid production, especially on the β-carotene content of some Mucoralean fungi in order to determine new producer strains potentially applicable in further analyses and developments.

## 2. THE STUDY

*Strains and growth conditions.*

The 21 fungal strains involved in this study are listed in Table 1. Strains were cultured on plates containing malt extract medium (5 % malt extract, 0.5 % yeast extract, 1% D-glucose, 1.5 % agar), grown for 4 days under continuous light.

*Carotenoid extraction and analysis.*

Carotenoids were extracted from 500 mg mycelial powder with 500 µl acetone and vortexing. This extraction step was repeated until the pellet was found to be devoid of pigments. Extracts were combined and then partitioned with an equal volume of 10% diethyl ether in petroleum ether. To facilitate the separation and to remove dissolved acetone, 1 ml distilled water was added. The petroleum ether fractions were combined and dried under nitrogen gas [6].

For high-performance liquid chromatography (HPLC), samples were analyzed by using a modular Shimadzu low-pressure gradient HPLC system equipped with an UV-Vis detector. The dried samples were dissolved in 100 µl tetrahydrofuran supplemented with butylated hydroxytoluene (100 µg/ml) directly before the analysis and 3 µl was subjected to HPLC analysis on a Phenomenex Prodigy column (4.6 x 250, ODS 3 µm). The separation was performed with a gradient (where min/solvent A%/solvent B% was 0/99/1; 8/60/40; 13/46/54; 15/0/100; 18/0/100; 21/99/1; 25/99/1) using 4% water-96% methanol as solvent A and 4% water-96% methyl-*terc*-butyl ether as solvent B, at a flow rate of 1 ml/min. The detection wavelength was 450 nm. To identify the carotenoids, the following standards were used: astaxanthin, lycopene and β-carotene from Sigma, β-cryptoxanthin, zeaxanthin and canthaxanthin from Carl Roth, and echinenone from DHI Water and Environment.

For spectrophotometry, samples were dissolved in petroleum ether; total carotenoid content was measured at 450 nm.

## 3. ANALYSIS AND DISCUSSION

For the study, 21 fungal isolates were selected on the basis of morphological observations, e.g. of their colony colour (Table 1). These isolates represent 10 different species belonging to the genera *Mucor*, *Rhizopus*, *Backusella* and *Gilbertella*. Overall carotenoid content of the isolates tested are shown in Fig. 1. The carotene production showed high variability even among the isolates of a same species. The most promising producers were the isolates M19, M59, M76 and MH1 with a carotene production more than 400 µg/g dry mass; *M. circinelloides* (M20) and *B. lamprospora* (B1) also had remarkable production. Maybe the high production of *M. bainieri* strain M76 can be connected with the obligate azigospore forming nature of this fungus. Trisporic acids, substances with hormonal activity forming during the zygosporogenesis (e.g. the mating), have been shown to stimulate the β-carotene biosynthesis [5].

Table 1. Investigated fungal strains and their overall carotenoid content
[a]These codes where used throughout the paper for clarity. [b]Strains were cultured at 25°C under continuous light; averages were calculated measuring 3 independent extracts.

| Species | Code of isolate[a] | Total carotenoid content[b] |
|---|---|---|
| *Mucor albo-ater* | M30 | 20 |
| *M. bainieri* | M51 | 36 |
| *M. bainieri* | M76 | 825 |
| *M. circineloides* | M20 | 378 |
| *M. circineloides* | M50 | 98 |
| *M. hiemalis* | MH1 | 570 |
| *M. hiemalis* | M18 | 135 |
| *M. hiemalis* | M12 | 25 |
| *M. hiemalis* | M22 | 105 |
| *M. hiemalis* f. *hiemalis* | M55 | 24 |
| *M. hiemalis* f. *luteus* | M57 | 46 |
| *M. hiemalis* f. *hiemalis* | M59 | 740 |
| *M. inequisporus* | M58 | 35 |
| *M. mucedo* | M19 | 420 |
| *M. rouxi* | M15 | 192 |
| *Backusella lamprospora* | B1 | 400 |
| *Rhizopus stolonifer* | Rh17 | 200 |
| *Rhizopus stolonifer* | Rh5 | 57 |
| *Gilbertella persicaria* | G10 | 29 |
| *Gilbertella persicaria* | G5 | 28 |
| *Gilbertella persicaria* | G6 | 29 |
| *Gilbertella persicaria* | G5-G6 | 151 |
| *Gilbertella persicaria* | G6-G10 | 127 |

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*Gilbertella persicaria* produced higher amounts of pigments only if it was plated as a mixture of the opposite mating types.

Ten strains were selected for further analysis (G6 and G10 examined in mixed cultures to achieve higher carotenoid production). Effect of the growth temperature on the carotenoid production was examined (Fig. 2). In an earlier study, three-times higher carotenoid content was observed in *M. rouxii* when the culturing temperature was increased from the optimum growth temperature (28°C) to 37°C [4].

In our experiments, higher growth temperature also stimulated the production in the majority of the strains. Elevation of the growth temperature led to the highest carotenoid production in the strains M59 (*M. hiemalis*) and M19 (*M. mucedo*), where the total carotenoid contents exceeded 1 mg/g dry weight at 30 and 35°C, respectively. It is worth to mention that all fungi showed more or less restricted growth at temperatures higher than 30°C. The only exception was the mating culture of *G. persicaria* (G6-G10) retaining its growth intensity even at 38°C where it produced about 4 times more carotenoids than at 25°C. Carotenoid production of the strains M20, M79 and Rh17 (*M. circinelloides*, *M. bainieri* and *Rhizopus stolonifer*, respectively) decreased at higher temperatures.

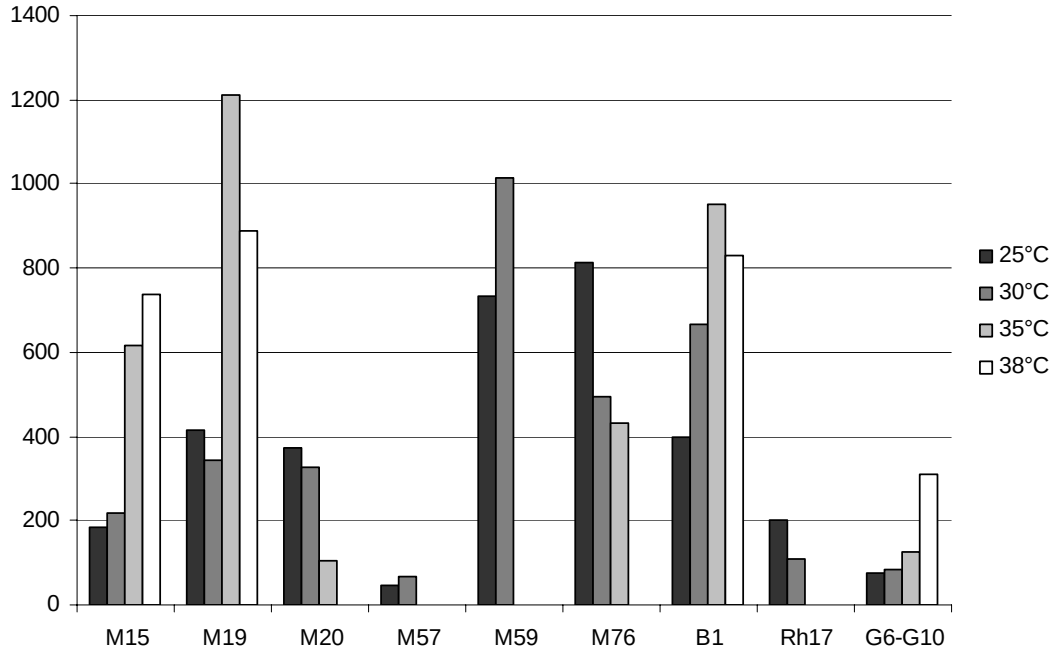



Figure 3. Total carotenoid production of Mucoralean fungi at different temperatures.
The averages were calculated from 3 different measures from independently cultured mycelia.

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# STRESS RESPONSES OF GENETICALLY MODIFIED *MUCOR CIRCINELLOIDES* STRAINS

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**Abstract**

The stress-related responses of *Mucor circinelloides* transformants altered in carotenoid production have been investigated. In zygomycetous fungi β-carotene is the predominant carotenoid, however, in transformants containing the *crtW* and *crtZ* astaxanthin biosynthesis genes from *Agrobacterium aurantiacum* new carotenoid compounds are present. *Mucor* strains with altered carotenoid content were treated with different concentrations of copper, cadmium, chromium and the oxidative stress-inducing agents, menadione, *tert*-butyl hydroperoxide and hydrogen peroxide. Results suggest that the intermediers of the β-carotene-astaxanthin pathway more efficiently increase the stress tolerance of the fungal cells as the astaxanthin, the end-product of the biosynthesis.

**Keywords**

astaxanthin, carotenoid biosynthesis, *Mucor circinelloides*, oxidative stress, transformation

## 1. INTRODUCTION

Carotenoids pigments are widely distributed in the nature. They are important, high-value additives in the cosmetic, food, and pharmaceutical industry. Their beneficial effects on human and animal health are also well documented. Among others, their antioxidant property linked to a preventive action on various types of cancer and an enhancement of the immune response makes them important in the human diet [5, 11].

Though some of these pigments could be manufactured synthetically, the demand for exploitation of natural source is continuously increasing. Microbial production is especially promising for the orange-red ketocarotenoids (e.g. astaxanthin, canthaxanthin) not available in other cheap and exploitable natural sources [2, 8, 13]. Metabolic engineering could assist for the development of commercially utilizable microbial carotene production. Recently, de novo carotenoid biosynthesis was performed in otherwise colourless organisms, such as *Escherichia coli* [17], or *Candida utilis* [10] by introduction of bacterial carotenogenic genes.

The β-carotene producer zygomycete fungus *Mucor circinelloides* is a favoured organism when fungal carotenogenesis has to be investigated. The existence of an efficient transformation system [1, 16], the capacity to express exogenous genes [6] and the ability to grow in a yeast-like form [12] are its most attractive characteristics.

Although, oxidative stress response has been extensively studied in pro- and eukaryotes, the information about filamentous fungi is fragmentary. The main objective of the present work was to investigate the stress response of various *M. circinelloides* transformants modified in their carotenoid production.

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## 2. THE STUDY

MS12, a *leuA-, pyrG*-mutant of the wild-type *M. circinelloides* strain (CBS277.49) and its transformants were used in the experiments. The *crtZ* and *crtW* genes of *Agrobacterium aurantiacum* (encoding β-carotene hydroxylase and β-carotene ketolase, respectively) [9] were used for obtaining transformants with modified carotenoid content. Transformants MS12-Z, MS12-W and the co-transformants MS12-ZW. harboured heterologous *crtZ*, *crtW*, and both of them, respectively [14].

Pigment samples were obtained as described by Papp et al [14]. Measurements of the pigment contents and pigment compositions were carried out by recording the absorbance at 492 nm and with thin layer chromatography (TLC) or with high pressure liquid chromatography (HPLC) analysis, respectively [14].

Genetically modified *Mucor* strains with altered carotenoid content were treated with different concentrations of copper, cadmium, chromium and the oxidative stress-inducing agents menadione, *tert*-butyl hydroperoxide (tBOOH) and hydrogen peroxide. For oxidative stress experiments, 20 ml of YNB (glucose 1%, ammonium sulphate 0.15%, glutamate 0.15%, leucine and/or uracil 0.02%, agar 3%, pH 4.5) supplemented with the required stressor was poured in Petri dishes. Before inoculation each fungal species was grown on YNB for 10-14 days at 28°C. A disk was cut using a cork borer from the actively growing margin of the source of fungus and transferred to the centre of each study plate. Tolerance against stress conditions was analyzed by measuring the colony diameters after 5 days incubation (25°C). Minimum inhibitory concentration (MIC) values were taken as the stressor concentrations causing >95% growth inhibition. All experiments were carried out in triplicates.

## 3. ANALYSIS AND DISCUSSION

Misawa et al. [14] isolated a gene cluster responsible for the synthesis of astaxanthin from the marine bacteria *A. aurantiacum*. In a previous study, plasmid constructs with the genes *crtZ* (encoding β-carotene hydroxylase) and *crtW* (encoding β-carotene ketolase) used to transform *M. circinelloides*. These enzymes mediate the oxigenation reactions from β-carotene to astaxanthin thus allowing the formation of many intermediates of astaxanthin, i.e., β-cryptoxanthin, zeaxanthin, adonixanthin, phoenicoxanthin, canthaxanthin and echinenone [14].

The *Mucor* transformants with modified carotenoid content (Table 1.) were subjected to the effect of copper, cadmium, chromium and some chemical compounds (menadione, *tert*-butyl hydroperoxide and hydrogen peroxide). The toxic manifestations of heavy metals and certain chemicals are caused primarily due to imbalance between pro-oxidant and antioxidant homeostasis of the cells which is termed as oxidative stress. This oxidative stress is a disparity between free radical production and the antioxidant defence of the cell [3]. Carotenoids are well-known antioxidants and therefore a modified carotenoid content has to result an altered sensitivity of the cells against the oxidative damage.

Table 1. The relative carotenoid composition of the *M. circinelloides* Ms12 strain and its transformants

| Strain | astaxanthin | canthaxanthin | zeaxanthin | β-cryptoxanthin | echinenone | β-carotene |
|---|---|---|---|---|---|---|
| MS12 | - | - | + | + | - | ++ |
| MS12-Z | - | - | ++ | ++ | - | ++ |
| MS12-W | ++ | + | - | + | ++ | ++ |
| MS12-ZW | + | ++ | + | ++ | ++ | ++ |

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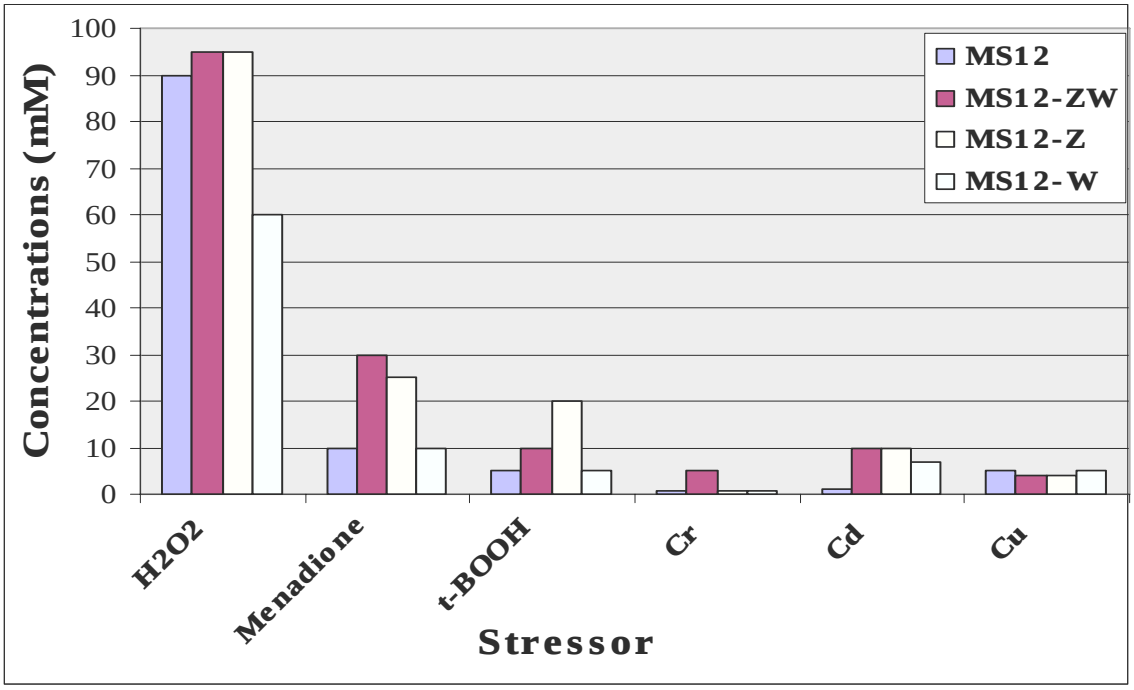



Figure 1. MIC-values against oxidative stressors for *Mucor* MS12 strain and its transformants. The values plotted represent the averages of triplicate samples. Individual values varied less than 10%.

Metal induced toxicity is very well reported in the literature [7]. One of the major mechanisms behind heavy metal toxicity has been attributed to oxidative stress [3]. Cadmium, unlike other heavy metals is unable to generate free radicals by itself, however, reports have indicated superoxide radical, hydroxyl radical and nitric oxide radicals could be generated indirectly [4]. Watanabe et al [18] showed generation of non-radical hydrogen peroxide which by itself became a significant source of free radicals via the Fenton chemistry. In the case of the investigated *Mucor* strains there were no difference detected against copper for the strain MS12 and its transformants. However, with chromium and cadmium treatment Ms12-ZW (containing both of the transforming bacterial genes) revealed substantially higher MIC values than the parental strain.

When oxidative stress inducing chemicals were tested, menadione and tBOOH treatment resulted in higher MIC values for MS12-ZW and MS12-Z than for MS12. There was no such difference for hydrogene-peroxide. Surprisingly, practically for all stressors MS12-W demonstrated similar or lower MIC values than the parental strain.

## 4. CONCLUSIONS

Several studies have shown metals like copper, cadmium, iron, mercury, nickel, lead and arsenic possess the ability to generate reactive radicals, resulting in cellular damage like depletion of enzyme activities, damage to lipid bilayer and DNA [15]. Similarly, there are a broad range of chemicals which impair cells through similar mechanisms. Carotenoids able to "quench" singlet oxygen primarily by a physical mechanism, in which the excess energy of singlet oxygen is transferred to the carotenoid's electron-rich structure: due to this feature they are well known antioxidants. The presented results reinforce that in metabolically engineered fungal cells new carotenoids express protective effect against oxidative stress. Surprisingly, various intermediers of the β-carotene-astaxanthin pathway seem to be more important from this respect than the end-product astaxanthin.

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# ACOUSTICAL ARRANGEMENT OF THE URBAN ROADS

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**Abstract**

The phonic pollution on the urban roads is mainly generated by the transportation means. This affects the human being's live and activity. In this paper we presented the results obtained in the investigation and mitigation of the phonic pollution generated by the transportation means in the urban area through acoustical arrangement of the roads. Specific noise sources, characteristic levels, noxious effects, admissible limits and propagation way are identified. Description of measurements and analysis of the results are presented along with some methods concerning the decrease of the phonic pollution. The efficiency of the implementation of these methods is also discussed.

**Keywords**

Phonic pollution, decrease, urban roads, acoustic arrangement

## 1. INTRODUCTION

Noises and vibrations are generated on the urban roads by road transportation means such as trams, buses, trolleybuses, microbuses, cars, trucks, tractors or motorcycles. Sometimes, these noises and vibrations are generated also by the rail and air transportation means. This is possible when the urban roads are near the railway or the airport. The noises and vibrations generated by transportation means have characteristic spectra and levels of intensity. In this way it is possible to identify the main noise sources from the road transportation means, specifying the noxious effects, admissible limits and propagation way.

Starting from the results of the measurements, we establish some methods concerning the phonic pollution reduction in the urban area through the acoustical arrangement of the roads. The efficiency of the implementation of these methods was evaluated by new measurements. The acoustical arrangement can be applied in every practical situation concerning the urban roads.

## 2. NOISE SOURCES ON THE URBAN ROADS

The noise is generated on the urban roads by transportation means. This is characterized by specific frequency spectra, acoustic pressures and their variations in time. This noise depends on the intensity and composition of traffic, as well as on the speed of movement and it is generated by three basic sources: the engine, the exhaust system and the tire/road contact. The trams generate noise and vibrations due to the variation of speeds, the clearance of the rail extremity (joints), the elasticity of the rails, the conicalness, the eccentricity and the deformations of the bandages, the wheel guide on the rails and the brakes and accelerations.

## 3. NOXIOUS EFFECTS OF THE PHONIC POLLUTION

The phonic pollution generated by the road transportation means on the urban roads is extremely injurious for the human beings' life and activity. Thus, for the 70 dB(A) equivalent noise level during the daytime, 60% of the population on the urban roads is disturbed [8].

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The phonic pollution affects human beings nervous system generating psycho-psychological and blood circulation modifications, as well as sleeps disturbances. Also the visual function and endocrine gland are adversely affected. At the same time the phonic pollution generates auditory tiredness and sonorous trauma.

In order to reduce the effects of the phonic pollution on the urban roads, limit values which cannot be exceeded are established. These limits are characterized by the equivalent noise level, by the noise curves ($C_z$) and by percentual noise level ($L_{10}$). The equivalent noise level corresponds to an equivalent intensity which could be constant during the whole considered period of time and it is defined by relation

$$L_{ech} = 10\,lg\left[\frac{1}{T}\int_0^T 10^{0,1L(t)}\,dt\right] \tag{1}$$

where L(t) is the instant acoustic level.

The noise curves ($C_z$) define the relation between the characteristic frequency of a sound and the proper acoustic pressure level in the conditions of a subjective equivalent intensity.

In this way, Romanian standard STAS 10009-88 "Urban acoustics" established the admissible limits of the noise level in urban environment, differentiated on zones and functional endorsements. For the noise level on the urban roads these values are presented in table 1.

Table 1

| Street type (according to *STAS 10144-80*) | $L_{eq}$ [dB] | $C_z$ [dB] | $L_{10}$ [dB] |
|---|---|---|---|
| I-main | 75-85 | 70-80 | 85-95 |
| II-linking | 70 | 65 | 75 |
| III-collecting | 65 | 60 | 75 |
| IV-local serving | 60 | 55 | 70 |

In the same time the location of residential buildings on streets having different technical categories or at the limit of some functional areas as well as the road traffic organizing must be made so that to be assured the admissible limits for the exterior noise level (which is 50 dB or $C_z45$ curve). This noise level is measured in a point located at 2m distance from the building's wall, according to STAS 6161/1-79. In order to limit the effects generated by rail traffic noise upon the urban environment, it is stipulated that this one cannot exceed 70 dB(A) at the limit of the rail area (or $C_z65$ curve). For the limitation of the noise generated by the air traffic, it is recommended that this noise arising from airplanes displacement do not exceed 90 dB(A) during the daytime between 7.00-19.00 hours, 85 dB(A) during the evening between 19.00-22.00 hours and 80 dB(A) during the night between 22.00-7.00 hours.

## 4. PROPAGATION WAY OF THE NOISE

During the activity of different noise sources from the urban roads, rail or air transportation ways, their vibrations propagate in the surrounding environment as spherical and cylindrical waves and, at long distance, as plane waves.

The equation of spherical waves, in an elastic, homogeneous and isotropic medium with the speed potential $\Phi$ as a parameter is

$$\phi = \frac{A_c}{r} e^{j(\omega t - kr)} \tag{2}$$

where $r$ is the radial coordinate, $A_c$ is the complex amplitude of the spherical wave at the frequency $f = \frac{\varpi}{2\pi}$ that travels from the source with the speed c and $k = \frac{\varpi}{c}$ is the wave number. If we consider $A_c = Ae^{j\alpha}$, then the acoustical pressure can be determined with relation [3]

$$p = \rho_0 \omega \frac{A}{r} sin(\omega t - kr + \alpha) \tag{3}$$

In the same time, taking into account that some parts of the sources from the transportation means have cylindrical shape, because of their vibrations, there are produced cylindrical waves.

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The equation of cylindrical waves is

$$\phi = \left[AJ_m(kr) + jBY_m(kr)\right]e^{-jm\varphi}e^{-j\omega t} \tag{4}$$

where $\phi$ has the known signification, $r$ and $\varphi$ are the cylindrical coordinates, $A$ and $B$ are constants, $J_m$ is the Bessel function of the first degree and m range and $Y_m$ is the Bessel-Neumann function of the second degree and m range.

In case of the waves that travel uniformly, then $m = 0$ and the acoustical pressure can be written

$$p = A\left[J_0(z) + jY_0(z)\right]e^{-j\omega t} \tag{5}$$

Propagation of spherical, cylindrical and plane waves is causing the variation of the pressure in a point of the acoustical field. If we consider that a pressure at a specific moment is $p$, then the level of the acoustical pressure is

$$L = 20\,lg\,\frac{p}{p_0} \tag{8}$$

where $p_0 = 2 \cdot 10^{-5}\left[N/m^2\right]$ is the reference acoustical pressure.

## 5. MEASUREMENTS ACCOMPLISHMENT

Taking into consideration the huge number and variety of sources that have a part to play in generating the noise on the urban roads, as well as the nature of the acoustic produced by these ones, the acoustic field is extremely complex and its study is indicated to be of an experimental nature.

Noise level measurements were carried out in 119 measurements points which were located near some of the most noisy roads crossings from Timişoara city [1], [5]. The measurements were performed using the Brüel & Kjaer 2237 Controller Integrating Sound Level Meter and the Hand-held Analyser Brüel & Kjaer 2250. These ones allowed measuring and automatic recording of the most important parameters of the noise such as: $L_{eq}$ (equivalent noise level), $L_{AE}$ (exposure level), $L_{max}$ (maximum noise level),$L_{min}$ (minimum noise level), $L_{0,1}$, $L_5$, $L_{10}$, $L_{50}$, $L_{90}$, $L_{95}$ (percentage noise levels). These parameters were obtained during a continuous 8 hours period of time (7.30-15.30), divided into 1 hour time intervals. By means of these measured parameters, it was possible to compute other physical indicators which characterize the effect of phonic pollution, such as:

- the noise climate

$$N.C. = L_{10} - L_{90} \tag{7}$$

- the traffic noise index

$$T.N.I. = 4(L_{10} - L_{90}) + L_{90} - 30 \tag{8}$$

- the level of phonic pollution

$$L.N.P. = L_{ech} + L_{10} - L_{90} \tag{9}$$

In order to perform the measurements, the microphone was placed next to the urban roads border at 7,5 m distance from the axis of the first runway, at 1,30 m high from the ground.

Simultaneously with the noise data recording, the traffic composition and intensity as well as the speed of the vehicles were determined.

The results of the measurements, the intensity and composition of the traffic were centralized in a data base designed for the study of phonic pollution in Timişoara City.

## 6. ANALYSIS OF THE MEASUREMENTS RESULTS

From the obtained data it results that the equivalent noise level exceeds the maximum admissible value (defined by Romanian standard STAS 10009-88 concerning "Urban acoustics") in 95 points from the total of 119 measured points, which means 79,85% of the total points.

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The overtaking was included into the interval 0,5-15,5 dB. Table 2 presents the statistical distribution of the equivalent noise level ($L_{eq}$) in the measured points, as well as the percentage of disturbed people [8]. In the majority of the measurement points, the peak noise level was exceeded with 1-9,5 dB while the admissible noise level established to 50 dB measured at 2 meters distance from the buildings was generally exceeded with 1,3-32,9 dB(A). The average equivalent noise level for the 119 measured points was 71,03 dB(A) and the average traffic intensity was 1202,3 aut./h. The traffic intensity ranged between 9 and 2681 aut./h while the speed of vehicles ranged between 40 and 60 km/h.

Table 2

| $L_{eq}$ | No. of points | % | Percentage of disturbed people |
|---|---|---|---|
| 54,3 | 1 | 0,85 | 8 |
| 55÷60 | 0 | 0 | 0 |
| 60,3÷63,5 | 9 | 7,6 | 25÷40 |
| 65,1÷70 | 37 | 31,1 | 42÷60 |
| 70,1÷74,9 | 51 | 42,8 | 60,1÷79,9 |
| 75,1÷79,6 | 18 | 15,1 | 80,1÷98 |
| 81,8 | 1 | 0,85 | 100 |
| 85,5÷85,9 | 2 | 1,7 | 100 |

Table 3

| Transportation means | Minimum percentage | Maximum percentage |
|---|---|---|
| Trams | 0,4 | 18 |
| Buses | 0,01 | 7,5 |
| Trolleybuses | 0,04 | 7,8 |
| Microbuses | 1,1 | 15,9 |
| Cars | 34,2 | 95,27 |
| Trucks | 0,3 | 18,1 |
| Tractors | 0,01 | 2,9 |
| Motorcycles | 0,01 | 4,1 |
| Trains | 0,08 | 54,7 |

The percentage of different transportation means is presented in table 3. The noise level generated by trains measured at the limit of the rail area exceeded the admissible value with 2,2-12,7 dB(A).

Because in the majority of the measured points the admissible limits were exceeded, it was found to be necessary to apply some measures for acoustic arrangement of the urban roads.

## 7. ACOUSTICAL ARRANGEMENT OF THE URBAN ROADS

In order to reduce the noise on the roads in Timişoara City, some measures for acoustic arrangement were established and implemented. In this way, the old rail system was completely changed and replaced with a modern one, more silent, with better insulating properties. All the old noisy trams were replaced with a newer generation, but unfortunately not the newest one. On many streets it was improved or replaced the superstructure of the runway. Many crossings were modernized and semaphores were installed. One-way traffic was imposed for some streets and the speed of vehicles was limited. It was eliminated the presence in traffic of heavy trucks in the central area of the City. On some roads it was allowed the access only for certain categories of vehicles. On the other side, in order to avoid the presence of heavy trucks on the urban roads, it was started the construction of a ring-road for Timişoara. Protective green zones were implanted between the runways and the residential areas.

The effect of the implementation of these measures on the noise abatement were evaluated through new measurements performed in 46 measurement points, selected near some of the most important crossings of the urban roads from Timişoara City.

From the obtained data it results that in the 46 measured points, the equivalent noise level was reduced with 0,1-12,4 dB and in 32 points (69,56%) the noise level does not exceed any more the admissible value defined by STAS 10009-88.

In the following section, we present a comparison between the situation existing in these 46 measurement points before and after the implementation of noise abatement measures.

In table 4 and 5 we present the statistical distribution of the equivalent noise level and the percentage of disturbed people in those 46 measurement points before (table 4) and after (table 5) the implementation of noise abatement measures.

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**Table 4**

| $L_{eq}$ [dB] | No. of points | % | Percentage of disturbed people |
|---|---|---|---|
| 63,5 | 1 | 2,2 | 37 |
| 66,2÷69,7 | 10 | 21,7 | 47÷59 |
| 70,1÷74,9 | 28 | 60,9 | 60÷79 |
| 75,1÷78,6 | 7 | 15,2 | 80,1÷97 |

**Table 5**

| $L_{eq}$ [dB] | No. of points | % | Percentage of disturbed people |
|---|---|---|---|
| 60,1÷65 | 16 | 38,4 | 25÷44 |
| 66,1÷69,9 | 18 | 39,1 | 47÷60 |
| 70,4÷74,2 | 11 | 23,9 | 61÷78 |
| 75,1 | 1 | 2,2 | 80,1 |

The average equivalent noise level in these 46 measurement points was 71,8 dB(A) for an average traffic intensity of 1260,7 aut./h before the application of noise abatement measures and 67,3 dB(A) for an average traffic intensity of 1429 aut./h after the implementation.

**Table 6**

| Transportation means | Minimum percentage | Maximum percentage |
|---|---|---|
| Trams | 0,4 | 15,1 |
| Buses | 0,01 | 2,7 |
| Trolleybuses | 0,04 | 3,0 |
| Microbuses | 2,9 | 10,9 |
| Cars | 68,7 | 95,27 |
| Trucks | 0,4 | 16,4 |
| Tractors | 0,03 | 1,4 |
| Motorcycles | 0,01 | 1,7 |
| Trains | 0,1 | 1,7 |

**Table 7**

| Transportation means | Minimum percentage | Maximum percentage |
|---|---|---|
| Trams | 0,4 | 47,9 |
| Buses | 0,1 | 8,6 |
| Trolleybuses | 0,1 | 1,9 |
| Microbuses | 2,1 | 16,8 |
| Cars | 39,6 | 93,6 |
| Trucks | 0,1 | 15,3 |
| Tractors | 0,1 | 1,4 |
| Motorcycles | 0,3 | 10,4 |
| Trains | 0,1 | 1,5 |

Regarding the average equivalent noise level existent at 2 meters distance from buildings, this one was 67,3 dB before the application of noise abatement measures and 62,7 dB after that.

The percentage of transportation means in these 46 measurement points is presented in table 6 (before application of noise abatement measures) and in table 7 (after application of noise abatement measures).

In the same time it was proved that an important contribution to the noise generated by the road transportation means on the urban roads has the tire/road contact, which can be reduced by covering the road superstructure with rubberized asphalt or with rubber pavement. Using these measures it is expected to obtain a noise level reduction with approximate 4 dB. These methods will be also useful for an increased traffic security realized through the elimination of the vehicle skidding.

## 8. CONCLUSIONS

After performing the investigations described in the paper, it was possible to evaluate the degree of phonic pollution for Timişoara City. The acoustical arrangement of the urban roads leads to a diminution of the pollution degree also a diminution of the percentage of disturbed people.

The measurements performed after the acoustical arrangement of the urban roads proved its efficiency. This can be underlined by comparing the results of the measurements performed before and after the acoustical arrangement of the urban roads. Once the acoustical arrangement of the urban roads proved its efficiency, these methods can be easily applied in every practical situation concerning traffic or industrial noise.

Finally one can conclude that the acoustical arrangement of the roads implemented in Timişoara City proved its efficiency.

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# HEAT TREATMENT OPTIMIZATION OF CANNED MEATS IN TERMS OF THE RESOURCE UTILIZATION AND THE QUALITY OF THE PRODUCTS

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**Abstract:**
Heat treatment of canned food products, particularly canned meat products, requires considerable energy as the cans need sterilization. A heat treatment with a long time span and with a temperature of around 120°C will consume considerable quantities of fuel.
The heat treatment is used to avert microbiological danger. The operation regulation has to be defined in a way which produces a microbiologically reliable product, without harming its organoleptic peculiarities, substance, taste and flavour with an oversized treatment. In the interest of safety we have to define the extent and the time span of the heat effect leading to the destruction of the microbiological pathogens with the use of engineering calculations, modelling and computer simulation. We also have to secure the observance of the regulations obtained this way for the sake of the higher quality and the less resource utilization. This observance ability is answered with the help of our developed model for the computer simulation of heat treatment processes.

**Keywords:**
autoclave, heat treatment, modelling, simulation

## 1.INTRODUCTION

Heat treatment provides increased shelf life and is a defensive measure against microbiological hazards. Thus, inappropriate handling and violation of the operation regulation might have serious consequences. Therefore, heat treatment is a crucial point of food safety. With longer heat treatment the risk is decreased. However, if the heat treatment is too long, the quality of the product may decrease; the smell, the taste and the substance is in danger (liver products might develop distinctive colours and meat products might drip liquids etc.). Therefore the operation regulation and the control should be designed in a way so that the operation fulfils both safety and quality.

Heat treatment of canned goods and especially of meat products requires large quantities of energy as these products require long treatment at around 120 degree Celsius. Reducing the use of natural resources is an important goal in industrial processes – a few years ago this only meant saving energy, today it includes the paradigm of environment management and the paradigm of sustainable development – the goal is to reduce the energy usage or at least to produce more products without increasing energy usage [3]. Although reduction in the use of these resources (water, electricity, heat energy) obviously decreases the cost of manufacturing and increases the economy of manufacturing, it is not trivial to implement in many production plants as the cost of these resources is not calculated or measured at all, thus wasting resources is not visible. Similarly, increased quality and nutrition parameters might also remain undetected.

Insulating the heat treatment equipment is easy, but it requires changes in the technological process which raises food safety problems. Moreover, production plants are uneager to change the technological processes. Another problem is the high initial cost of measuring equipment and the required periodical replacement of sensors. The result is that only the most important data is collected. In heat treatment, this data is the core temperature and the outer temperature. In the field of heat treatment, general heat loss was an important

field around 1970 [4, 5, 8]. Around 1980, the heat utilization and heat intake ratio were important issues [1, 6, 7]. If the insulation is changed on the equipment, the technological processes must be changed in accordance with engineering calculations. Because of the above mentioned reasons, and because of the many parameters and many different processes, modelling and simulation should be combined with engineering calculations. The intensity and the length of the heat treatment must be calculated in a way to effectively neutralize microbiological hazards, and the resulting requirements must be implemented and monitored in order to achieve a higher quality.

In this work, we demonstrate the mathematical model of the steam requirements of a heat treatment process and a simulation application which incorporates the model and is capable of determining the collective resource usage of parallel heat treatment processes.

## 2. THE STUDY

### 2.1. Heat treatment values and calculations of the length and temperature of heat treatments

The neutralization of micro-organisms with heat treatment is studied since 1920. The most important micro-organisms' neutralization with wet steam can be expressed with a negative exponential equations (the correspondence and acceptability of the kinetic description of the primary reaction is based on the biological reason that supposedly wet steam denaturises vital proteins according to the monomolecular reaction) which means that consecutive identical heat treatments leave the same proportion of the initial number of micro-organisms alive.

For a given micro-organism and a given temperature, $D$ denotes the required time to destroy 1 log cycle (90%) of the microorganism and $z$ denotes the heat increment required to reduce $D$ by a magnitude. The heat treatment value is denoted with $F$ and is the value used for the longest time. $F_0$ is the same as $F$ but implies $z=10$ °C for a given heat treatment, for a micro-organism with $z=10$ °C, the temperature changes on the slowest heat point of the treated object have the same neutralizing effect as keeping the temperature on $121.1$ °C for $F_0$ minutes. The efficiency of heat treatments can be compared using $F_0$.

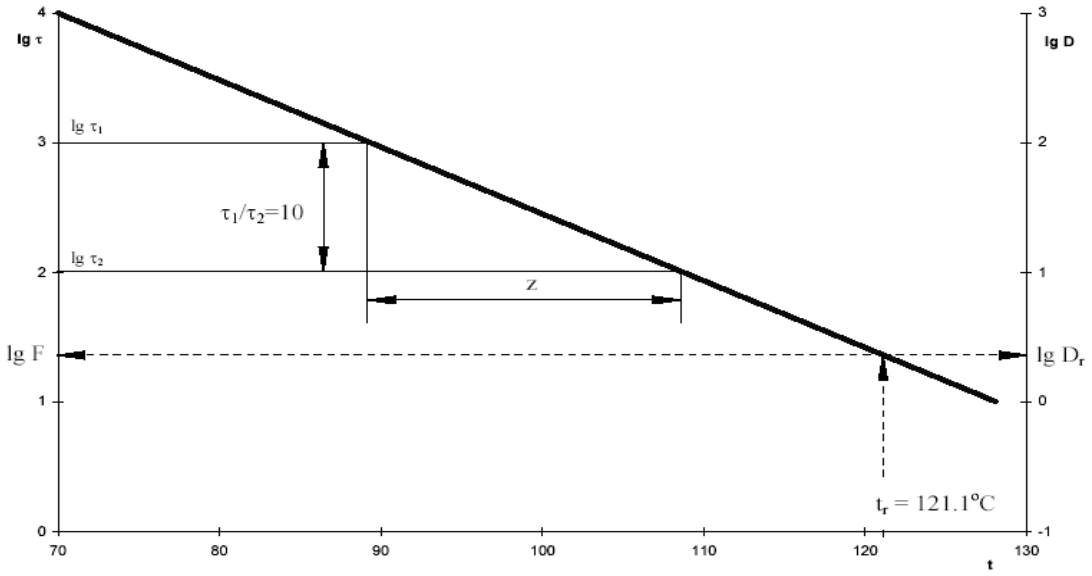



Figure 1. Neutralization of micro-organisms depending on the temperature

Figure 1 demonstrates the difference in temperature denoted by $z$, which reduces the thermal death time to one tenth. We might also plot a curve that is parallel with the thermal death curve with the help of the decimation times. As the decimation time measures the heat resistance of a micro-organism, this curve is referred to as heat resistance curve. We can calculate the formula of the equality of thermal death curve from the gradient and a point of the curve. A special point, according to international agreements, is the thermal death time at $121.1$ °C (250 Fahrenheit) which is referred to as F-value. The $D$-value of the heat resistance

curve plotted with the decimation times at *121.1* °C (reference temperature, $t_r$) is denoted by $D_r$.

We calculate the desired temperature of the sterilization bath (pasteurization bath, autoclave) and the desired length of the heat treatment with the help of the thermal death curve – referred to as the sterilization formula in the industry – if we know the temperature curve of the slowest heating point of the product, referred to as heat penetration curve in the industry.

The temperature of the slowest heat point of the product to be treated can be plotted against the time; this is the heat penetration curve. The curve displays the temperature change according to the three phases: heating, maintaining temperature, cooling. To design the heat treatment, the longest $\tau$ time required to destroy the required proportion of the micro-organisms relevant to the product on a feasible *t* temperature must be known. That is, the thermal death curve, similar to the one on *Figure 1* must be known.

We can calculate the relative neutralization speed for different *t* temperatures if we know the value of *F* and *z*, relative to the value of $F/\tau$ at *121.1 °C*. To calculate the requirements of the heat treatment, the so-called sterilization curves are plotted from known heat penetration curve and the *z*-value from the micro-organism's thermal death curve. Such a sterilization curve is demonstrated in *Figure 2*. On Figure 2, the heat penetration curve used to calculate the points of the sterilization curve is also displayed (with *z=10 °C*).

To calculate the sterilization curve, we plot the relative thermal death speed ($F/\tau$) instead of the temperature against the axis of heat treatment time. The integral of the sterilization curve is the sterilization value ($F_0$ value) which is in *F*-units.

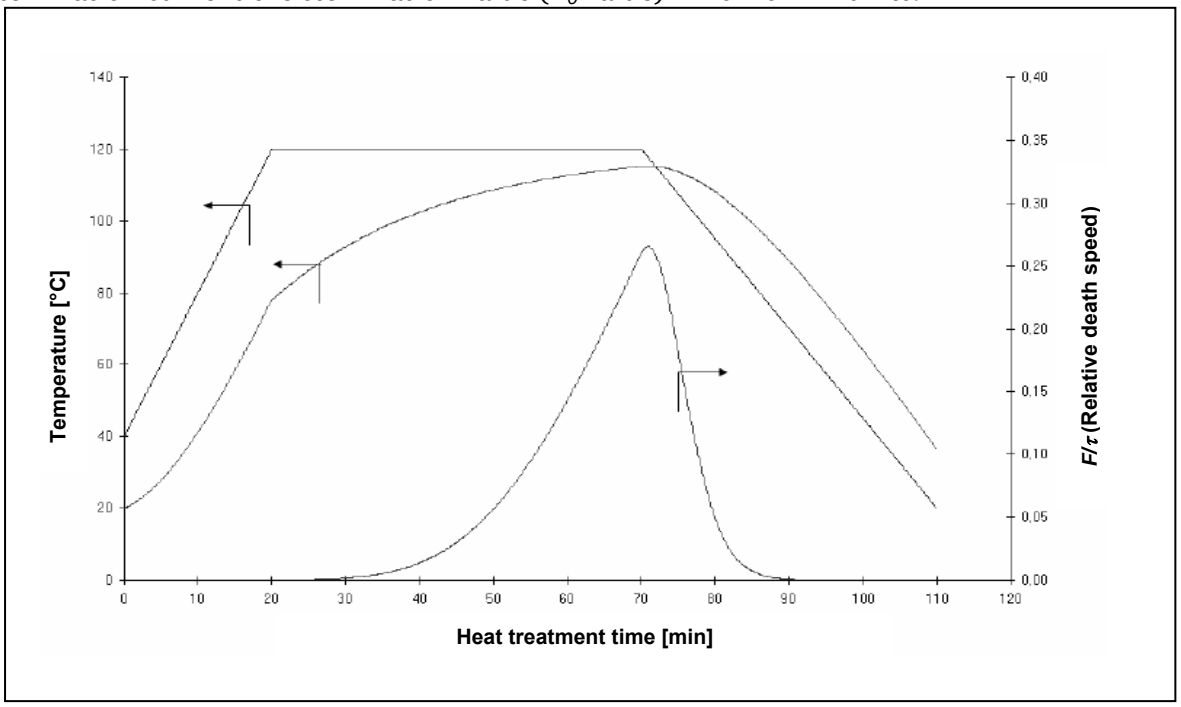



Figure 2. Plotting a sterilization curve from a heat penetration curve

As the *z*-value of the thermal death curve of Clostridium botulinum spores is between *14.7-16.3 °F*, depending on the product, and the *z*-value of the thermal death curve of the internationally accepted reference spores of the putrefactive anaerobe bacteria strain Clostridium sporogenes P.A. 3679 is between *z=16.6 °F* and *z=20.5 °F*. That is the reason of using an average value of *z=18 °F=10 °C* in calculations. For C. botulinum spores, the highest registered *D*-value was *0.21* minutes on *121.1 °C*. A worldwide standard for food products with a pH greater than *4.5* (for example, meat products) is to require a heat treatment that reduces the number of C. botulinum spores by twelve magnitudes. This is known as the 12D-concept. For that a *12*D* minute long heat treatment is required which is *12*0.21=2.52* minutes on *121.1 °C* (so, the *F*-value of C. botulinum spores is *2.52* minutes). The required

length of the heat treatment for other temperatures can be calculated according to the information above with *z=10 ºC*.

### 2.2. Modelling the steam usage of a heat treatment

Heat treatment is performed in closed, pressurized units (autoclaves) from which typically 10 to 20 units are needed for treating canned food arriving from different production flows with a different flow rate and with different sizes and geometry [2]. The heat treatment in an autoclave is started when it is full with products requiring the same heat treatment. This results in a lower relative energy usage. An automated control system controls the temperature by regulating the amount of steam input (for heating and for keeping a temperature) and water input (for cooling).

On the upper part of Figure 3, the required temperature is displayed (as calculated from the sterilization curves). On the lower part of Figure 3, the required amount of steam is displayed (to be calculated later).

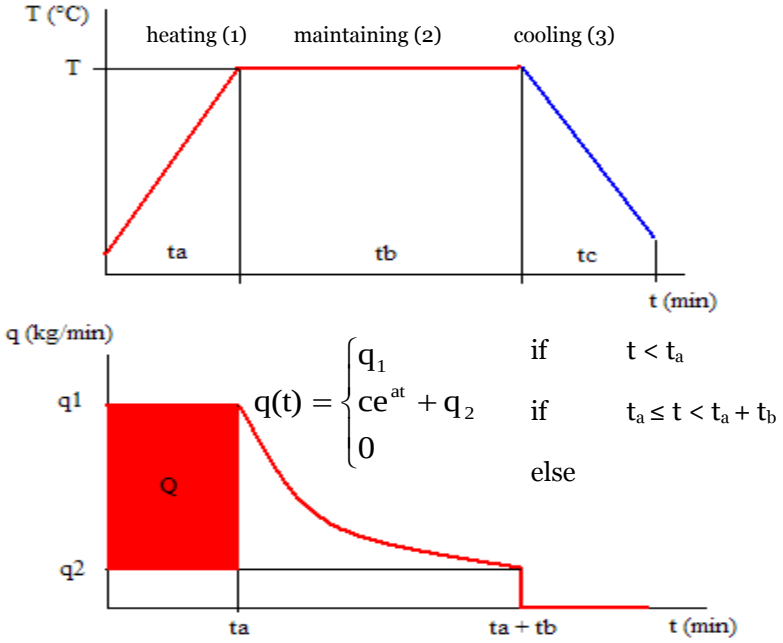



Figure 3. Development of temperature and steam mass flow in function of time

Product-dependent data calculated from the sterilization curves:

*T*: required temperature (°C)
$t_a$: heating time (minutes)
$t_b$: heat keeping time (minutes)
$t_c$: cooling time (minutes)

The parameters of the *q(t)* steam mass flow (kg/minute) are yet to be calculated:

*Q*: Steam required for heating (kg), a product-independent constant
$q_2$: steam mass flow loss (kg/minute), a product-independent constant
*c*, *a*: The curvature parameters of the *q(t)* function, the first is independent of the product and the second depends on the first.

## 3. ANALISES, DISCUSIONS, APPROACHES, INTERPRETATIONS

### 3.1. Mathematical model for steam mass flow

When modelling real-world phenomenon, considering every condition is impractical, if not impossible. For a simpler model, or even for a feasible model we must omit details that are (thought to be) less important. On the other hand, we should not over-simplify our model. We have to identify the parameters of the phenomenon and the connections between them.

In an autoclave, we have to determine the required steam mass flow, as a function of time, for a given heat treatment. The steam mass flow loss ($q_2$) is the amount of heat exiting on the hull of the equipment which depends on the insulation of the equipment from the

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internal temperature and from the external temperature. On the other hand, individual autoclaves can be modelled as identical and all products are treated on almost the same temperature, so $q_2$ can be modelled as a product-independent constant during the whole heat treatment.

The amount of steam required for heating ($Q$) depends on the quantity of the product and from the difference of the maximum temperature and the initial temperature. As these are almost identical for every product, $Q$ is also a product-independent constant.

Knowing $q_2$, $Q$ and $t_a$, the steam required for one time unit of the heating phase, the steam mass flow ($q_1$) can be calculated:

$$q_1 = q_2 + \frac{Q}{t_a} \tag{1}$$

In the second phase of the heat treatment, the heat keeping phase, the temperature of the cans converges to the internal temperature of the autoclave, thus the required steam mass flow is exponentially reducing from $q_1$.

The curvature can be described by either the $a$ or $c$ parameter of the exponential arc, and the other can be calculated from the constraint that the arc starts from the value $q_1$ at the beginning of the heat keeping phase (at the $t_a$ time instance). For example, for an arbitrary negative $a$:

$$q(t_a) = c \cdot e^{at_a} + q_2 = q_1 \Rightarrow c = \frac{q_1 - q_2}{e^{at_a}} \tag{2}$$

### 3.2. The adjustment of the parameter of the mathematical model

Using our results above, we can calculate the required steam mass flow for a single autoclave from three arbitrary chosen parameters ($q_2$, $Q$, $a$). Now, which value combination of these parameters will result in the best model? To answer this question, we have to compare our measurements of the real process and the calculated process and find the parameter values with the smallest error. However, we do not have measurement data and the production plant is not planning to buy expensive measuring equipment to find the best model which can be simplified. As the gas usage of the furnace that produces the steam is measured, and we can calculate the gas usage of our model, we can calibrate our model based on the error in the gas usage between the simulated process and the real process. For that, we had to create a computerized simulation tool that is able to calculate the total gas usage for every minute of a 24-hour period, calculated from the total steam requirement (as in Figure 4) which is calculated from the individual steam requirements of the simulated heat treatments.

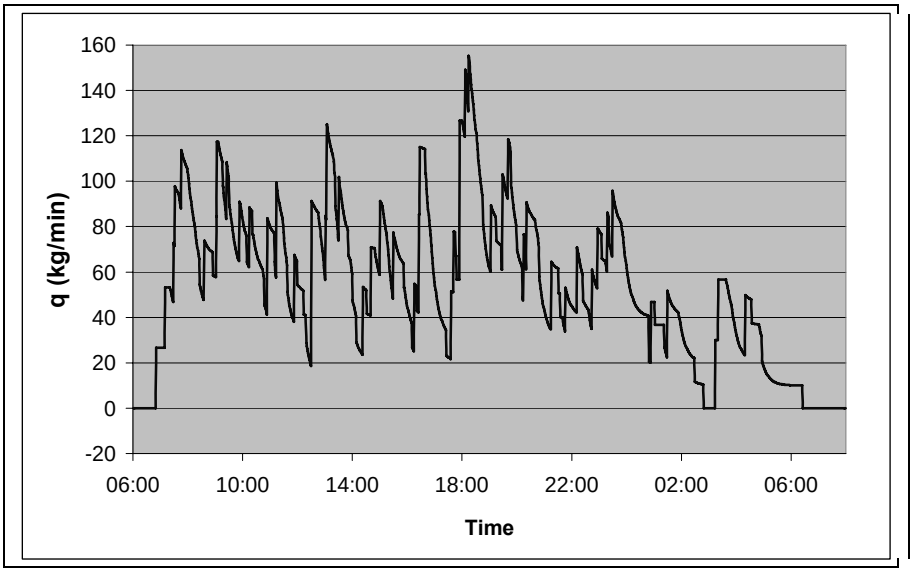



Figure 4. Total steam requirements of multiple autoclaves operating simultaneously

## 4. CONCLUSIONS

By comparing the simulated gas usage and the measured gas usage for the past heat treatments, the parameters of our mathematical model can be adjusted. At this point, the future gas usage can be calculated as well on a minute scale, thus we have an opportunity to prevent wasteful gas usage caused by an inefficient, unbalanced gas usage. That can be achieved by delaying some of the heat treatments in the heat treatment plan or production programming at the production lines. For this, we need adequate computer software and applications which requires further research.

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# BLACK POPLAR *(POPULUS NIGRA)* GENE CONSERVATION IN THE SAND RIDGE REGION BETWEEN THE DANUBE AND THE TISZA

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**ABSTRACT**

The objective of black poplar (*Populus nigra*) gene conservation:

Black poplar is a native tree species of the Carpathian Basin. In the Danube-Tisza Mid-Region there are only some remaining scattered individual trees or population fragments at best, which are unsuitable for conducting sexual reproduction processes. Among the descendants via free-pollination of the few black poplar trees, which are situated in the crowd of hybrid poplars, we can hardly find black poplar-like descendants.




Black poplar parent stock tree outside Bugacpusztaháza

Its domestic spread, sylvicultural and horticultural use as an ornamental plant shows an increasing tendency compared with the previous period, primarily because of the restrictions in nature reserve areas, the future use is expected to increase. In nature reserve areas, during forest establishment and forest regeneration it is the only possibility to afforest native tree species regardless of the previous culture.

In the Danube-Tisza Mid-Region we establish an identified ex-situ gene collection by questing the findable parent stock trees and by integrating ecotypes being conform to the environmental conditions of the region taking gene conservation and research aspects into consideration.

We carry out isoenzyme and DNA surveys on the parent stock trees marked due to the phenotypical characteristics. After receiving the laboratory results, we keep the species-identical (100% black poplar) genotypes in ex situ gene collections. We carry out monitoring of the collected material and create groups based on the characteristics as seen in order to be able to plan the further use.

We evaluate the characteristics and than we can create clone mixtures using the collected material offering the users alternative solutions, which are practicable for tree cultivation, nature preservation, gene conservation and farm or road afforestation, however natural and native.

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# MORPHO-ANATOMICAL ANALYSIS OF SPIKE OF WHEAT GENOTYPES

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**Abstract**

The goal of the paper is to find, by means of an analysis of morpho-anatomical characteristics of the spike of tetraploid and hexaploid wheat genotypes, characteristics which most strongly influence the differences in yield. The hexaploid genotypes have a significantly longer spike, with a greater number and mass of grain/spike. For both groups, a normal distribution of the number and mass of grain/spikelet of a main shoot spike is notified. An analysis shows that the hexaploid genotypes have a greater cross section rachis area, and a greater number of the smaller vascular bundles, in comparison to the tetraploid ones.

**Key words:**

wheat, spike, morpho-anatomical analysis

## 1. INTRODUCTION

In different wheat cultivars, the total contribution of nonleaf green organs, including spikes and peduncles, accounts for about 40–50% of grain mass per spike, which is higher than the total contribution of the flag leaves and penultimate leaf blades [23, 1, 24]. In wheat, all parts of the spike, such as the awn, glume, lemma, palea, pericarp, and even peduncle, are capable of photosynthetic $CO_2$ fixation, and a considerable portion of grain mass derives from the photosynthesis of these organs [6, 18, 24]. Results of [13] suggested that awns play a dominant role in contributing to large grains and a high grain yield in awned wheat cultivars, particularly during the grain-filling stages.

To what extent will the spike realize its genetic potential depends on genetic factors and a number of physiological and biochemical processes both in the spike itself and in the whole plant. Besides by these factors, the yield is strongly influenced by environmental factors [20, 21]. The number of formed flowers per spike is higher than the number of formed grain [7]. One possible way how to affect assimilate distribution is to increase grain weight through increasing grain number [19, 8,]. Besides all other factors, flower formation is affected by the presence of adequate vascular tissue [12]. Analysing the twenty-six winter wheat varieties of different earliness and stem height [16] concluded that under conditions favourable for both a high rate of assimilate production and high sink capacity, the number and size of vascular bundles, and especially the phloem cross-sectional area, limit wheat productivity.

The goal of the paper is to find, by means of an analysis of morpho-anatomical characteristics of the spike of two tetraploid and two hexaploid wheat genotypes, those characteristics which most strongly influence the differences in final yield.

## 2. MATERIAL AND METHODS

The morpho-anatomical analysis of the main shoot was done in two tetraploid (NSD 3/93 and Novinka) and two hexaploid (NS032 and NSP11) wheat genotypes. The experiment was conducted in field conditions, applying random block system with three replications, with planting density of 650-700 seedlings/m$^2$. The main shoot spikes were sampled during physiological maturity for the morphological analysis of the spike. For the anatomical analysis of the rachis, the sampling was done 10 days before full physiological maturity. For both analyses the sample was 30 spikes per genotype. Cross sections of the rachis, 20 μm thick, were made with Leica CM 1850 cryostat. Sections were observed and measurements made using Image Analyzing System Motic 2000 and included cross sections made at the 2$^{nd}$, 8$^{th}$ and 13$^{th}$ internodes. The following characteristics were analysed: spike length, mass and number of grains per spike, mass and number of grains per spikelet, area of the cross section of the rachis, as well as number, height and width of central vascular bundles. The data were statistically processed using STATISTICA for WINDOWS version 8.0. The significance of differences in

mean values of measured parameters was determined using Duncan's test, between the genotypes of the same ploidity level (means marked with the same letter do not differ) and t-test, between the genotypes that differ in ploidity level (* – significant for 0.05% and ** – significant for 0.01%).

## 3. RESULTS AND DISCUSSION

Yield is influenced by adequate production of photosynthetic assimilates and by the adequate capacity of the acceptor organ to accept products of photosynthesis. As the source and the acceptor of assimilates are affected by the effects of feedback, it is often difficult to determine whether it is the source or the acceptor that limits the yield in a particular case [25]. In our research, a significantly longer spike, with greater number and mass of grain/spike was found in the hexaploid genotypes (Table 1). Larger biomass, number of spikes and larger grain yield per plant in hexaploid wheat in comparison with tetraploids were found by [9].

Our results show that with the hexaploids the number of grains per spike is a more variable characteristic than grain mass or spike length, whereas with the tetraploids it is grain mass/spike which is a more variable characteristic (Table 1). The number of grains per unit area and the mass of individual grains are considered to be two main factors of yield [22]. Research has proved that the number of grains is a characteristic which has a stronger effect on the variation in grain yield, whereas the mass of grain is a more stable characteristic [10, 21]. During the period after flowering, the grain yield of wheat is either limited by the acceptor or co-limited by both the source and the acceptor, but is never limited by the source of assimilates [22].

Table 1. The spike morphological characteristics of wheat genotypes *

| Genotype | | Spike length (cm) | | Grain number/spike | | Grain mass/spike (g) | |
|---|---|---|---|---|---|---|---|
| | | $\bar{X}$ ±Se (CV%) | | $\bar{X}$ ±Se (CV%) | | $\bar{X}$ ±Se (CV%) | |
| T | NSD3/93 | 6.5 ± 0.1 (2.3) | a | 29.1± 0.2 (1.4) | a | 1.2 ± 0.1 (12.2) | a |
| | Novinka | 6.1 ± 0.0 (0.5) | b | 30.3 ± 0.6 (3.9) | a | 1.3 ± 0.0 (4.6) | a |
| $\bar{X}$ | | 6.3 ± 0.2 | | 29.7 ± 1.6 | | 1.25 ± 0.3 | |
| H | NS 032 | 8.6 ± 0.1 (0.3) | a | 41.6 ±1.1 (2.4) | a | 1.5 ± 0.0 (0.1) | a |
| | NSP 11 | 8.1 ± 0.1 (0.2) | b | 39.3 ± 0.7 (1.4) | b | 1.8 ± 0.0 (0.1) | b |
| $\bar{X}$ | | 8.3 ± 0.2 | | 40.4 ± 1.6 | | 1.6 ± 0.1 | |
| t- test | | * | | * | | * | |

* T-(tetraploid), H-(hexaploid), $\bar{X}$ (means), Se (standard errors) and CV (coefficients of variation %)

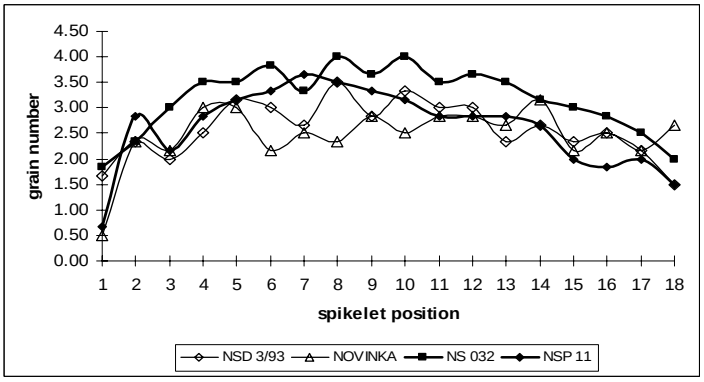



Figure 1. Distribution of grain number/spikelet for tetraploid and hexaploid genotypes

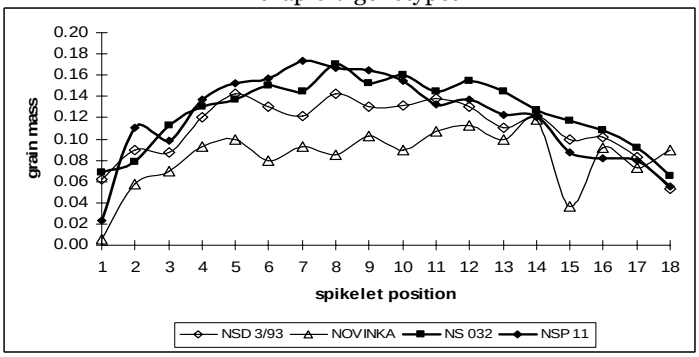



Figure 2. Distribution of grain mass/spikelet for tetraploid and hexaploid genotypes

The analysis of the number and mass of grain/spike of the main shoot in different positions in the spike shows greater variability and dispersion of these parameters in the tetraploid genotypes than in the hexaploid genotypes. In both groups these values rise from the basal spikelet (1st) to the more central ones, so they are highest from the 8th spikelet, and then they fall as we progress towards the 18th spikelet (Fig. 1, 2).

Miralles and Slafer [14] indicate that the mass of basal grains (grain next to the rachis) in central spikelets of the spike is larger than the mass of grains found in the same position in apical or basal spikelets. Similar findings are reported by [3], grains from the lower and middle section of the spike and the proximal floret positions were heavier than those from the upper spike section and the distal floret positions. The values for the number of grain/spike range from 0.5 (1st spikelet – Novinka)

to 4.0 (8th spikelet – NS 0.32) grains, and for the grain mass from 0.005g (1st spikelet – Novinka) to 0.173g (7th spikelet – NSP 11). Hexaploid genotypes have a greater number and mass of grains in almost all examined positions of the spikelet (Fig. 1, 2). Variability of grain mass in wheat is a result of the interaction between the potential to gather nutrients and the realization of this potential [11]. To a large extent, grain mass also depends on the speed and duration of the grain-filling period, as well as on the combination of these factors [2, 17, 4, 22, 15].

Significant differences between tetraploid and hexaploid genotypes were found in cross section rachis area for 2nd, 8th and 13th internodes level (Table 2, 3 and 4). Higher values were obtained in hexaploids. The values for number, height and width of vascular bundles of tetraploid genotypes were similar to the values of hexaploid genotypes for all internode levels.

Table 2. The anatomical 2nd internode rachis characteristics of wheat genotypes

| | | 2nd internode | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | genotype | cross section rachis area (µm²*10⁴) | | number of vascular bundles | | height of vascular bundles (µm) | | width of vascular bundles (µm) | |
| | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | |
| T | NSD 3/93 | 213±18.0 (30.5) | a | 17.1±1.2 (12.2) | b | 176.4±2.9 (2.9) | a | 151.9±2.2 (2.5) | a |
| | Novinka | 190±6.1 (9.6) | a | 23.3±0.5 (3.8) | a | 172.2±5.7 (5.7) | a | 150.5±5.9 (6.7) | a |
| | $\bar{X}$ | 201.5 ± 14.0 | | 20.2 ± 0.9 | | 174.3 ± 4.1 | | 151.2 ± 5.2 | |
| H | NS 032 | 315±31.2 (38.3) | a | 21.8±0.3 (2.3) | a | 174.7±6.1 (6.1) | a | 160.9±8.7 (9.3) | a |
| | NSP 11 | 337±22.4 (25.7) | a | 22.5±0.6 (4.9) | a | 176.4±1.0 (1.0) | a | 162.0±2.5 (2.6) | a |
| | $\bar{X}$ | 326.0 ± 15.6 | | 22.1 ± 0.5 | | 175.5± 2.1 | | 161.4 ± 3.5 | |
| t- test | | * | | ns | | ns | | ns | |

Table 3. The anatomical 8th internode rachis characteristics of wheat genotypes

| | | 8th internode | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | genotype | cross section rachis area (µm²*10⁴) | | number of vascular bundles | | height of vascular bundles (µm) | | width of vascular bundles (µm) | |
| | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | |
| T | NSD 3/93 | 105±5.7 (21.1) | a | 12.6±0.7 (10.3) | b | 166.4±4.5 (4.6) | a | 150.0±2.0 (2.3) | a |
| | Novinka | 112±6.3 (17.2) | a | 17.1±0.9 (9.3) | a | 159.8±7.9 (8.5) | a | 134.4±7.9 (10.2) | b |
| | $\bar{X}$ | 108.5 ± 12.9 | | 14.8 ± 0.7 | | 163.1± 3.4 | | 142.2 ± 3.6 | |
| H | NS 032 | 199±21.0 (29.1) | b | 15.0±0.3 (4.0) | a | 163.9±7.6 (7.9) | a | 135.4±3.7 (4.6) | b |
| | NSP 11 | 247±7.1 (17.3) | a | 15.0±0.8 (8.6) | a | 169.5±6.9 (7.0) | a | 150.9±5.1 (5.8) | a |
| | $\bar{X}$ | 223 ± 8.4 | | 15.0 ± 0.5 | | 166.7 ± 3.4 | | 143.1 ± 3.2 | |
| t- test | | ** | | ns | | ns | | ns | |

The mass and volume of mature grain are highly correlated with the diameter of vascular bundles in the terminal internode [17]. The increase in the participation of assimilates which are transported to the spike is related to the adequate increase of phloem area, through which the assimilates are transported [6]. The variation in the development of the vascular system of the terminal internode affects the variation in the development of the seed. Pande et al. [17] think that these two factors are genetically related and that this is why wide variation of the vascular system of the terminal internode would be used to further increase the grain mass.

Table 4. The anatomical 13th internode rachis characteristics of wheat genotypes

| | | 13th internode | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | genotype | cross section rachis area (µm²*10⁴) | | number of vascular bundles | | height of vascular bundles (µm) | | width of vascular bundles (µm) | |
| | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | | $\bar{X}$ ±Se ( CV%) | |
| T | NSD 3/93 | 84.0±6.4 (29.1) | a | 7.4±0.6 (13.5) | b | 162.5±2.7 (2.8) | a | 144.5±4.4 (5.3) | a |
| | Novinka | 62.0±1.5 (7.3) | b | 10.7±0.2 (3.7) | a | 148.6±6.8 (7.9) | b | 130.2±7.8 (10.4) | a |
| | $\bar{X}$ | 73.0 ± 11.9 | | 9.0 ± 0.5 | | 155.5 ± 6.6 | | 137.3 ± 3.4 | |
| H | NS 032 | 113±7.5 (18.9) | b | 8.9±0.2 (3.4) | a | 158.3±3.0 (3.3) | a | 135.5±6.8 (8.7) | a |
| | NSP 11 | 159±7.1 (31.1) | a | 8.6±0.5 (9.3) | a | 154.1±3.1 (4.1) | a | 138.1±1.7 (2.2) | a |
| | $\bar{X}$ | 136 ± 27.2 | | 8.7 ± 0.3 | | 156.2 ± 1.8 | | 136.8 ± 2.2 | |
| t- test | | ** | | ns | | ns | | ns | |

The results of this paper confirm the findings from the literature about the longer spike, larger number and mass of grain/spike of hexaploid genotypes. Higher variability and dispersion of the

number and mass of grain/spikelet of the main shoot in different positions in the spike were found in the tetraploid genotypes. The largest number and mass of grain per spikelet are detected in central spikelets in both groups. The analysis of the cross section of the rachis of tetraploid and hexaploid genotypes shows that significant differences exist only in the area of cross section of the 2nd, 8th and 13th internodes. The number and dimensions of central bundles of tetraploid and hexaploid wheat genotypes do not differ significantly. An analysis of the number and area of all vascular bundles, as well as the share of hlorenchyma in the peripheral parts of the rachis at individual levels of the rachis, will give more complete data in the anatomical analysis of the rachis.

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# STATISTICAL EXPERIMENTAL DESIGN OF THE REMOVAL OF DIFFERENT COMPOUNDS FROM SYNTHETIC WASTEWATER BY MICELLAR-ENHANCED ULTRAFILTRATION

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**Abstract**

In this study, the removal of zinc ions ($Zn^{2+}$) and n-butanol (n-BuOH), including salt (NaCl) from model synthetic wastewater was investigated by micellar-enhanced ultrafiltration (MEUF) using sodium dodecyl sulfate (SDS). Statistical experimental design was used in order to analyze the effect of initial concentration of $Zn^{2+}$, n-BuOH, SDS, NaCl on the process performance. Further, the effect of Transmembrane Pressure (TMP) and membrane nominal molecular weight limit (NMWL) were also studied. It was found that n-butanol could not be removed by using MEUF. On the contrary, $Zn^{2+}$ was successfully removed obtaining rejection coefficients up to 99% in the most favorable conditions.

**Keywords**

MEUF, SDS, Zinc, MODDE, Factorial Design

## 1. INTRODUCTION

Heavy metal ions such as zinc are detected in the waste streams of mining operations, tanneries, electronics, electroplating and petrochemical industries, as well as in textile mill products [1]. Heavy metals toxicity in air, soil and water is a global problem and a threat to the environment and human health. Therefore, removal of heavy metals is a technological challenge with respect to industrial and environmental applications. Furthermore, volatile organic compounds (VOCs) such as n-butanol are also commonly present in industrial wastewaters. VOCs have been proven to be carcinogens and mutagens [2]. MEUF is a viable membrane-based separation technology for the simultaneous removal of heavy metals and organic compounds [3]. The principle of the process is that the surfactant monomers are aggregated to form micelles at concentrations higher than its critical micelle concentration (CMC) [4]. The solutes can be retained after being trapped by the micelles, whereas the untrapped species readily pass through the UF membranes [5]. Organic compounds are solubilised in the micelle interior and the metal ions get trapped on the surface of the oppositely charged micelles by electrostatic interaction [6]. The advantages of MEUF are low energy consumption as compared to Reverse Osmosis or Nanofiltration, relatively high fluxes and high removal efficiency. There is very few published information on the application of factorial designs by MODDE in the study of MEUF [7]. Factorial design is an efficient technique that can be applied to determine the main effects and interactions of these factors on process performance. Results of factorial design can subsequently be used to optimize and decreases the number of experiments needed. Furthermore, the use of raw material, time and natural resources will be decreased improving the efficiency of the process. This paper reports the removal of zinc ions from aqueous solutions containing n-butanol and sodium chloride by MEUF. The micelles were formed by adding the anionic surfactant sodium dodecyl sulfate (SDS) to the solutions. The main purpose was to separate zinc ions from the aqueous solutions. Additionally, the removal of n-butanol was also expected. Another goal of the present study was to screen the effect of pressure, membrane nominal molecular weight limit, the feed concentration of zinc, n-butanol, sodium chloride and SDS on the process performance.

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## 2. MATERIAL AND METHODS

### 2.1. Chemicals and equipments

All chemicals involved in the experiments were of analytical reagent grade. Zinc chloride ($ZnCl_2$ extra pure 99.99%) and sodium dodecyl sulfate (SDS, purity > 99%) from Fisher Scientific, UK were used without further purification. SDS has a molecular weight of MW = 288.38 g/mol and it's CMC equal to 8.2mM (2.36 g $l^{-1}$) [8].

N-butanol (obtained from Kemfine Oy, Finland) was supplied by Aldrich. The distilled water used in this study was purified by a Milli-Q plus water purification system (Millipore, USA) and had an initial resistivity of 18.2 MΩ-cm. N-butanol was determined by gas chromatography with a flame ionized detector (Agilent, 6890N). Sodium chloride (Merk, pro-analysi) was quantified.

The concentration of zinc was determined by Atomic Absorption Spectroscopy (Perkin Elmer 4100 with 3047 and 3044 flame atomization methods). The SDS content was analyzed by Total organic carbon portable analyzer (Sievers 900 Portable).

### 2.2. Experimental design

A set of experiments was designed by Modde 8.0 (Umetrics) using a fractional factorial design (Table 1). The factors and their respective range to be studied were pressure (P, 20 and 70 psi), SDS feed concentration ($C_{SDS}$, 3.5 and 20 mM), Zinc feed concentration ($C_{Zn^{2+}}$, 0.5 and 3mM), Sodium Chloride feed concentration ($C_{NaCl}$ 0 and 1w%), butanol feed concentration ($C_{BuOH}$ 1 and 13 mM) and membrane nominal molecular weight limit (NMWL 3 and 10 kDa). Three centre points were included to analyze the reproducibility of the experiments.

Table 1. Experiments conducted using fractional factorial design and their respective results.

| Screening Part | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Experimental Number | Factors | | | | | | Responses | |
| | $C_{SDS}$ [mM] | $C_{BuOH}$ [mM] | $C_{Zn2+}$ [mM] | $C_{NaCl}$ [mM] | Pres. [psi] | NMWL [kDa] | J [$Lm^{-2}h^{-1}$] | $R_{Zn2+}$ [%] |
| 1 | 3.5 | 1 | 0.5 | 0 | 20 | 3 | 3.26 | 73.38 |
| 2 | 20 | 1 | 0.5 | 0 | 70 | 3 | 17.51 | 99.22 |
| 3 | 3.5 | 13 | 0.5 | 0 | 70 | 10 | 69.51 | 53.70 |
| 4 | 20 | 13 | 0.5 | 0 | 20 | 10 | 13.15 | 95.98 |
| 5 | 3.5 | 1 | 3 | 0 | 70 | 10 | 60.81 | 37.83 |
| 6 | 20 | 1 | 3 | 0 | 20 | 10 | 11.36 | 96.86 |
| 7 | 3.5 | 13 | 3 | 0 | 20 | 3 | 3.46 | 36.98 |
| 8 | 20 | 13 | 3 | 0 | 70 | 3 | 20.15 | 90.02 |
| 9 | 3.5 | 1 | 0.5 | 1 | 20 | 10 | 10.34 | 17.52 |
| 10 | 20 | 1 | 0.5 | 1 | 70 | 10 | 63.31 | 57.70 |
| 11 | 3.5 | 13 | 0.5 | 1 | 70 | 3 | 18.60 | 23.19 |
| 12 | 20 | 13 | 0.5 | 1 | 20 | 3 | 2.64 | 56.75 |
| 13 | 3.5 | 1 | 3 | 1 | 70 | 3 | 34.10 | 9.91 |
| 14 | 20 | 1 | 3 | 1 | 20 | 3 | 4.17 | 42.29 |
| 15 | 3.5 | 13 | 3 | 1 | 20 | 10 | 12.88 | 13.42 |
| 16 | 20 | 13 | 3 | 1 | 70 | 10 | 54.30 | 54.87 |
| 17 | 11.75 | 7 | 1.75 | 0.5 | 45 | 5 | 12.21 | 65.36 |
| 18 | 11.75 | 7 | 1.75 | 0.5 | 45 | 5 | 12.88 | 65.68 |
| 19 | 11.75 | 7 | 1.75 | 0.5 | 45 | 5 | 12.76 | 65.05 |

The measured responses were the rejection coefficients for zinc ($R_{Zn}$) and butanol ($R_{BuOH}$) and the absolute permeate flux ($J_V$), which were calculated with the following equations:

$$R = 1 - \frac{C_p}{C_r}, \tag{1}$$

where $C_p$ and $C_r$ are the zinc or n-butanol concentration in the permeate and retentate, respectively.

$$J_V = \frac{V}{t \times A}, \tag{2}$$

where $J_v$ is the absolute permeate flux, V is the volume of the permeate sample collected, t is the time needed for collecting the permeate sample and A is the membrane effective area. The validity of the empirical models fitted with multiple linear regression (MLR) was tested with analysis of variance (ANOVA). The confidence level used was 95 %.

### 2.3. Dead-end micellar-enhanced UF experiments

All UF experiments were carried out in batch solvent resistant stirred cell (Millipore, Model 8400) with a capacity of 400 $cm^3$. In all MEUF tests the TMP was controlled and adjusted with pressurized $N_2$ gas by means of a transducer. The operating temperature was 25 ± 1°C controlled by an air conditioner. The solution in the reservoir was agitated using a magnetic stirrer to provide efficient mixing at 500 rpm. This stirring speed was selected because it could lead a sufficient agitation to result

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a homogenic solution without excessive vortex formation. The permeate flux was determined by measuring the first 100 $cm^3$ (five times 20 $cm^3$) of the feed solutions. In each experiment the first, second and the fifth permeate sample was analyzed and then integrally averaged because the compositions of the permeate varied during the experiments.

In the dead-end ultrafiltration (UF) experiments, UF flat sheet membranes of Amicon regenerated cellulose (PL series, Millipore) of different nominal molecular weight limits were used. Each membrane has a membrane effective area of 0.004$m^2$. Only the membranes with a deviation of the pure water flux, measured before and after MEUF tests, smaller than 5 % were repeatedly used. Ultra distilled water was used after each experiment test for membrane cleanings.

### 2.4. Experimental procedures

The initial feed volume was 200 $cm^3$. The average permeate flux was calculated by measuring the time needed for collecting permeate samples of 20 $cm^3$. The ultrafiltration experiments were carried out until 100 $cm^3$ of the total sample was filtered (VCF = 2). The VCF is defined in Eq. (3):

$$VCF = V_b / V_e \quad (3)$$

where $V_b$ and $V_e$ are the volumes of solutions in the MEUF device at the beginning and at the end of the test, respectively. The membrane was submerged before the concentration tests for 1 h to reach equilibrium with the solution.

## 3. RESULTS AND DISCUSSIONS

The main purpose was the simultaneous removal of $Zn^{2+}$ and n-BuOH by MEUF. From table 1 can be observed that butanol was not removed using micellar-enhanced ultrafiltration. The reason why the $R_{BuOH}$ is not included in Table 1 is that, in all cases, the rejection coefficients of BuOH were very low (average 5 ± 2 %). Therefore, the research was continued in order to see the effect of the mixture of butanol and salt in the removal of zinc by micellar-enhanced ultrafiltration. In this way, the responses included in the experimental design were $R_{Zn}$ and $J_v$.

### 3.1. Effects of factors on the absolute permeate flux

The effect of single factors on the permeate is illustrated in Fig. 1, displaying the change in the response when a factor varies from its low level to its high level while all other factors are kept at their averages. Negligible effects are those where the confidence interval includes zero.

As it can be observed from Fig. 1, pressure has a positive effect on the absolute permeate flux as expected. This means that increasing the pressure, higher permeate flux will be achieved. When pressure is increased the driving force is also increased obtaining a higher flux. NMWL has also a positive effect. Consequently, using a higher pore size membrane higher flux will be observed. Further, concentrations of SDS, BuOH, $Zn^{2+}$ and NaCl show a negligible effect on the absolute permeate flux.

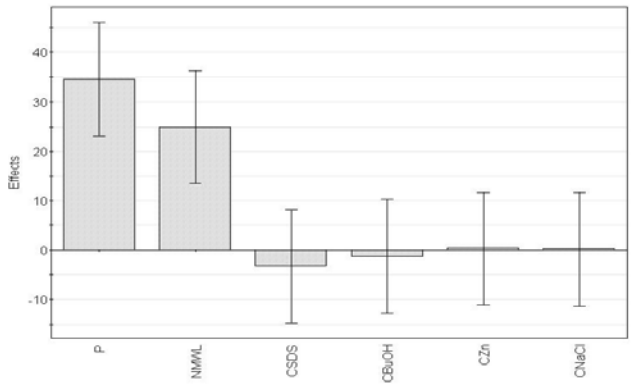



Figure 1. Effect of main factors on the absolute permeate flux

When evaluating the validity of the fitted model with ANOVA, the regression model is statistically significant with a 95% confidence level in the range studied. The response variation percentage explained by the model, $R^2$, for the permeate flux is 0.85. The response variation percentage predicted by the model, $Q^2$, is 0.60. The reproducibility of the experiments is good.

### 3.2. Effect of factors on the rejection coefficient

The effect of single factors on the permeate is illustrated in Fig. 2, displaying the change in the response when a factor varies from its low level to its high level while all other factors are kept at their averages. Negligible effects are those where the confidence interval includes zero.

As it can be observed from Fig. 2, the concentration of SDS, NaCl and the $Zn^{2+}$ have the major effect on the rejection coefficient. Concentration of SDS has a most significant positive effect, thus, when increasing the SDS feed concentration, the rejection coefficient is also increased. This is because at higher SDS concentration, more SDS is present in micellar form. NaCl concentration of the feed has a negative effect on the rejection coefficient, therefore, increasing it will decrease rejection. This result complies with earlier study [9] reported in the literature. Since $Na^+$ is a monovalent ion, it can readily bind with the negative charge head of the micelle competing with the heavy metal cations. Therefore, rejection coefficient decreases with an increase in the salt concentration. Further, zinc feed concentration also shows a negative effect on the rejection coefficient. Consequently, when increasing the zinc feed concentration rejection coefficient decreases. This shows that MEUF is more efficient for

diluted heavy metal streams. Further, concentrations of NMWL, BuOH and pressure show a negligible effect on the rejection coefficient.

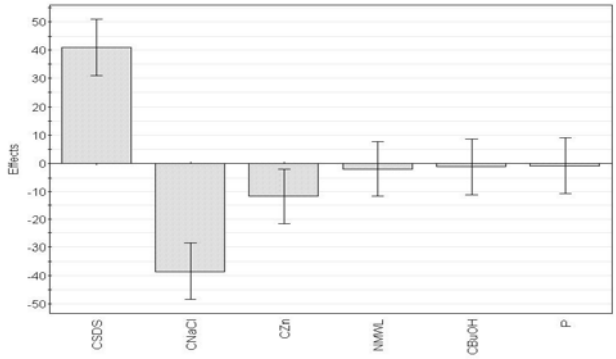



Figure 2. Effect of factors on the rejection coefficient of zinc

When evaluating the validity of the fitted model with ANOVA the regression model is statistically significant with a 95% confidence level in the range studied. The response variation percentage explained by the model, $R^2$, for the permeate flux is 0.93. The response variation percentage predicted by the model, $Q^2$, is 0.82. The reproducibility of the experiments is good.

## 4. CONCLUSIONS

In this study, the removal of zinc ions ($Zn^{2+}$) and n-butanol (n-BuOH), including salt (NaCl) from model synthetic wastewater was investigated by micellar-enhanced ultrafiltration (MEUF) using an anionic surfactant agent, sodium dodecyl sulfate (SDS).

It was found that n-butanol could not be removed by using MEUF. On the contrary, $Zn^{2+}$ was successfully removed obtaining rejection coefficients up to 99% in the most favorable experimental conditions.

A statistical experimental design (including Screening Part, SP) was used in order to analyze the effect of initial concentration of $Zn^{2+}$, n-BuOH, SDS, NaCl on the process performance. Further, the effect of Transmembrane Pressure (TMP) and membrane nominal molecular weight limit (NMWL) were also studied.

Pressure and NMWL have the most significant positive effects on the absolute permeate flux. Concentration of SDS has the most important positive effect, while NaCl has the most important negative effect on the rejection coefficient. Further, $Zn^{2+}$ feed concentration has the major negative effect on the rejection coefficient.

By using fractional factorial design, the effects of 6 different factors on the MEUF process performance were evaluated in only 19 experiments. This shows the high effectiveness of experimental design for screening experiments. Further, experimental designs can now be developed as the factors with statistically no significant effect are identified.

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# PLANT COVER OF THE SALINE GRASSLAND IN THE RIPARIAN ZONE OF THE OKANJ OXBOW LAKE (THE VOJVODINA PROVINCE, SERBIA)

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**Abstract**

The Okanj oxbow lake is located in the alluvial flood plain of the Tisza River, north of the village of Elemir in central Banat (the Vojvodina Province, Serbia). Saline pastures predominate in the riparian zone of Okanj. The plant cover of the zone is characterized by the following floristic (182 identified taxa, i.e., 166 species, 7 subspecies, 2 varieties, 6 forms and 1 lusus naturae) and phytocoenological (3 classes, 5 orders, 6 alliances and 14 associations) elements. It is important to mention that out of the 174 characteristic taxa (166 species, 7 subspecies and, because of its plant-geographic and ecological significance, the Pontic-Pannonian plant species *Aster tripolium* var. *pannonicus*), 44 or 25.29% of them have the ecological index **S**$_{+}$, which defines the Okanj oxbow lake as a part of a halobiome occupying the Tisza's meander scars.

Associations *Scirpo-Phragmitetum*, *Bolboschoenetum maritimi continentale*, *Suaedetum pannonicae*, *Salsoletum sodae*, *Puccinellietum limosae*, *Pholiuro-Plantaginetum tenuiflorae*, *Hordeetum histricis*, *Camphorosmetum annuae*, *Halo-Agrostetum albae*, *Agrostio-Alopecuretum pratensis*, *Agrostio-Beckmannietum*, *Plantagineto-Festucetum pseudovinae*, *Artemisio-Festucetum pseudovinae* and *Achilleo-Festucetum pseudovinae* are the specific phytocoenological elements of the observed halobiome.

Droughts and increasing anthropogenic influences keep degrading the ecosystem and if protective measures are not applied shortly, the rare stenovalent euhalophytes *Suaeda pannonica* and *Salsola soda* as well as the associations they predominate, *Suaedetum pannonicae* and *Salsoletum sodae*, respectively, will soon disappear.

**Key words**:
the Okanj oxbow lake, flora, vegetation, halobiome, protection

## 1. INTRODUCTION

In the region of central Banat (the Vojvodina Province, Serbia), several oxbow lakes had been formed in cut off meanders of the Tisza River by the action of ground and surface waters and precipitation. Significant among those, going from north to south, are Slano Kopovo, northeast of the town of Novi Bečej, Ostrovo, north of the village of Melenci, Rusanda, west of Melenci, and Okanj, north of the village of Elemir.

Plant covers of the riparian zones of Slano Kopovo, Ostrovo and Rusanda have been studied in considerable detail (Knežević et al. 2003, Knežević et al. 2005a, Knežević et al. 2005b). On the other hand, data on the plant cover in the riparian zone of Okanj are much scantier (Knežević 1994).

The objectives of this paper are to bring to attention the specific features of the flora and vegetation of saline pastures located in the riparian zone of Okanj, to support the

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initiative for protection of the Okanj ecosystem, submitted by "Okanj", Society for Environmental Protection from Elemir, to the Directorate for Environmental Protection of Serbia, and to urge the Directorate to legislate the initiative on a short notice because the Okanj ecosystem is seriously threatened in consequence to persistent droughts and intensive negative anthropogenic influences.

## 2. INVESTIGATED AREA

According to Walter climodiagram made at the meteorological station in Zrenjanin, the region of central Banat which includes the village of Elemir has an average annual rainfall of 574 mm and an average annual temperature of 11.1°C. The beginning of vegetation period (April) in that region is characterized by an abrupt increase in the amount of rainfall and a considerable but gradual increase of temperature. After reaching peak discharge in June, the amount of rainfall drops abruptly. Conversely to the rainfall, the gradually increased temperatures persist through the medium part of the vegetation period and they start to go down at an increased rate only after most severe droughts in October. Because of such relationship of rainfall to temperature, the period from July to October is semidry, which is unfavorable for the vegetation of the investigated region (Knežević et al. 2003).

As a result of such climate pattern, the Okanj ecosystem has highest water level in the course of spring. During that period, the length of Okanj is up to 4.5 kilometers, the width is about 500 meters, and the depth in the middle zone is over 1 meter. Each year during the semidry period, the water level in Okanj drops down significantly. In some years, because of intensive evaporation, the entire lake runs dry.

The soil of the riparian zone of Okanj is solonchakic solonetz, but in the extensive pastures around Okanj the solonchakic solonetz soil surrounds areas under uncultivated calcareous chernozem (micellar) on the loess terrace (Nejgebauer et al. 1971).

## 3. MATERIAL AND METHODS

The presented date on the plant cover of the saline sites in the riparian zone around the Okanj oxbow lake include results from previous studies of saline flora of Banat (Knežević 1994) and the results of the present study.

Plants have been determined and their names used in accordance with the nomenclatures published in "Flora of SR Serbia" (Josifović, M. ed. I-X, 1970-1976), "Flora Europaea" (Tutin et al. 1960-1980, "A magyar flóra és vegetació rendszertani-növényföldrajzi kézikönyve" (Soó I-VII, 1964-1985) and "Iconography of the Flora from the South-Eastern part of Central Europe" (Jávorka & Csapody, 1975).

Salinity values have been assessed on the basis of the ecological index of Landolt (Landolt 1977; Knežević 1994).

Syntaxonomic position of the halophytic communities occupying the sites surrounding the Okanj oxbow lake has been defined in accordance with the publications "A magyar flóra és vegetació rendszertani-növényföldrajzi kézikönyve" (Soó V. 1973) and "Halophytic Vegetation of the Yugoslav Portion of the Banat Region" (Knežević et al. 1989).

## 4. RESULTS AND DISCUSSION

Following taxa have been found at sites in the riparian zone of the Okanj oxbow lake:

1. *Achillea millefolium* L. /**S**-/,
2. *Achillea millefolium* L. subsp. *pannonica* (Scheele) Hayek /**S**-/,
3. *Achillea setacea* W. et K. /**S**-/,
4. *Agrimonia eupatoria* L. /**S**-/,
5. *Agropyrum repens* (L.) Beauv. /**S**+/,
6. *Agrostis alba* L. /**S**-/,
*Agrostis alba* L. f. *coarctata* Rchb.,
7. *Allium atropurpureum* W. et K. /**S**-/,
8. *Allium vineale* L. /**S**-/,
9. *Alopecurus pratensis* L. /**S**-/,
10. *Althea officinalis* L. /**S**-/,
11. *Anthemis austriaca* Jacq. /**S**-/,
12. *Arabidopsis thaliana* (L.) Heynh. /**S**-/,
13. *Artemisia maritima* L. subsp. *salina* (Willd.) Gams. /**S**+/,
14. *Artemisia pontica* L. /**S**-/,
15. *Artemisia vulgaris* L. /**S**-/,
16. *Aster tripolium* var. *pannonicus* (Jacq.) Beck /**S**+/,
17. *Atriplex litoralis* L. /**S**+/,
18. *Ballota nigra* L. /**S**-/,
19. *Beckmannia eruciformis* (L.) Host /**S**+/,
20. *Bidens tripartitus* L. /**S**-/,
21. *Bolboschoenus maritimus* (L.) Palla /**S**+/,
*Bolboschoenus maritimus* (L.) Palla var. *compactus* (Hoffm.) Jáv.,

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22. *Bromus commutatus* Schrad. /**S**-/,
23. *Bromus mollis* L. /**S**-/,
*Bromus mollis* L. f. *nanus* Weig. ,
24. *Bromus sterilis* L. /**S**-/,
25. *Bupleurum tenuissimum* **L.** /**S**+/,
26. *Calystegia sepium* (L.) R. Br. /**S**-/,
27. *Camphorosma annua* Pall. /**S**+/,
28. *Capsella bursa-pastoris* (L.) Medik. /**S**-/,
29. *Carduus acanthoides* L. /**S**-/,
30. *Carduus nutans* L. /**S**-/,
31. *Carex gracilis* Curt. /**S**-/,
32. *Carex humilis* Leysser /**S**-/,
33. *Carex pseudocyperus* L. /**S**-/,
34. *Carex vulpina* L. /**S**-/,
35. *Centaurea banatica* Roch. ex Rchb. /**S**-/,
36. *Centaurea pannonica* (Heuff.) Simk. /**S**-/,
37. *Cephalaria transilvanica* (L.) Schrad. /**S**-/,
38. *Cerastium dubium* (Bast.) Schwarz. /**S**-/,
39. *Cerastium pumilum* Curt. /**S**-/,
40. *Chartamus lanatus* **L.** /**S**-/,
41. *Chenopodium apulifolium* Schrader /**S**-/,
42. *Chenopodium glaucum* L. /**S**+/,
43. *Chondrilla juncea* /**S**-/,
44. *Cichorium intybus* L. /**S**-/,
45. *Cirsium arvense* **(**L.) Scop. /**S**+/,
46. *Cirsium palustre* **(**L.) Scop. (**S** -),
47. *Consolida orientalis* (Gay.) Schröd. /**S** -/,
48. *Convolvulus arvensis* L. /**S**-/,
49. *Crepis foetida* L. subsp. *rhoaedifolia* (M. B.) Fiori et Paol. /**S**-/,
50. *Crepis setosa* Hall. /**S**-/,
51. *Crepis tectorum* L. /**S**-/,
52. *Crypsis aculeata* (L.) Aitt. /**S**+/,
53. *Cynoglosum montanum* Höjer /**S**-/,
54. *Cynodon dactylon* (L.) Pers. /**S**-/,
55. *Dactylis glomerata* L. /**S**-/,
56. *Daucus carota* L. /**S**-/,
57. *Descurainia sophia* (L.) Webb**.** /**S**-/,
58. *Dipsacus laciniatus* L. /**S**-/,
59. *Epilobium adnatum* Griseb. /**S**-/,
60. *Erigeron canadensis* L. /**S**-/,
61. *Erophila verna* (L.) Schevall. /**S**-/,
62. *Erysimum repandum* L. /**S**-/,
63. *Euclidium syriacum* /L./ R. Br. /**S**-/,
64. *Euphorbia esula* L. /**S**-/,
65. *Festuca ovina* L. /**S**-/,
66. *Festuca vallesiaca* Sch. subsp. *Pseudovina* (Hack.) A. et G. /**S**+/,
67. *Fragaria viridis* Duchesne /**S**-/,
68. *Gagea arvensis* (Pers.) Dumort. /**S**-/,
69. *Gagea pratensis* (Pers.) Dumort. /**S**-/,
70. *Galium aparine* L. /**S**-/,
71. *Galium molugo* L. /**S**-/,
72. *Galium pedemontanum* All. /**S**-/,
73. *Galium verum* L. /**S**-/,
74. *Geranium columbinum* L. /**S**-/,
75. *Geranium dissectum* Jusl. /**S**-/,
76. *Geranium molle* L. /**S**-/,
77. *Geranium pusillum* Burm. /**S**-/,
78. *Glyceria maxima* (Hortm.) Holombg. /**S**-/,
79. *Gratiola officinalis* L. /**S**-/,
80. *Gypsophila muralis* L. /**S**-/,
81. *Heleocharis palustris* (L.) R. Br. /**S**-/,
82. *Helminthia echioides* (L.) Gärtn. /**S**-/,
83. *Holosteum umbelatum* L. /**S**-/,
84. *Hordeum maritimum* With. subsp. *gussoneanum* (Parl.) A. et G. /**S**+/,
85. *Hordeum murinum* L. /**S**-/,
86. *Inula britannica* L. /**S**+/,
*Inula britannica* L. f. *angustifolia* Marson.,
87. *Lactuca saligna* L. /**S**+/,
88. *Juncus compressus* Jacq. /**S**+/,
89. *Juncus gerardi* Lois. /**S**+/,
90. *Lamium amplexicaule* L. /**S**-/,
91. *Lamium purpureum* L. /**S**-/,
92. *Lepidium draba* L. /**S**-/,
93. *Lepidium perfoliatum* L. /**S**-/,
94. *Lepidium ruderale* L. /**S**-/,
95. *Lolium perenne* L. /**S**-/,
96. *Lotus tenuis* Kit. /**S**-/,
97. *Lycopus europeus* L. /**S**-/,
98. *Lythrum salicaria* L. /**S**-/,
99. *Lythrum virgatum* L. /**S**-/,
100. *Malva silvestris* L. /**S**-/,
101. *Matricaria chamomilla* L. /**S**+/,
*Matricaria chamomilla* L. f. *salina* (Schur) Jáv.
102. *Matricaria inodora* L. /**S**+/,
103. *Medicago lupulina* L. /**S**-/,
104. *Melilotus officinalis* (L.) Pallas /**S**-/,
105. *Mentha pulegium* L. /**S**+/,
*Mentha pulegium* L. l. *roseiflora* Priszter
106. *Muscari racemosum* (L.) Mill. /**S**-/,
107. *Myosotis collina* Hoffm. /**S**-/,
108. *Myosurus minimus* L. /**S**-/,
109. *Oenanthe silaifolia* M.B. /**S**+/,
110. *Ononis spinosa* L. /**S**-/,
111. *Ornithogalum umbellatum* L. /**S**-/,
112. *Papaver rhoeas* L. /**S**-/,
113. *Pastinaca sativa* L. /**S**-/,
114. *Pholiurus pannonicus* (Host) Trin. /**S**+/,
115. *Phragmites communis* Trin. /**S**+/,
*Phragmites communis* Trin. f. *stolonifera* (G. F. W. Meyer) Hegi,
116. *Picris hieracioides* L. /**S**-/,
117. *Plantago maior* L. /**S**+/,
118. *Plantago schwarzenbergiana* Schur /**S**+/,
119. *Plantago tenuiflora* W. et K. /**S**+/,
120. *Poa pratensis* L. /**S**-/,
121. *Podospermum canum* C.A. Mey. /**S**+/,
122. *Polygonum arenarium* W. et K. /**S**-/,
123. *Polygonum aviculare* L. /**S**-/,
124. *Potentilla argentea* L. /**S**-/,
125. *Prunus spinosa* L. **(S -)**,
126. *Puccinellia limosa* (Schur) Holmb. /**S**+/,
127. *Pulicaria dysenterica* (L.) Gaertn. /**S**+/,
128. *Ranunculus pedatus* W. et K. /**S**-/,
129. *Ranunculus sardous* Cr. /**S**+/,
130. *Roripa kerneri* Menyh. /**S**+/,
131. *Rubus fruticosus* L. /**S**-/,
132. *Rumex crispus* L. /**S**+/,
133. *Salsola soda* L. /**S**+/,
134. *Salvia austriaca* Jacq. /**S**-/,
135. *Salvia nemorosa* L. /**S**-/,
136. *Sambucus ebulus* L. /**S**-/,
137. *Sambucus nigra* L. (**S** -),
138. *Schoenoplectus lacuster* (L.) Palla /**S**-/,
139. *Scilla autumnalis* L. /**S**-/,
140. *Senecio vernalis* W. et K. /**S**+/,
141. *Silene alba* (Mill.) Krause /**S**-/,
142. *Silene viscosa* (L.) Pers. /**S**+/,
143. *Sinapis arvensis* L. /**S**-/,
144. *Sonchus arvensis* L. /**S**+/,
145. *Statice gmelini* Willd. subsp. *Hungaricum* (Klokov) Soó /**S**+/,
146. *Suaeda pannonica* Beck /**S**+/,
147. *Symphytum officinale* L. /**S**-/,

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148. *Taraxacum laevigatum* (Willd.) DC. /**S**-/,
149. *Taraxacum officinale* Weber /**S**+/,
150. *Taraxacum serotinum* (W. et K.) Poir. subsp. *bessarabicum* (Horn.) Hand. –Mazz. /**S**+/,
151. *Thlaspi arvense* L. /**S**-/,
152. *Thymus marschallianus* Willd. /**S**-/,
153. *Trifolium angulatum* W. et K. /**S**+/,
154. *Trifolium campestre* Schreb. (**S** -),
155. *Trifolium fragiferum* L. /**S**+/,
*Trifolium fragiferum* L. f. *rigidifolium* Hendrych.
156. *Trifolium pratense* L. /**S**-/,
157. *Trifolium repens* L. /**S**-/,
158. *Trifolium strictum* (L.) Jusl. /**S**+/,
159. *Tussilago farfara* L. /**S**-/,
160. *Urtica dioica* L. /**S**-/,
161. *Urtica urens* L. (**S** -),
162. *Valerianella dentata* Pall. /**S**-/,
163. *Valerianella locusta* (L.) Betcke /**S**-/,
164. *Valerianella rimosa* Bast. /**S**-/,
165. *Verbascum blattaria* L. /**S**+/,
166. *Verbena officinalis* L. /**S**-/,
167. *Veronica anagalloides* Guss. /**S**-/,
168. *Veronica arvensis* L. /**S**-/,
169. *Veronica hederifolia* L. /**S**-/,
170. *Veronica polita* Fr. /**S**-/,
171. *Vicia angustifolia* L. /**S**-/,
172. *Vicia hirsuta* (L.) S. F. Gray. /**S**-/,
173. *Vicia striata* M. Bieberst. /**S**-/, i
174. *Xanthium spinosum* L. /**S**-/.

Out of the 182 recorded taxa, 174 have been numbered as characteristic. Those were 166 species, 7 subspecies and, because of its plant-geographic and ecological significance, 1 variety (the Pontic-Pannonian species *Aster tripolium* var. *pannonicus*). Eight taxa (1 variety, 6 forms and 1 lusus naturae) were left unnumbered.

Of the 174 numbered characteristic taxa, 44 or 25.29% of those were labeled with the ecological index $\mathbf{S}_+$, and 130 or 74.71% with the ecological index **S**-.

Comparing the florae of the riparian zones of Okanj on one side and Slano Kopovo (Knežević et al. 2005a), Ostrovo (Knežević et al. 2005 b) and Rusanda (Knežević et al. 2003) on the other, we found the following.

The flora of the Okanj riparian zone (174 numbered taxa) was richer than the florae of the riparian zones of Slano Kopovo, Ostrovo and Rusanda (91, 77 and 134 numbered taxa, respectively).

The percentage of taxa labeled with the ecological index $\mathbf{S}_+$ was lower for the flora of the Okanj riparian zone (25.29% or 44 taxa) than those for the florae of the riparian zones of Slano Kopovo, Ostrovo and Rusanda (50.54% or 46 taxa, 31.17% or 24 taxa and 31.34% or 43 taxa, respectively).

Obviously, the highest floristic richness and the lowest percentage of taxa bearing the ecological index $\mathbf{S}_+$ in the sites around Okanj are due to a higher diversity of these sites and a higher degree of preservation of that ecosystem compared with the other analyzed ecosystems.

Rationale

The ecosystem of the riparian zone of the Okanj oxbow lake is larger (areawise) than the other ecosystems under comparison. It includes spacious pastures with the solonchakic solonetz soil. In several spots, solonchakic solonetz surrounds areas under uncultivated calcareous chernozem (micellar) on the loess terrace (Nejgebauer et al. 1971).

The ecosystem of the riparian zone of the Slano Kopovo oxbow lake covers a smaller area. It consists of a narrow riparian and inundated zone with the solonchak soil of an unusually high salinity rate (Janjatović, Kastori 1979) and adjoining pastures with the solonchakic solonetz soil (Nejgebauer et al. 1971). The calcareous chernozem soil (micellar) on the loess terrace surrounding these pastures has mostly been turned to field crop production.

The ecosystem of the riparian zone of the Ostrovo oxbow lake is made up of a system of fishponds whose construction had destroyed a considerable area under the solonchakic solonetz soil while the remaining area has been floristically impoverished by intensive anthropogenic activities. Most of the surrounding calcareous chernozem soil (micellar) on the loess terrace has been turned to field crop production (Nejgebauer et al. 1971).

The ecosystem of the riparian zone of the Rusanda oxbow lake is smallest of the analyzed ecosystems. Its narrow riparian zone under the solonchakic solonetz soil and the surrounding calcareous chernozem soil (micellar) on the loess terrace suffer intensive anthropologic influences coming from the village of Melenci, the Rusanda spa and field crop production (Nejgebauer et al. 1971).

The actual number of taxa labeled with the ecological index $\mathbf{S}_{+}$ in the riparian zone of Okanj is fairly high (44 taxa). This number is below than that for the riparian zone of Slano Kopovo (46 taxa) but it is higher than those for the riparian zones of Rusanda (43 taxa) and especially Ostrovo (24 taxa).

Therefore, judging by the percentage of the recorded halophytes (25.29%) and especially by their actual numbers (44 taxa), the ecosystem of the Okanj riparian zone is obviously a part of the halobiome occupying the meander scars of the Tisza River in central Banat.

Together with the other observed taxa, the recorded halophytes form numerous plant communities in the Okanj riparian zone.

The syntaxonomic position of the plant communities registered at the saline sites surrounding the Okanj oxbow lake is as follows.

*Phragmitetea* Tx. et Prsg. 1942
*Phragmitetalia* W. Koch1926 emend. Pign 1953
*Phragmition communis* W. Koch 1926 emend. Soó 1947
Ass. *Scirpo-Phragmitetum* W. Koch 1926
*medioeuropaeum* Tx. 1941
p.p. emend. Soó 1971
*Bolboschoenetalia maritimi* Hejný 1967
p.p. (*Bolboschenetea maritimi* Tx. 1969, *Scirpetalia maritimi* Borhidi 1970 p.p.)
*Bolboschoenion maritimi continentale* Soó (1945) 1947 emend. Borhidi 1970
Ass. *Bolboschoenetum maritimi continentale* Soó (1927) 1957
(*Scirpetum maritimi* Tx. 1937)
*Thero-Salicornietea* Tx. 1955, Tx.et Oberd. 1958
*Thero-Salicornietalia* (Br.–Bl.1931) Tx. 1954 ex Tx. et Oberd. 1958
*Thero-Salicornion* Br.–Bl. 1933 em Tx. 1950
Ass. *Suaedetum pannonicae* Soó 1927 Wendel. 1943
Ass. *Salsoletum sodae* Slavnić (1939) 1948
*Festuco-Puccinellietea* Soó 1968
*Festuco-Puccinellietalia* Soó 1968
*Puccinellion limosae* (Klika 1937) Wendel. 1943
Ass. *Puccinellietum limosae* (Rapcs. 1927) Soó 1930
Ass. *Pholiuro-Plantaginetum tenuiflorae* (Rapcs. 1927) Wendel. 1943
Ass. *Hordeetum histricis* (Soó 1933) Wendel. 1943
Ass. *Camphorosmetum annuae* (Rapcs. 1916) Soó 1933 corr. Soó 1938
*Halo-Agrostion albae pannonicum* Knežević 1990
Ass. *Halo-Agrostetum albae* Vučković 1985
Ass. *Agrostio-Alopecuretum pratensis* Soó (1933) 1947
Ass. *Agrostio-Beckmannietum* (Rapcs. 1916) Soó 1933
*Artemisio-Festucetalia pseudovinae* Soó 1968
*Festucion pseudovinae* Soó 1933.
*Halo-Festucenion pseudovinae* Vučković 1985
Ass. *Plantagineto-Festucetum pseudovinae* Parabućski 1980
Ass. *Artemisio-Festucetum pseudovinae* (Magyar 1928) Soó 1945
*Xero-Festucenion pseudovinae* Vučković 1985
Ass. *Achilleo-Festucetum pseudovinae* (Magyar 1928) Soó 1945.

The plant cover of the Okanj riparian zone comprises stands belonging to 3 classes, 5 orders, 6 alliances and 14 plant associations, bearing witness of a considerable diversity of the existing ecological niches.

Some of the registered plant communities cover a limited area or even are not completely formed in some parts of the vegetation period. On the shoreline of the oxbow lake that is not covered with stands of the communities *Scirpo-Phragmitetum* and *Bolboschoenetum maritimi continentale*, there are stands of the communities *Suaedetum pannonicae* and *Salsoletum sodae*. Since the oxbow lake serves as watering hole for cattle, the latter stands are frequently crushed down before *Suaeda pannonica* and *Salsola soda*, their respective characteristic species, reach the stage of full seed maturity. This practice, in combination with increasingly severe droughts, has led to a situation that only scant populations of the species *Suaeda pannonica* and *Salsola soda* could be observed in recent years. Stands of plant communities *Pholiuro-Plantaginetum tenuiflorae*, *Hordeetum histricis*, *Camphorosmetum annuae*, *Agrostio-Beckmannietum* and *Plantagineto-Festucetum pseudovinae* develop on limited areas. Largest areas in the riparian zone of the Okanj oxbow lake are occupied by stands of the plant communities *Puccinellietum limosae*, *Halo-Agrostetum albae*, *Agrostio-Alopecuretum pratensis*, *Artemisio-Festucetum pseudovinae* and *Achilleo-Festucetum pseudovinae*. These stands cover the saline pastures which are subject to intensive cattle grazing and sheep folding and which are daily traversed by horse-drawn wagons and agricultural machines in the course of the vegetation period.

## 5. CONCLUSION

Distinguishing features of the plant cover of the saline pastures in the riparian zone of the Okanj oxbow lake (the Vojvodina Province, Serbia) make its floristic (182 recorded taxa,

i.e., 166 species, 7 subspecies and 2 varieties, 6 forms and 1 lusus naturae) and phytocoenological constituents (3 classes, 5 orders, 6 alliances and 14 associations).

It is important that out of the 174 characteristic taxa (166 species, 7 subspecies and, because of its plant-geographic and ecological significance, the Pontic-Pannonian plant species *Aster tripolium* var. *pannonicus*) 44 or 25.29% of them were assigned the ecological index $\mathbf{S}_{+}$ which defines the Okanj oxbow lake as a part of the halobiome that occupies the meander scars of the Tisza River in central Banat.

The following associations make this halobiome phytocoenologically specific: *Scirpo-Phragmitetum*, *Bolboschoenetum maritimi continentale*, *Suaedetum pannonicae*, *Salsoletum sodae*, *Puccinellietum limosae*, *Pholiuro-Plantaginetum tenuiflorae*, *Hordeetum histricis*, *Camphorosmetum annuae*, *Halo-Agrostetum albae*, *Agrostio-Alopecuretum pratensis*, *Agrostio-Beckmannietum*, *Plantagineto-Festucetum pseudovinae*, *Artemisio-Festucetum pseudovinae* and *Achilleo-Festucetum pseudovinae*.

Droughts and increasing anthropogenic influences keep degrading the ecosystem and if protective measures are not applied soon, the rare stenovalent euhalophytes *Suaeda pannonica* and *Salsola soda* as well as the associations they predominate, *Suaedetum pannonicae* and *Salsoletum sodae*, respectively, will disappear in near future.

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# GREEN MOULD DISEASE OF OYSTER MUSHROOM IN HUNGARY AND ROMANIA: ECOPHYSIOLOGY OF THE CAUSATIVE AGENTS

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**Abstract:**
The green mould disease of oyster mushroom (*Pleurotus ostreatus*) has been recently reported to cause great crop losses in Hungary and Romania. *Trichoderma pleurotum* and *Trichoderma pleuroticola*, the lately described fungal species responsible for the disease are present in both countries. The presented analysis has revealed that the growth of *T. pleurotum* shows a narrower temperature range (15-30°C) than that of *T. pleuroticola* (10-35°C). Acidic and neutral pH values and higher water activities were found to favour the growth of both pathogens. These data provide useful information for mushroom growers to optimize the ecophysiological parameters during oyster mushroom cultivation.

**Key Words:**
ecophysiology, green mould disease, oyster mushroom, *Pleurotus ostreatus*, *Trichoderma pleuroticola*, *Trichoderma pleurotum*

## 1. INTRODUCTION

Following champignon (*Agaricus bisporus*) and shiitake (*Lentinula edodes*), oyster mushroom (*Pleurotus ostreatus*) is the third-most important commercially grown edible basidiomycete worldwide [1]. In the past few years severe green mould infections of cultivated *P. ostreatus* have been reported in South Korea [7], Italy [10], Hungary [4] and Romania [6], which might indicate a worldwide threat.

The two filamentous fungal species responsible for the problem proved to be different from *T. aggressivum* f. *aggressivum* and *T. aggressivum* f. *europaeum*, the causative agents of green mould disease in the case of *A. bisporus* [9]. In 2006 they were described as *Trichoderma pleurotum* S.H. Yu & M.S. Park, sp. nov. and *Trichoderma pleuroticola* S.H. Yu & M.S. Park sp. nov. [8]. Komon-Zelazowska et al. [5] used an integrated approach for the comprehensive characterization of several *T. pleurotum* strains from Hungary, Romania and Italy, as well as *T. pleuroticola* isolates from Canada, the USA, Italy, Hungary, Romania, Iran, The Netherlands, Germany and New Zealand. Both species belong to the *Harzianum* clade of *Hypocrea/Trichoderma*. Morphological studies have revealed that *T. pleuroticola* shows pachybasium-like properties characteristic of the *Harzianum* clade, while *T. pleurotum* possesses gliocladium-like conidiophore morphology. BIOLOG phenotype microarrays were used to determine the carbon source utilization profile of the isolates and the results have shown unequivocal differences between the two species, namely the growth of *T. pleurotum* was slower or impaired on the majority of the carbon sources tested as compared with *T. pleuroticola*, which showed similar growth to that of *T. aggressivum*,

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indicating a closer relationship. The results suggest that the evolution of *T. pleurotum* was accompanied with the loss of the utilization ability of certain carbon sources. The phylogenetic analysis of a fragment including the internal transcribed spacer (ITS1-5.8S rRNA-ITS2) region of the ribosomal RNA gene cluster, a fragment covering the 4th and 5th introns and the last long exon of the *tef1* gene encoding for translation elongation factor 1α, and a fragment including a portion of the 5th exon of the *chi18-5* (previously named *ech42*) gene encoding a family 18 chitinase confirmed the involvement of the two distinct species in causing the green mould disease of oyster mushroom worldwide [5]. A DNA BarCode for identification of these species based on ITS1 and ITS2 sequences was also provided and integrated in the main database for *Hypocrea/Trichoderma* (www.isth.info, [3]).

The aim of this study was to examine the effect of environmental factors (temperature, pH and water activity) on the mycelial growth of *T. pleuroticola* and *T. pleurotum*, the causative agents of oyter mushroom green mould disease, in comparison with related *Trichoderma* species (*T. harzianum*, *T. aggressivum* f. *aggressivum* and *T. aggressivum* f. *europaeum*).

## 2. THE STUDY

The *Trichoderma* strains included in this study are listed in Table 1. Strains were maintained on YEGK medium (0.5% glucose, 0.5% $KH_2PO_4$, 0.1% yeast extract, 2% agar).

Table 1. *Trichoderma* strains involved in the study

| Species | Strain | Isolation source |
|---|---|---|
| *T. harzianum* | C8, C22 | *Agaricus* compost, Hungary |
| *T. aggressivum* f. *aggressivum* | CBS 100527, CBS 450.95 | *Agaricus* compost, Canada |
| *T. aggressivum* f. *europaeum* | CBS 100526, CBS 433.95 | *Agaricus* compost, United Kingdom |
| *T. pleurotum* | A5, A11, A13, A14, A19, A26, A28, C2 | oyster mushroom substrate (wheat straw), Hungary |
| *T. pleuroticola* | CPK 2902, CPK 2894, CPK 2897 | natural substrate of wild-growing oyster mushrom, Hungary |
| | E10 | oyster mushroom substrate (wheat straw), Romania |
| | CPK 230 | decayed *Acer* stump, Canada |
| | CPK 882 | Iran |

The effect of temperature, pH and water activity ($a_w$) on linear mycelial growth was examined on synthetic minimal medium (0.5% $(NH_4)_2SO_4$, 0.5% $KH_2PO_4$, 0.1% $MgSO_4x7H_2O$, 1% glucose, 2% agar) and on a medium containing dried *Pleurotus* powder (0.1% glucose, 0,1% *Pleurotus* powder, 1% $KH_2PO_4$, 2% agar). Strains were inoculated onto the media with mycelial agar plugs cut from the edge of actively growing colonies. For studying the temperature dependence of the growth, plates were incubated at different temperatures (5, 10, 15, 20, 25, 30, 35 and 40°C). The effect of pH was examined at seven different pH values (pH 2,2, 3, 4, 5, 6, 7, 8) adjusted by McIlvain buffer solutions (mixtures of 0.3 M $Na_2HPO_4$ x 2 $H_2O$ and 0.1 M citric acid stock solutions in different proportions). $a_w$ values between 0.997 and 0.922 were adjusted with NaCl according to Chirife and Resnik [2] (0.997: 0% NaCl, 0.991: 1% NaCl, 0.980: 3% NaCl, 0.968: 5% NaCl, 0.962: 6% NaCl, 0.951: 8% NaCl, 0.945: 9% NaCl, 0.922: 12% NaCl). Colony diameters were measured daily along two perpendicular axes. Growth curves were recorded with the aid of Microsoft Excel 2002, the colony diameter extension rates were expressed in mm/day.

## 3. ANALYSES, DISCUSSION, INTERPRETATIONS

The examined *T. pleuroticola* strains showed mycelial growth in the range of 10-35°C (Table 2). The optimum temperature for growth proved to be 30°C, while the growth rate significantly decreased at 35°C and no growth could be observed at 40°C and 5°C. The *T. harzianum* strains showed a temperature dependence similar to that of the *T. pleuroticola* strains. Based on our results, the examined *T. aggressivum* and *T. pleurotum* strains can be

characterized with a narrower temperature spectrum. In the case of *T. pleurotum* strains, no growth could be observed at 5, 10, 35 and 40°C, while the temperature optimum proved to be 25-30°C both on synthetic minimal medium and on *Pleurotus* powder medium. No significant differences in the temperature profiles could be observed between the two types of the media.

Table 2. Temperature dependence of the examined *Trichoderma* species. Colony diameter extension rates on minimal medium and *Pleurotus* powder containing medium in mm/day

| | Temperature | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Minimal medium | *5°C* | *10°C* | *15°C* | *20°C* | *25°C* | *30°C* | *35°C* | *40°C* |
| *T. harzianum* | – | 0.00-1.72 | 6.35-14.20 | 21.76-26.40 | 27.33-32.50 | 23.10-23.66 | 2.04-6.32 | – |
| *T. aggressivum* f. *aggressivum* | – | 0.00-1.68 | 3.58-10.84 | 9.91-21.42 | 25.66-28.00 | 8.35-25.33 | – | – |
| *T. aggressivum* f. *europaeum* | – | – | 0.00-16.25 | 14.00-30.30 | 18.57-36.50 | 18.35-25.30 | – | – |
| *T. pleurotum* | – | – | 2.50-5.93 | 17.71-21.23 | 22.69-23.46 | 18.42-23.76 | – | – |
| *T. pleuroticola* | – | 3.33-3.66 | 5.89-10.90 | 24.00-26.80 | 22.00-30.00 | 19.60-33.00 | 0.18-1.67 | – |
| *Pleurotus* powder medium | | | | | | | | |
| *T. harzianum* | – | – | 0.00-1.43 | 9.25-13.92 | 21.46-26.00 | 27.33-31.00 | 2.22-10.02 | – |
| *T. aggressivum* f. *aggressivum* | – | – | 0.00-12.28 | 20.10-25.33 | 22.00-24.00 | 6.00-23.66 | – | – |
| *T. aggressivum* f. *europaeum* | – | – | 4.56-18.30 | 17.23-21.30 | 22.69-34.50 | 13.14-22.76 | – | – |
| *T. pleurotum* | – | – | 4.83-8.14 | 10.07-22.53 | 23.46-30.00 | 22.23-30.00 | – | – |
| *T. pleuroticola* | – | 2.36-4.31 | 12.30-20.60 | 21.00-25.10 | 27.50-30.00 | 29.00-30.50 | 0.29-2.07 | – |

Although the temperature ideal for the growth of oyster mushroom varies among strains, room temperatures of approximately 25°C, 13-15°C and 18°C are needed for spawn-run, induction of the development of fruit bodies and fruiting, respectively [11]. The substrate is exposed to green mould infection mostly during spawn-run, when the substrate temperature is elevated up to 30°C due to the generation of metabolic heat by mushroom mycelia. Based on our results, the *Pleurotus*-pathogenic *Trichoderma* species show maximal mycelial growth at 25-30°C, while limited, or no growth was observed at 10°C. Woo et al. [10] reported that the temperature optimum for the growth of *Pleurotus* was 28°C, while *Trichoderma* could grow well at a wider range (20–28°C), and exceeded the growth rate of *Pleurotus* by three times at 25°C. These findings suggest that the temperature of the growing room should be maintained between 15 and 18°C after spawn-run in order to minimize the possibility of green mould infection.

In the case of most *T. pleuroticola* and *T. pleurotum* isolates, the highest values of colony diameter extension rates were recorded in the pH range of 5.0-6.0 on synthetic minimal medium, while the pH optimum of the *T. harzianum*, *T. aggressivum* f. *aggressivum* and *T. aggressivum* f. *europaeum* isolates proved to be lower, at pH 4.0 (Table 3). Interestingly, the pH profiles were narrower on *Pleurotus* powder containing medium, with an optimum shifted to pH 4.0 in the case of the *Pleurotus* pathogenic *Trichoderma* species. Only *T. pleuroticola* was capable of growing at all examined pH values on *Pleurotus* powder containing medium. The growth of *T. pleurotum* and *T. aggressivum* f. *aggressivum* ceased at pH values above 5.0, while no growth of *T. harzianum* and *T. aggressivum* f. *europaeum* could be observed at pH values above pH 4.0. Our results suggest that the pH spectrum of mushroom pathogenic *Trichoderma* species can be narrower in the cultivation substrate than it can be expected based on data deriving from *in vitro* studies on synthetic media.

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Table 3. pH dependence of the examined *Trichoderma* species. Colony diameter extension rates on minimal medium and *Pleurotus* powder containing medium in mm/day

| Minimal medium | pH | | | | | | |
|---|---|---|---|---|---|---|---|
| | *2.2* | *3.0* | *4.0* | *5.0* | *6.0* | *7.0* | *8.0* |
| *T. harzianum* | 4.20-4.68 | 5.40-19.17 | 16.55-20.71 | 19.78-20.25 | 5.80-19.77 | 2.85-14.02 | 4.20-15.21 |
| *T. aggressivum* f. *aggressivum* | 5.10-8.34 | 10.05-18.94 | 10.15-19.10 | 5.60-18.62 | 2.60-16.30 | 2.20-6.41 | 2.40-4.32 |
| *T. aggressivum* f. *europaeum* | 5.52-6.55 | 14.80-25.25 | 18.20-25.55 | 16.25-17.37 | 3.70-12.55 | 3.95-8.05 | 3.15-9.28 |
| *T. pleurotum* | 2.90-5.21 | 14.08-18.78 | 9.50-19.65 | 13.75-20.08 | 15.28-20.27 | 10.27-18.74 | 9.40-14.45 |
| *T. pleuroticola* | 4.00-4.90 | 11.80-22.35 | 8.60-15.65 | 12.40-23.85 | 11.30-24.95 | 3.85-18.40 | 4.05-19.20 |
| *Pleurotus*powder medium | | | | | | | |
| *T. harzianum* | 12.90-15.15 | 10.70-16.9 | 20.70-21.05 | – | – | – | – |
| *T. aggressivum* f. *aggressivum* | 8.20-9.30 | 8.85-23.35 | 8.70-24.75 | 2.45-3.05 | – | – | – |
| *T. aggressivum* f. *europaeum* | 12.35-15.75 | 15.70-18.85 | 13.30-19.25 | – | – | – | – |
| *T. pleurotum* | 9.90-11.70 | 15.05-19.65 | 18.70-23.15 | 2.10-2.70 | – | – | – |
| *T. pleuroticola* | 14.25-19.05 | 21.90-23.20 | 17.35-34.75 | 19.35-29.00 | 0.45-0.80 | 0.35-0.55 | 1.20-1.80 |

These data are in accordance with the findings of Woo et al. [10], who reported that the pH optimum for the growth of *Pleurotus* was alkaline (pH 8.0-9.0) whereas *Trichoderma* preferred acidic-neutral conditions. Woo et al. [10] suggested that adjusting the pH of the substrate to 8.0-9.0 might slow down the growth of *Trichoderma* resulting in a reduction in the spreading of the infection. However, during the spawn-run period, the pH of the substrate decreases rapidly (within 5-6 days) from 8.0-9.0 to 4.5-5.0 due to the growth of oyster mushroom mycelia. Thus the higher pH can provide protection only in the initial phase, later the oyster mushroom itself changes the circumstances, resulting in a medium with a pH optimal for the pathogen.

Table 4. Water activity dependence of the examined *Trichoderma* species. Colony diameter extension rates on minimal medium and *Pleurotus* powder containing medium in mm/day

| | Water activity | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Minimal medium | *0.997* | *0.991* | *0.980* | *0.968* | *0.962* | *0.951* | *0.945* | *0.922* |
| *T. harzianum* | 19.15-24.20 | 22.45-25.90 | 11.60-12.14 | 7.25-10.13 | 6.62-8.35 | 6.48-6.98 | 2.02-4.80 | – |
| *T. aggressivum* f. *aggressivum* | 23.35-25.80 | 19.30-24.80 | 14.68-20.70 | 8.21-14.77 | 7.07-14.77 | 3.55-7.20 | 1.51-4.37 | – |
| *T. aggressivum* f. *europaeum* | 19.20-34.25 | 19.10-25.20 | 10.77-18.42 | 5.94-9.90 | 5.14-7.88 | 2.97-3.67 | 0.00-2.05 | – |
| *T. pleurotum* | 18.10-19.03 | 9.28-19.00 | 5.14-13.25 | 4.97-6.80 | 2.20-5.85 | 0.00-5.17 | 0.00-1.60 | – |
| *T. pleuroticola* | 17.05-26.75 | 20.90-30.75 | 10.67-16.77 | 7.42-8.80 | 6.68-7.64 | 4.08-5.11 | 0.00-3.94 | – |
| *Pleurotus*powder medium | | | | | | | | |
| *T. harzianum* | 28.50-30.00 | 22.40-35.00 | 15.67-21.20 | 8.95-16.97 | 5.42-7.97 | 3.68-4.14 | 2.42-2.54 | – |
| *T. aggressivum* f. *aggressivum* | 21.00-23.35 | 21.40-24.80 | 14.68-18.20 | 8.21-13.40 | 7.07-13.82 | 3.55-5.82 | 1.51-4.71 | – |
| *T. aggressivum* f. *europaeum* | 22.70-34.25 | 24.40-25.20 | 13.71-18.42 | 9.90-10.54 | 6.65-7.88 | 2.82-3.67 | 0.00-1.82 | – |
| *T. pleurotum* | 21.90-26.50 | 21.30-25.60 | 16.20-18.25 | 7.80-13.49 | 6.86-8.22 | 3.05-4.42 | 1.37-2.82 | – |
| *T. pleuroticola* | 29.25-33.25 | 31.75-34.00 | 16.61-25.55 | 11.78-15.34 | 8.22-9.45 | 3.85-5.74 | 0.00-3.67 | – |

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Concerning water activity, most of the *Trichoderma* strains showed higher mycelial growth rates on *Pleurotus* powder containing medium with an optimum of $a_w$=0.991, than on synthetic minimal medium, where the optimal water activity for most of the isolates proved to be $a_w$=0.997 (Table 4). In the case of *T. pleurotum*, the presence of *Pleurotus* powder induced mycelial growth also at water activity values where no growth could be observed on minimal medium. All the examined strains showed a lowering mycelial growth rate with the decrease in water activity, while none of the strains were able to grow at $a_w$=0.922.

Yu [11] examined the effect of substrate moisture content (SMC) on the growth of *Pleurotus* and *Trichoderma*. The optimum for oyster mushroom fell into the 60-70% range, and the growth of it was inhibited at 80%. In contrast to this, the mycelial growth of the green mould isolates was proportional to SMC, reaching its maximum at 80%.

## 4. CONCLUSIONS

In the latest years the most severe crop losses in oyster mushroom cultivation have been caused by green mould infections worldwide. The causative agents were identified as new-to-science species of the filamentous fungal genus *Trichoderma*, and they have recently been described as *T. pleurotum* and *T. pleuroticola*. The pieces of information about the ecophysiology of these two green mould species provided in the present study might help oyster mushroom growers to prevent green mould disease of *P. ostreatus*, and thereby reduce crop losses.

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# CHANGES OF FLORISTIC COMPOSITION IN THE GLOŽAN CONSTRUCTED WETLAND SYSTEM (THE VOJVODINA PROVINCE, SERBIA)

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**Abstract**

The constructed wetland system for municipal wastewater treatment in Gložan (near Novi Sad) is the first facility of its kind in Serbia. This biological purification system, whose final recipient in the Danube River, covers an area of 1 ha. Biomonitoring was conducted in the period 2004-2008 to assess the changes and dynamics of the floristic structure at the examined site. In the first year (2004), 41 vascular flora taxa were recorded. The respective figures in 2005, 2006, 2007 and 2008 were 34, 33, 21 and 25 taxa. Considering the total period (2004-2008), we recorded a total of 53 taxa of which 14 occurred in all study years. The paper presents also the changes in the biological spectrum and range of habitat types registered over the five-year period. In addition to its main function within the process of biological purification of municipal wastewaters, the constructed wetland system also plays an important role in the framework of sustainable development, since environmental protection is one of its major components.

## 1. INTRODUCTION

The first constructed wetland system (CWS) for municipal wastewater treatment prior to discharge into a watercourse was built in England in late 1970s and early 1980s [11]. Nowadays, this method is used worldwide but it is not universally accepted everywhere. In our country, the method was used for the first time in 2004. The EU Directive 91/271/EEC (1991), which deals with municipal wastewater treatment, strongly recommends constructed wetland systems. Within the framework of a pilot project titled „Municipal wastewater treatment by the method of constructed wetlands", the first biological purification system in Serbia, with the Danube River as the final recipient, was constructed in the village of Gložan, near Novi Sad. The Gložan constructed wetland system was built on a site of a natural swamp, its area is 1 ha and it comprises three separately constructed cells.

This method is based on the utilization of phytofiltration and phyto-accumulation capacities of semiaquatic plants (macrophytes) which take up, retain and accumulate different substances from soil and water [1,2,8,9,13,6,10]. Furthermore, owing to well-developed rhizomes and root system, these plants provide in their rhizosphere a viable environment for microorganisms, which, together with plants, play an important role in the processes of decomposition of debris in water and its underlying soil substrate.

While conventional methods of wastewater purification are time- and energy-consuming as well as expensive, wetlands are a natural water filter that grow and purify the environment, acting as super-absorbers of phosphates, nitrates and various hazardous substances. CWSs are an example of clean technology that exploits solar energy and provides useful biomass as final product.

Monitoring of floristic structure, biological spectrum and chorological spectrum, are integral parts of permanent biological and ecological studies, which were the objectives of this paper. The obtained data may serve as indicators of course of succession of the studied anthropogenic wetland ecosystem.

## 2. MATERIAL AND METHODS

The floristic study in the Gložan CWS covers a five-year period (2004-2008). Plant species were determined in accordance with the publications Flora SR Srbije [7], Visügyi hidrobiologia [3] and Flora Europaea [15]. Presence of life forms was estimated on the basis of A magyar flóra és vegetáció rendszeretani növényfoldrajzi kézikonyve [12], floristic elements on the basis of Pregled vrsta flore SR Srbije sa biljnogeografskim oznakama [4].

Table 1. Flora review of the Gložan constructed wetland system (2004-2008)

| Floristic element | Life form | Plant species | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| Adv. | Th | *Abutilon theophrastii* Medik. | + | + | + | + | + |
| Adv. | Th | *Amaranthus retroflexus* L. | + | | + | | |
| Adv. | Th | *Ambrosia artemisiifolia* L. | + | + | | | |
| Sub-M. | H (G) | *Aristolochia clematitis* L. | + | | | | |
| Adv. | G(H) | *Armoracia lapathifolia* Gilib. | + | | | | |
| Adv. | H | *Aster salignus* Willd. | + | + | + | + | + |
| Cosm. | HH-G | *Bolboschoenus maritimus* (L.) Palla. | | | + | | |
| Eur. | H | *Calystegia sepium* (L.) R. Br. | | + | + | + | + |
| Sub-CE | TH | *Carduus acanthoides* L. | | + | + | | |
| Cosm. | Th | *Chenopodium album* L. | + | | + | + | + |
| Sub-Eur. | Th-H | *Conium maculatum* L. | | | | | + |
| Cosm. | H-G | *Convolvulus arvensis* L. | + | | + | | |
| Sub-Eur. | G | *Cirsium arvense* (L.) Scop. | + | + | + | | |
| Cosm. | Th(H) | *Datura stramonium* L. | + | | | | + |
| Sub-Eur. | Th-H-H | *Daucus carota* L. | | + | | | |
| Adv. | Th | *Echinocystis lobata* (Michx.) Torr.et Gray. | + | + | + | + | + |
| Sub-Eur. | H-HH | *Epilobium hirsutum* L. | | + | + | | + |
| Adv. | Th-TH | *Erigeron canadensis* L. | + | + | + | + | |
| Sub-CE | H | *Eupatorium cannabinum* L. | + | + | + | + | + |
| Sub-CE | Th | *Galinsoga parviflora* Cav. | + | | + | | |
| Sub-M. | M | *Galega officinalis* L. | + | + | | | |
| Eur. | H(Ch-G) | *Glechoma hederacea* L. | | + | | | |
| Sub-M. | TH-Th | *Helminthia echioides* (L.) Gärtn. | + | | | | |
| Sub-CE | TH-H | *Innula britanica* L. | + | + | + | | + |
| Subpont. subca.subm | Th-TH | *Lactuca serriola* L. | + | | + | | |
| Eur. | Th-TH | *Leonurus marrubiastrum* L. | + | | | | |
| Sub-Eur. | HH | *Lycopus europaeus* L. | + | + | + | + | + |
| Sub-CE | Ch | *Lysimachia numularia* L. | | + | | | |
| Eur. | HH | *Lysimachia vulgaris* L. | | + | | | |
| Eur. | H-HH | *Mentha aquatica* L. | | | | | + |
| Circ. | H(G) | *Mentha arvensis* L. | + | | + | + | |
| Adv. | Th | *Panicum capillare* L. | + | + | + | + | + |
| Cosm. | Th | *Panicum crus-galli* (L.) P.B. | + | + | + | + | + |
| Sub-M. | H | *Parietaria officinalis* Mert. et Koch | + | | | | |
| Cosm. | HH | *Phragmites communis* Trin. | + | + | + | + | + |
| Sub-circ. | Th | *Polygonum lapathifolium* L. | + | + | + | + | + |
| Cosm. | Th | *Polygonum aviculare* L. | + | | | | |
| Sub-Eur. | Th | *Pulicaria vulgaris* Gaert. | + | | + | | |
| Subjsib. | H-N | *Rubus caesius* L. | + | + | | | + |
| Sub-CE | H-HH | *Rumex hydrolapathum* Huds. | + | + | | | |
| Sub-Eur. | Th | *Setaria viridis* (L.) P.B. | + | + | + | | |
| Sub-Eur. | Th | *Sinapis arvensis* L. | + | | | | |
| Sub-Eur. | Ch | *Solanum dulcamara* L. | | + | + | + | |
| Cosm. | Th | *Solanum nigrum* L. | | | | + | + |
| Adv. | H | *Solidago serotina* Aiton. | + | + | + | + | + |
| Eur. | H | *Sonchus arvensis* L. | + | + | + | + | + |
| Circ. | H | *Stachys palustris* L. | + | + | + | | + |
| Cosm. | Th-TH | *Stellaria media* L. | + | + | + | | |
| Adv. | Th | *Stenactis annua* (L.) Nees. | + | + | | | |
| Sub-CE | H | *Symphytum officinale* L. | + | + | + | + | + |
| Eur. | H | *Urtica dioica* L. | + | + | + | + | + |
| Adv. | Th | *Xantium strumarium* L. | + | + | + | + | + |
| Adv. | Th. | *Xantium italicum* Mor. | + | + | + | + | + |
| **Total number of species** | | | **41** | **34** | **33** | **21** | **25** |

**Legend: Adv. –** Adventive**, Sub-M. –** Sub-Mediterranean, **Cosm. –** Cosmopolitan, **Eur. –** Eurasian, **Sub-CE -** Sub-Central European, **Sub-Eur. –** Sub-Eurasian**, Sub-Pont. sub-CA - sub-M. -** Sub-Pontic-Sub-Central Asian - sub-Mediterranean**, Circ. –** Circumpolar**, Sub-circ. –** Sub-circumpolar**, Subjsib**. - Sub-South Siberian; **Th** – Therophyte, **H** – Hemicryptophyte, **HH** - Hydato–helophyte, **M** - Microphanerophyte, **G** - Geophyte, **TH** – Hemitherophyte, **Ch** - Chamaephyte

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## 3. RESULTS AND DISCUSSION

Study results include an analysis extant flora, percent presence of plant life forms and their floristic elements in the Gložan CWS. Within the framework of continual floristic studies conducted in the period 2004-2008, a total of 53 taxa were recorded, of which 14 taxa were common in all study years (Table 1). The highest floristic richness, that included 41 taxa of vascular flora, was registered in the first year (2004). The respective figures in the subsequent years, 2005, 2006, 2007 and 2008, were 34, 33, 21 and 25 taxa.

The richness of the recorded flora results from a number of factors, but primarily from favorable hydrological conditions in the Gložan CWS, which had been constructed at the site of a natural swamp. Additionally, the continual inflow of municipal wastewater resulted in profuse growth of reed (*Phragmites communis* Trin.) stands. At first, the reeds had thrived naturally and later on they were additionally planted. The reeds achieve their maximum growth and the height of about 4 m in the first cell of the CWS, which has highest moisture content in the underlying substrate. Because of very favorable ecological conditions (moisture, temperature, light, presence of nutrients in wastewater), the reeds formed a thick stand which suppressed the other species in the cell itself and pushed them to the very perimeter of this part of the system.

It seems important to mention at this point that, in spite of a relative floristic richness which was characteristic only for the perimeter of the first cell of the system, the reed was absolutely predominant in all three cells of the system and across the entire five-year period, being the main factor of phytofiltration and phyto-accumulation of a variety of substances from the wastewater coming from the village of Gložan. Only around the weirs between the system's cells, where the reeds were thinner and the light regime was better, did a hemicryptophyte *Calystegia sepium* (L.) R. Br. manage to thrive, climbing up the reed stalks and causing their partial lodging.

The analysis of the biological spectrum of recorded species indicated that therophytes (Th) predominated in all study years. Their numbers and percentages in 2004, 2005, 2006, 2007 and 2008 were 21 species (51.22%), 13 species (38.23%), 15 species (45.45%), 10 species (47.62%) and 11 species (44%), respectively. Presence of hemicryptophytes (H) was also significant. Their respective numbers and percentages were 13 species (31.71%), 12 species (35.29%), 11 species (33.33%), 8 species (38.09%) and 11 species (44%). Hydro-helophytes were present in low numbers, but here it should be mentioned that the predominant species in the Gložan CWS was the reed, a hydro-helophyte perfectly adapted to the conditions in the studied anthropogenic ecosystem. Hemitherophytes, chamaephytes, geophytes and microphanerophytes were also present in low numbers. The last two life forms were not recorded in the last two years of the study at all (Table 2).

Table 2. Review of life forms in the Gložan constructed wetland system (2004-2008)

| GROUP OF LIFE FORM | LIFE FORM | SPECIES NUMBER AND PERCENTAGE | | | | |
|---|---|---|---|---|---|---|
| | | 2004 | 2005 | 2006 | 2007 | 2008 |
| Therophyte Th | Th | 16 (39.02%) | 10 (29.41%) | 12 (36.36%) | 9 (42.86%) | 9 (36.00%) |
| | Th (H) | 1 (2.44%) | | | | 1 (4.00%) |
| | Th –TH | 4 (9.76%) | 2 (5.88%) | 3 (9.09%) | 1 (4.76%) | 1 (4.00%) |
| | Th -TH-H | | 1 (2.94%) | | | |
| Hemicryptophyte H | H | 8 (19.51%) | 8 (23.53%) | 8 (24.24%) | 7 (33.33%) | 8 (32.00%) |
| | H-HH | 1 (2.44%) | 2 (5.88%) | 1 (3.03%) | | 2 (8.00%) |
| | H (G) | 2 (4.88%) | | 1 (3.03%) | | |
| | H-G | 1 (2.44%) | | 1 (3.03%) | 1 (4.76%) | |
| | H-N | 1 (2.44%) | 1 (2.94%) | | | 1 (4.00%) |
| | H (Ch - G) | | 1 (2.94%) | | | |
| Hydato–helophyte HH | HH | 2 (4.88%) | 3 (8.82%) | 2 (6.06%) | 2 (9.52%) | 2 (8.00%) |
| | HH-H | | | 1 (3.03%) | | |
| | HH-G | | | | | |
| Microphanerophyte M | M | 1 (2.44%) | 1 (2.94%) | | | |
| Geophyte G | G | 1 (2.44%) | 1 (2.94%) | 1 (3.03%) | | |
| | G (H) | 1 (2.44%) | | | | |
| Hemitherophyte TH | TH | | 1 (2.94%) | 1 (3.03%) | | |
| | TH-H | 1 (2.44%) | 1 (2.94%) | 1 (3.03%) | | 1 (4.00%) |
| | TH-Th | 1 (2.44%) | | | | |
| Chamaephyte Ch | Ch | | 2 (5.88%) | 1 (3.03%) | 1 (4.76%) | |

The analysis of the chorological spectrum indicated a predominance of species of wide distribution: **adventive** – 12 (29.27%) in 2004, 10 (29.41%) in 2005, 9 (27.27%) in 2006, 8 (38.09%) in 2007 and 7 (28%) in 2008; **Eurasian** – 9 (21.95%) in 2004, 12 (35.3%) in 2005, 9 (27.27%) in 2006, 5 (23.81%) in 2007 and 8 (42%) in 2008; **circumpolar and cosmopolitan** - 10 (24.39%) in 2004, 5 (14.7%) in 2005, 9 (27.27%) in 2006, 6 (28.57%) in 2007 and 7 (28%) in 2008. The species of wide distribution comprised over 75% of the spectrum in all study years (75.61% in 2004; 79.41% in 2005; 81.81% in 2006; 90.47% in 2007 and 88% in 2008), which is in agreement with the ecological conditions prevailing in this anthropogenic ecosystem.

The presence of species of narrow distribution (sub-Central European, Pontic-Central Asian and sub-Mediterranean) was low. The presence of Pontic-Central Asian and sub-Mediterranean species in the first three years was an indication of an intensive water release during the summer period in initial years of operation of the system (Table 3).

Table 3. Review of chorological spectrum in the Gložan constructed wetland system (2004-2008)

| CHOROLOGICAL TYPE | FLORAL ELEMENT | NUMBER OF SPECIES AND CORRESPONDING PERCENTAGES | | | | |
|---|---|---|---|---|---|---|
| | | 2004 | 2005 | 2006 | 2007 | 2008 |
| Adventive | Adventive | **12** (29.27%) | **10** (29.41%) | **9** (27.27%) | **8** (38.09%) | **7** (28%) |
| Eurasian | Eur.<br>Sub-Eur.<br>Sub-s. Sib. | **3** (7.32%)<br>**5** (12.19%)<br>**1** (2.44%) | **5** (14.71%)<br>**6** (17.65%)<br>**1** (2.94%) | **3** (9.09%)<br>**6** (18.18%) | **3** (14.29%)<br>**2** (9.52%) | **4** (16%)<br>**3** (12%)<br>**1** (4%) |
| Circumpolar and cosmopolitan | Cosm.<br>Circ.<br>Sub-circ. | **7** (17.07%)<br>**2** (4.88%)<br>**1** (2.44%) | **3** (8.82%)<br>**1** (2.94%)<br>**1** (2.94%) | **6** (18.18%)<br>**2** (6.06%)<br>**1** (3.03%) | **4** (19.05%)<br>**1** (4.76%)<br>**1** (4.76%) | **5** (20%)<br>**1** (4%)<br>**1** (4%) |
| Central European | Sub-CE | **5** (12.19%) | **6** (17.65%) | **5** (15.15%) | **2** (9.52%) | **3** (12%) |
| Pontic-Central-Asian | Sub-Pont.-sub-CA.sub-M. | **1** (2.44%) | | **1** (3.03%) | | |
| Sub-Mediterranean | Sub-M. | **4** (9.76%) | **1** (2.94%) | | | |

The plant cover formed in the Gložan CWS comprises 13 adventive plant species. Among these, invasive plant species (*Abutilon theophrasti, Ambrosia artemisiifolia, Erigeron canadensis, Xantium italicum, Xanthium strumarium*) are of particular concern because of their negative impact on the native flora. Their aggressive expansion tends to degrade the ecological balance [16, 14]. The presence of invasive plant species in systems for purification of communal wastewater calls for their permanent monitoring because these plants may negatively affect the biodiversity of a given site, while a CWS may in itself become a focal point for further spread of these plants [14].

The analyses of floristic composition, biological spectrum and chorological spectrum made over the five-year study period indicated a succession towards a swamp ecosystem predominated by *Phragmites communis,* a cosmopolitan hydro-helophyte which plays a key role in the purification of communal wastewater in the Gložan CWS. The above data show that the reed adapted perfectly to the ecological conditions of the studied site and, due to high competitiveness and allelopathic action [5], it suppressed the other plant species, as indicated by a steady reduction in the number of plant species across the study years.

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# ECOLOGICAL RECONSTRUCTION IN THE BANAT BLACK PINE SITE FROM "DOMOGLED-VALEA CERNEI" NATIONAL PARK

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**Abstract:**
The ecological reconstruction, included in the project LIFE04NAT/RO/000225, came as a result of the fact that in 2000, a forest surface over 90 ha was destroyed by fire. Following field observations and evaluations, a perimeter of 25 ha was identified, on which forestry vegetation was severely damaged at levels of trees, underbrush, shrub and seedlings. In this area it was considered necessary an ecological reconstruction through plantation of Banat black pine. The works was done between 2003 – 2007 and have included following actions: the analyse of the stationary and vegetation conditions, collecting the black pine seeds, producing seedlings with protected roots, land release and clearing and digging the hearths for plantation . Some succes evaluations of this ecological reconstruction were made in the summer and fall of the year 2007 and 2008. The averages of the survival percent were 79,56%, in 2007 and 74,80% in 2008.

**Key words**:
Banat black pine, producing seedlings, planting in hearths

## 1.INTRODUCTION

During time, karsts areas with hilly landforms were frequently affected by phenomena of destructive nature, such as fires or flooding, which lead to the disappearance of forestry and shrub vegetation on certain area. Reintroducing forestry vegetation in these areas has always been a problem, because through excessive erosion, an obvious antagonism was created between climatic and soil factors, exercised through the plants reduced possibilities, due to the humidity soil deficit, to maximum use the solar heat and light [5]

Regarding to the calcareous cliffs pine forests from Cerna Valley, information exist that they were affected by the catastrophic floods from 1910. At the time, the Austrian forestry regime attempted to teforests the surfaces with black locus and black pine, but with poor results [3].

Reforestation difficulties of such degraded field required a necessary scientific analyze of how the plantation can be realized, under the aspects of species composition and plantation technique. In this directions, several studies tested the reintroduction of black pines in areas of calcareous cliffs [2,3,5,6]

From methodological point of view these studies analyzed:

- The way in which already existent black pine forests installed and developed in this area;
- Stationary characteristics from point of experiment (geomorphology, climate, soil physical and chemical characteristics, soil erosion etc.);
- Black pine sapling development in different experimental variants of plantation (sapling pricked from different nurseries, direct plantation in hearths, plantation in saplings grown in bags of polyethylene);

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## 2. ECOLOGICAL RECONSTRUCTION IN THE BANAT BLACK PINE SITE

The Banat black pine (*Pinus nigra* ssp. *banatica)* is an endemic subspecies with a restricted area in the south-west of Romania. It constitues today representative forest ecosystems on the western slopes of Mehedinti Mountains, at altitudes between 500 and 1200 m, alongside the thermal rupture Baile Herculane and on the calcareous Domogled plateau. The Banat black pine ecosystems represent a prioritary europeean habitat: 9530*" Sub-Mediterranean pine forest with endemic black pine ", included in the ROSCI0069 site, from "NATURA 2000" network , which overlaps on the territory of "Domogled-Valea Cernei" National Park.

This action, included in the project LIFE04NAT/RO/000225, came as a result of the fact that in 2000, a surface of over 90 ha, from the U.P. (Production Unit) IV Domogled was destroyed by fire. The forest lasted approximatively 20 days and affected the forestry vegetation of Banat black pine and mixtures whit different deciduous species. The burned forestry parcels were 108, 109, 112, 113, 116. Following field observations and evaluations a perimeter of 25 ha from u.a. (forestry parcel inside of production unit) 108B was identified, on which forestry vegetation was severly damaged at levels of trees, underbrush shrub and seedlings. In this area it was considered necessary an ecological reconstruction through plantation of Banat black pine. On the rest of the surface, it has been appreciated that plantation isn't possible, because in some cases the soil totally lacks from cliff, and isn't necessary where the fires produced partial damages, and forestry vegetation can regenerate in a natural manner [1, 4]

Ecological reconstruction in the project considered the previous experience of black pine plantation from calcareous cliff in Banat, both from the methodological and practical point of view, and the results of the researches in the field. Thus, before the ecological reconstruction:

- was made and analyze of the stationary and vegetation conditions in the established perimeter;
- the black pine seeds collecting was assured from seeds reservations found near the ecological reconstruction area;
- sowing material with protected roots was produced;
- a plantation scheme adequate to the hilly field conditions was established ;
- an evaluation of the success percentage was made one year after the plantation.

### 2.1. Stationary and vegetation conditions

The soil type that characterizes u.a. 108 B is rendsine. The horizons profile successions is Am-A/R-Rrz.

Regarding the forestry evolution older management studies proof that species proportion, in this u.a., were 50% beech, 10% Banat black pine, 10% mountain maple, 10% manna, 20% diverse strong essences. Today, the beech proportion has reduced whit about 10% in favor of the Banat black pine, species that evolved through natural regenerations and by completion whit saplings of local provenance.

The most important elements regarding the stationary and vegetation conditions are classified and described in the types of stations and forest (Table 1)

Table 1- Stationary and forest types in u.a. 108B

| No. | Stationary type | Forest type | |
|---|---|---|---|
| | | Code | Name |
| 1. | Mountain/premountain beech forests, Bi, cliffs. | 3.2.1.3. | Black pine mixture with deciduous, on limestone (i) |
| 2. | Mountain/premountain beech forests, Bi, rendsines, little soils | 2.3.2.2. | Mixted mountain beech forests |

In the ecological reconstruction perimeter surface erosion is generalized, process emphases after the fire by the disappearance of shrubs and grass. In the future these phenomena can accentuate, leading to land slides, debris and cliffs rubbing, justifying the

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ecological reconstruction. The following compensatory factors need to be considered for the success of the works:

- the altitudinal decrease of temperatures and reductions of the vegetation season are compensated by an increase of the solar radiation intensity;
- the reduced organic capacity of some soils can be compensated by extra humidity and a large useful soil volume;
- soil of sunny versants are droughty, instead the microbiological activity is more intense;
- shaded expositions have a shorter vegetation seasons, and the danger of early and late frosts is smaller;
- limestone presence reduced the adverse influence of altitudinal growth on the lenth on the vegetation season.

**2.2. Works for land release and clearing**

Following the 2000 year fires, trees from the ecologically reconstruction area were partially affected, through barks burns, in some case entirely, leading to the destruction of a large volume of trees. The land occupied by these trees was submitted to clearing works, consisting on feelings, clearing, fashioning and gathering the foot-dry wood material in parcel 108B, that had to be reforested. The wood material had to be cut and evacuated from this perimeter was almost 1740 $m^3$, corresponding to a number or 2100 trees. The wood material generated from the clearing works, was cut down and rough converted in ster wood, gathered with arms and deposited in stockpiles on knags.

**2.3. Producing implantation material**

According to the stationary conditions a planting plan of 1x2m was established, requiring the introduction of 5000 black pine sapling/ha. Therefore, to the 25 ha integral plantation a number of over 125000 black pine sapling was utilized, and in the next 2 years, for the completions, that in principle will represent about 12 ha, another 60000 more saplings shall be required.

Starting from these necessities, since the fall of 2003 were applied measures for obtaining this implantation material. This process consisted of: harvesting Banat black pine seeds from the nearest forest to the plantation area, showing in solariums and pricking out saplings from nurseries.

The black pine seeds harvesting was made in fall 2003 from the seed reservation PI.N-F232-1, situated in UP VI, u.a. 89, Băile Herculane Forestry Unit. In the spring of 2004, these seeds were showed in the Brăduț nursery solarium, from the Bozovici Forestry Unit on a nutritive bed formed from 60% beech humus, 20% spruce humus and 20% sand. The showing was made manual, on gutters, the distance between them being 5 cm. The wetting of the germinative bed was done immediately after the sowing, and continued periodically, through aspersion, assuring the permanent moisture of the superior layer in which seed germinate. For the soil fertilization , 5 $l/m^2$ of ammonium nitrate, simple superphosphate and potassium salt, dissolute in water, were applied (Figure 1)



**Figure 1.** Banat black pine seeds sowing in the Brăduț nursery solarium

Weeds control in the solarium was done manually, through hand weeding. After the sapling were removed from the solarium, they were sorted, the healthy and vigorous ones, well raised, and with a rich radicular system were considered fit for pricking and temporary

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deposited at ditch. In the spring of the year 2005 the pricking of 126900 sapling, in polyethylene bag of 12 cm diameter and 25 cm length, were made [6]. These sapling with protected roots were disposed on layers, and the holes between bags were filed with dirt, they being directly used in plantation in the years 2006 and 2007 (Figure 2)



**Figure 2.** Saplings layer disposal- Brăduț-Bozovici nursery

In order to produce the saplings required for completions in the next two years, the block station nursery "Domogled" was also established, in which saplings were pricked out in layers, without root protection. In this case we can observe a good development of saplings, explained by the fact that the block station nursery, being situated near the seeds harvesting place, benefitted from climatic and soil almost similar to the trees that supplied the seeds [1,2]. A number of 53800 saplings were produced here, and are still maintained in culture.

After pricking all the saplings, the cultures were maintained trough hand weeding the saplings layers, wetting the cultures with rain water, and their fertilization with chemicals. In the fall of 2006, after a development period of about 2 years in open field, the bags contained saplings were transported from the Forestry Unit Bozovici in the plantation area Domogled. (figure 3)



**Figure 3.** Bags with saplings, transported to the plantation area Domogled

### 2.4. Works for Planting

The effective preparation for plantation consisted of a partial land clearings from rocks and debris, arrangement of the plantation space and digging the hearths. The field's clearing from rocks and debris on about 30% of the surface, meaning 7,5 ha, and supposed the rocks removal from the soil and their storage in stacks and rows.

Following the plantation scheme of 1x2 m, the wooden scraps and litter were removed from 60x80 cm surfaces in the centre of with hearths of 30x30x30 cm were digged, corresponding to the earth bowl from the bag. The plantation was made after the removal of the plastic bag that protected the roots.(Figure 4).



**Figure 4**
The removal of plastic bag

After introducing the bowl and the roots in the special prepared hearth, followed the compression, by foot, of the soil surrounding the sapling to ensure a good contact between the roots with the nutritive environment (Figure 5).



**Figure 5**
Earth compressions after plantation, in order to assure a good contact of the pine radicular system with the nutritive emvironment

## 3. CONCLUSIONS

A first evaluation of the ecological reconstructions was made in the summer and fall of the year 2007, by determination of the plantation's success percent after one year, followed by a second similar evaluation, in 2008, after two years. Evaluating the success percent assumed the inventory, in 25 testing rectangular plots of 10/20 m, of the surviving saplings and their percent from the total saplings used. Each corners of these testing plots was materialized trough a wooden peg, for returning at inventories, in the same surfaces, until the definitive success of the plantation and closing the massive status.

The chart from figure 6 expresses the variations of the survival percent in different testing plots. Generally, it can observe that the survival percents in the first year (2007) were higher than in the second year (2008).
Calculating some statistical values, one year after plantation (2007) the average of the survival percent was 79,56%, with a variation coefficient (s%) among the testing plots of 6,8%. In the second year (2008) , the average of the survival percent was only 74,80%, with a variation coefficient (s%) among the testing plots, of 11,8%.

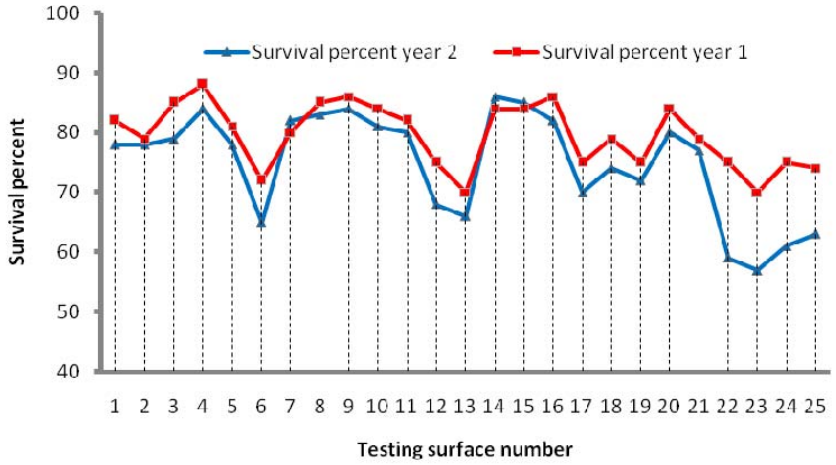



**Figure 6 . Survival percent variation, one year (2007) after plantation and two year (2008) after plantation**

It can, also, be observed on the graph that in 10 surfaces, the survival percents are higher than 80%. On the field, this area has been identified at the base of the versant. On the other side, in 4 plots situated in the superior parts of the versant, survival percents are under 65%.

Al these data, in characteristic conditions of climate and soil of the ecological reconstruction perimeter, represent a high quality work .

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# MENTAL MAPPING IN GEOGRAPHICAL APPROACH AND REGIONAL ENVIRONMENTAL DISPARITIES AT FRONTIERS

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**ABSTRACT**

Literature follows with attention the process of globalization and inter-regionalisation of environmental market. It offers and requests new possibilities and demands in agriculture too. Using of new, modern technologies in developed countries and conserve outmoded ones take difference among different less-developed and developed countries of the world. Well-known, environmental pollution does not know frontiers, so the gap between countries can be huge. What is the situation and what we can do in this area? Where to invest to win the best output?

Speaking about values we can find different measures in different countries. It takes many difficulties against how to solve problems. One is the most important factor is the disparity of short-term and long-term interests.

It has subjective and objective ways to transform and understand. People often create preconception by their mental map and connect territories and problems. It is not so simple.

We can assert reduction of over mentioned situation can be stimulated. Discrepancy and discrepancy along areas of frontiers cannot sustainable, mainly not in Central and Eastern Europe.

## 1. INTRODUCTION

The process of internationalization can be observed in the case of environmental programs, as well. The importance of financial funds that stimulates new technologies is increasing. This way the emphasis has been put on prevention from cleaning and controlling. It is realized differently in the case of countries on different levels, as the change to a reasonably modern technology from an undeveloped one is a significant leap forward in Eastern Europe. The problem is that the developed world appreciates only „future technologies". The structure of environmental market in Eastern and in certain Central European countries will be similar to the earlier structure of EU, whereas a certain change in structure is proceeding towards integrated, intensive solutions in developed world. At the boundaries of regions we can often find different indexes, different measuring technologies, and significant differences in attitude (e.g. Finland and Russia) but – mainly in the case of smaller countries – the only solution is reduction of these differences and elaboration of common, harmonized solutions. The members of EU question the unification of problem management in big regions because of their disparity in measurement. Only a unified measuring technology and index system can be regarded as the basis of objective judgment of processes. An essay from Brussels confirms it. (Communication from the Commission 2003) This question is particularly problematic in the successor states of the Soviet Union, as they consider certain cases as successful ones but according to other methods these cases can be valued very modest. Placing the capital outside EU appears in this field, too, so its specific efficiency can be multiplied. Nevertheless, the process (stimulation) of abandonment of conflict between the long-term interests of environment, and the short-term interest of economy has begun in the Central and Eastern European countries-with different intensity and methods.

A kind of idea about the future is required in which different regions can develop in intensive division of labour and not in subordination to each other. The territorial inequality is lessening, the main centers of development are regions and counties, and their cooperation with other regions along the borders creates the opportunity to join the European integrating processes (Gal, J. – Valko, L. 1998). Discrepancies where countries in different state of development can be found will get more important role.

The environmental responsiveness of governments in these countries is very different. A number of enterprises deal with production, development of environmental technology and with environment protection. The role the government takes has an impact of crucial importance on them. Deriving from the nature of the market, only smaller amounts are typical that are rarely supplemented by a bigger order. This situation requires flexibility, significant capital from the enterprises; therefore a lot of them cannot survive in the rapidly changing market. From the prospect of demand the legal regulation, the lawful behavior of enterprises ensure motivation, and the pulling-impeding-moving unity of market mechanism, too, which is able to move the situation from its deadlock. The condition of its function is that it affects the whole economy including the society. In this terminology „impediment" means that we have to prevent materials, energy, products from leaving the process of production and consumption too soon. It should be realized within national frames. Regulation supporting the pull factor removes by-products from the system and it does not let it accumulate to harm the environment. Recycling, collection and managing of waste materials play important roles in this process. Most processes have regional impacts, so the role of cooperation is appraised. Only a small part of these activities can be done on purely market base, in most cases the token of effective solution is in the hand of the state. We can find both good and unacceptable examples for it in Central and Eastern Europe. For instance, Austria's efforts prove that results can be reached in the fields of collection of paper refuse and its use as a second raw material etc.-, which projects have failed in other, mainly Eastern European, countries.

The judgment of environmental market is changing into a favorable direction in Central and Eastern Europe because of the accepted positive externalities of the environment protection. Its effect can be observed in the legal phase, in regional development, in manpower market and in other innovative processes, as well.

## 2. DISCUSION

The above mentioned facts are supported by a study from Tubingen (Valko L. 1998), according to which 45% of the Western European environment technical enterprises can survive the first 5 years, and only 35% of them the first 10 years. It is mentioned that the condition of survival is that the given enterprise can comprehend the whole market scale from planning through analysis, consultation, execution, operation, and service to the after-care. An enterprise with only one of these activities financially runs a grave risk. Long-term situation of services with oversupply in environmental market is getting more risky comparing to firms presenting intensive environmental technique, technology. The condition of survival is adjustment to the regional and local conditions, this way the role of eco-marketing is going to be appraised. In this context the state's role can be mentioned again, and the dynamic effect of steps that increase demand. There are regional programs not only in EU but in discrepancies, as well. Regional approach is supported by the fact that Eastern European countries that were excluded from joining in 2004 should change their environmental policy and their environment economical programs rapidly, since their backwardness is significant.

Chart no 1
National Environment Protection Program II Hungary
Source: NKP-II

| TAP megnevezése | A 2003-2008 közötti időszak teljes költsége (mFt) | kp-i költségvetésből (mFt) | % |
|---|---|---|---|
| 1. Quality of urban environment | 1.626.561 | 900.647 | 29,3% |
| 2. Water protection and sustainable use | 1.095.875 | 680.100 | 19,7% |
| 3. Change of climate | 961..273 | 262.575 | 17,3% |
| 4. Health and safety | 682.273 | 386.757 | 12,3% |
| 5. Use of fields | 541.752 | 245.046 | 9,7% |
| 6. Waste management | 363.000 | 94.817 | 6,5% |
| 7. Biodiversity and ecological protection | 181.166 | 106.706 | 3,3% |
| 8. Safety of environment | 64.527 | 61.677 | 1,2% |
| 9. Development of environmental awareness | 40.577 | 32.612 | 0,7% |
| Together: | 5.556.820 | 2.770.937 | 100,0% |

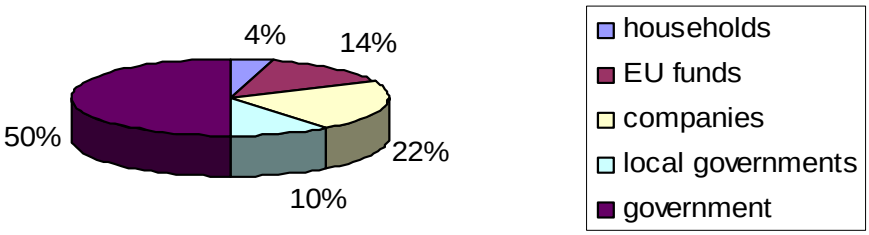
In the National Environment Protection Program II Hungary (chart no 1) has formulated a thematic action program and has planned expenses which show that harmful effects of urbanization and water protection claim the highest expense. These two problematic fields are typical of the Central and Eastern European countries. Technical-technological side of solution is ensured in these countries; the problem is the lack of financial sources. It is worth examining what distribution of sources Hungary planned in order to realize her planned obligation. I suppose that the proportions are similar in other joining countries, as well. The situation is entirely different in the case of other

countries as the rate of EU-funds is essentially smaller. The source-proportion (diagram no 1) coming from the central and municipal budgets exceeds 60%, EU makes a contribution of 13,9 % to it, and finally, there is a problematic self-share, as well.

In the early 60's American psychologists and geographers modeled a special method of cartography, which is surveying the familiarity with a place by means of the mental map. With the mental map we analyze the map formed in people's brain about their immediate environment.

Diagram no 1
Distribution of financial means in Hungary 2003-2008
(planned)

Source: NKP-II




This method helps us to see which places, flows approaching solutions are known for the inhabitants of a settlement; according to the data we can get a picture about the question that which the most interesting and the less interesting environmental impacts are, where the cardinal points of a region or a town can be found. It is worth comparing these notes with the mental maps of those who are interested in the environmental flows.

The answers to these questions help us to examine which are the questions about the areas that have aroused the people's attention and which are we have to highlight.

To serve this purpose we have to introduce the following terms: region, factors that form the region, regional development, environmental conditions. Then we show the development of the region and the immediate environment, together with the advantages and disadvantages that follow the development of the given area. If a really consistent and environmentally friendly transformation is expected, it is worth calling the attention to it.

For the sake of the efficient teaching-learning form the students should be able:

- to analyze the typical region according to different points of view,
- to recognize the typical region with the help of pictures and descriptions,
- to recognize and to name its most important features,
- to make a drawing about the region, to make a description of it,
- to try to imagine and to draw the possible future changes of the typical region,
- to inform about the rehabilitation of an environmentally destroyed region from different sources of information.

The question of the method of the process is very important here. It is the most obvious to make a task sheet where the following methodological possibilities can be exploited well:

- to draw a region on the basis of their knowledge and experience,
- to make a description of a region on the basis of lesson experiences, visual or map information,
- to analyze a region according to some given points of view,
- to make students recognize the process of a regional development with ordering pictures and drawings,
- comparative regional analysis on the basis of a written text (for example the same region in different times or different regions in the same time).

The analysis was about a region at border of Romania, Serbia and Hungary by means of which it was possible to show the connection between man and his environment, and it pointed out how the natural region became economic region.

Global problems of our environment has been revealed during decades, and at the same time the favorable counter moves have been formulated more accurately. Content of these frameworks (international organizations, contracts, financial funds etc.) depends on the responsibility taken by the region and nation. The level of environmental knowledge of nations and the available system of means move on a very wide scale. Therefore, the different short-term interests of developed and undeveloped countries have a significant impact on the international cooperation of environment protection. It

seems that the most effective way of managing global problems is the cooperation between small regions. This solution is able to handle regional disparities and discrepancies above all. In the Central and Eastern European countries the regional cooperation has been getting stronger in most regions since the 90's –after the former political alliance system had collapsed. „Visegrád countries", Carpathian-Europe-Region, Alps-Adria or the league of Vajdasag, Transylvania and South-Eastern Hungary are good examples for it. In the field of environmental protection these cooperation could not have results that would take their environmental status closer to the Western European level. The main reason for it is the lack of financial sources.

## 3. CONCLUSIONS

As a result of a new attitude on both sides of discrepancies the more developed country stimulates the environmental problems, rehabilitation of the less developed one with her increased role. In the case of Austria and her Eastern neighbours the regional environmental investments can bring bigger benefit for the less developed countries but at the same time they have a positive effect on the whole region, as well. According to a certain research the economical and ecological profit of Austria's foreign environmental investments can be the triple of the same investment inside the borders of Austria.

This change means that environment political principles have new definitions, so does the principle of prevention which emphasizes the efficiency of prevention as opposed to rehabilitation of damages. The principle of the individual, who caused damage which says, that this individual has to bear the costs of rehabilitation. The principle of subsidiary, which says that adequate steps have to be taken on the most efficient institutional level. The principle of cooperation and harmonization which attempts to synchronize the environment protection policy of different countries in the interest of the most favorable output. According to the principle of compatibility the environment policy should be integrated into the work of other fields, so it has to be in harmony with the social and economical policy.

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# BIOSOLIDS AND VOLCANIC TUFF INFLUENCE OVER THE UPTAKE COEFFICIENT OF CADMIUM AND ZINC FROM POLLUTED SOILS IN MAIZE CULTIVATION

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**Abstract:**
Potentially toxic elements such as cadmium, lead and zinc can accumulate in cropland soils through fertilizer application. This study analyzes, comparatively, the uptake coefficient (UC) of cadmium and zinc in maize (Zea mays L.) destined as fodder for animals. Results indicate that the addition of biosolids can change the plant bioavailability for metals from soil. During the first phenophases of plant development, it especially accumulates cadmium into the aerial tissues. The use of the pillared volcanic tuff of type tuf-$Al_n$ as an addition to the organic fertilizer, determines metal bioaccumulation reduction in young plants.

**Keywords:**
cadmium, zinc, bioaccumulation, bioavailability, soil, Zea mays

## 1. INTRODUCTION

The long application of organic fertilizers as manure, biosolids (municipal sludge anaerobic fermented) or anorganic fertilizers based on phosphatic rocks, determines both the enrichment of the agricultural land in nutritive substances, nitrogen and phosphorus, and a gradual accumulation of cadmium, lead and zinc. [5, 8, 9].

The accumulation level of heavy metals in agricultural soils reached a point which alerted the specialists from numerous countries in Europe (England, Germany, Norway), America (USA) and Australia [1, 2, 3, 4, 12]. The statistic analysis of the gathered data regarding the transfer of these metals from soil into plants, intended for human and animal consumption, is of general concern. Researches demonstrated that in plant tissues the heavy metal quantity accumulates directly proportional with the rhythmic addition of metal in soil. Accumulation rate depends on soil characteristics, plant species, plant age, hydroclimatic conditions, and type of tillage [5].

Mankind faces, in the last years, different aspects of waste storage, especially of the increasing amounts of municipal sludge. Many countries chose as solution the reuse of these as organic fertilizers for agricultural crops, due to the high content in fertilizing agents, nitrogen, and phosphorus [2, 11, 13]. Analysis of the agricultural lands fertilized with biosolids on a long period of time shows that soils can accumulate between 0.035-33.8 mg Cd/kg of D.M. and 16-5,010 mg Zn/kg of D.M., for those cultivated with wheat, and between 0.02-2.31 mg Cd/kg of D.M. and 19-429 mg Zn/kg of D.M. for those cultivated with barley [1]. Plants can also accumulate significant quantities of heavy metals. Thus, maize can accumulate in the aerial parts between 1-9 mg Cd/kg of D.M. [12]. Metal accumulation in crops represents now one of the greatest problems of the world [2]. The addition of metal immobilizing agents in soil, such as zeolites from volcanic tuffs, can significantly reduce the bioavailability of plants for certain metals [13].

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To perform this study we took under consideration the following aspects: - cadmium and zinc content increase from cropland soils as a result of some anthropic activities, as is the case of the area adjacent to the mining activity from Moldova Noua, located in south-western part of Romania; - the use over long periods of some fertilizers that annually add small quantities of toxic metals, metals that accumulated in time; - crop bioavailability to accumulate metals such as cadmium and zinc in the aerial parts; - the soil addition of a metal immobilizing agent such as the modified domestic volcanic tuff, which can significantly reduce the content of the metal up-taken by plants from the soil solution.

## 2. MATERIALS AND METHODS

The experimental field is located at Banat's University of Agricultural Sciences and Veterinary Medicine in Timisoara (western Romania). The study was done on an experimental block comprising plots with a 13.6 m²/lot surface. Cadmium, lead and zinc salts were added to the soil, in order to obtain a pollution level similar to the one determined in the analyzed soils from Moldova Noua. Maize (*Zea mays* L.) was used as a test plant. Heavy metals were applied to soil in soluble form before seeding with maize.

The variants of the treatments of the soils on which the experiments were done are:

**V1** - variant without organic fertilizer (biosolids) addition, which comprises three categories of soil (Fig.1): M - control soil with characteristics of normal soil; P - soil polluted with cadmium, zinc and lead salts; T - soil polluted with cadmium, zinc and lead salts and amended with pillared materials, of tuff-$Al_n$ type;

**V2** - variant of fertilized soil with organic fertilizer (biosolids), which also contains three categories of soil (Fig.2): FM - control soil; FP - polluted soil; FT - soil polluted and amended with pillared materials, of tuff-$Al_n$ type.

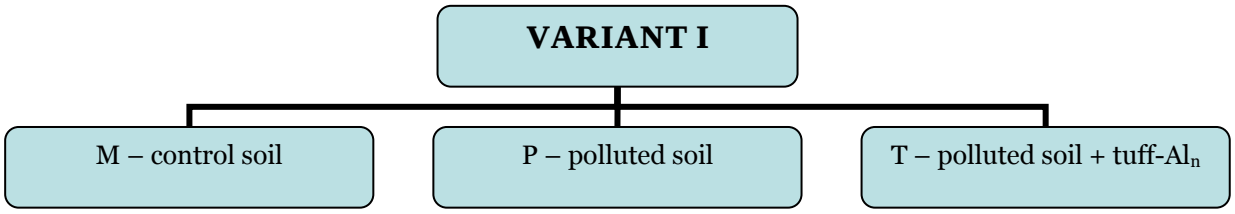



Figure.1. Variant I of treatment without biosolids addition.
M - control soil with normal soil characteristics; P- soil polluted with cadmium, zinc and lead salts; T - soil polluted with cadmium, zinc and lead salts and amended with pillared materials of the tuff-$Al_n$ type

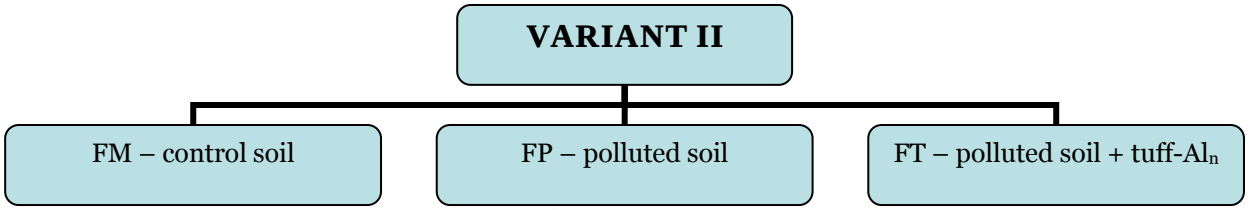



Figure.2. Variant II of treatment with biosolids addition.
MF - control soil with normal soil characteristics; FP- soil polluted with cadmium, zinc and lead salts; FT – soil polluted and amended with pillared materials of the tuff-$Al_n$ type.

Fertilization was done with organic fertilizer (biosolids). Fertilizer dose was of 30 to of D.M./ha. Table 1 shows the characteristics of biosolids for the experiment.

Soil analysis after the artificial heavy metal pollution and fertilization, showed the following: cadmium from polluted soil was of 1-3.4 mg/kg of D.M., zinc was of 670-720 mg/kg of D.M, lead was of 58-70 mg/kg of D.M., and the stabilized pH was of 6.2-6.3.

Metal content from the polluted soils in this experiment ranks as sensitive soils and/or less sensitive, alert level, according to the effectual norms in Romania (Table 2).

Table 1. Characteristics of the biosolids used for fertilization for the experimental plots and heavy metal quantity introduced in soil for the 30 tonnes/ha dose.

| Biosolids characteristics | Value | Addition of metals and other substances from biosolids (30 to of D.M./ha) in soil |
|---|---|---|
| pH | 5.80 | - |
| Dried matter, % | 18.3 | - |
| Humidity, % | 81.7 | - |
| Volatile substance, % | 32.0 | - |
| Extractible in ether of petroleum, mg/kg | 2.11 | - |
| Manganese, mg/kg D.M. | 536.2 | 5.89 |
| Zinc, mg/kg D.M. | 1,575 | 17.9 |
| Copper, mg/kg D.M. | 481.0 | 5.29 |
| Cadmium, mg/kg D.M. | 76.60 | 0.84 |
| Chromium, mg/kg D.M. | 1,420 | 15.62 |
| Nichel, mg/kg D.M. | 220 | 2.42 |
| Lead, mg/kg D.M. | 591 | 6.51 |
| $N_{total}$ ,% | 0.57 | 0.06 |
| $P_{total}$,% | 0.33 | 0.035 |
| Organic substance, % | 34.3 | 3.77 |

Table 2. Reference values for metals in soils, according to MAPPM 756/1997, in mg/kg of D.M.

| Element | Normal values | Alert level | | Intervention level | |
|---|---|---|---|---|---|
| | | Sensitive soils | Soils less sensitive | Sensitive soils | Soils less sensitive |
| Cadmium | 1 | 3 | 5 | 5 | 10 |
| Lead | 20 | 50 | 250 | 100 | 1,000 |
| Zinc | 100 | 300 | 700 | 600 | 1,500 |

Soils from the T and FT categories were amended with a quantity of 2 to/ha of pillared domestic volcanic tuff, of tuff-$Al_n$ type (ECOIND patent) [6].

After the geochemical stabilization for 30 days, the fertilized and amended polluted soils were seeded with forage maize. Analysis of plant metal accumulation from aerial tissues of plant parts (stem, leaves, and grains) was done on dried plants. Plant sampling was done accordingly to the methodology described in STAS 9597/1-74, and the sample analysis was done accordingly to STAS 9597/17-86. Plant extract analysis was done by using a spectrophotometer with atomic absorption, Varian Spectra AAS.

The comparative analysis of metal bioaccumulation from aerial tissue of plants was done through the uptake coefficient by plants, designated as UC (uptake coefficient) [7, 10]

The uptake coefficient is obtained by the ratio between the metal quantity accumulated in plant tissues that are grown on adjacent soils with anthropic activities and the metal quantity from the same part of the plant, grown on the unpolluted, control soil:

$$UC = Q_P / Q_M$$

where: Qp – metal concentration accumulated in tissues of the plant grown on polluted soils;

Om – metal concentration accumulated in the tissues of the same plant grown on the unpolluted, control soil.

## 3. RESULTS AND DISCUSSIONS

The following tables present data regarding the accumulation level of cadmium and zinc in the aerial parts of maize (*Zea mays* L.) destined for animal forage.

From sample analysis of the aerial parts of the plants, resulted that lead was absent. Probably the two metals, cadmium and zinc, were competitively assimilated, and lead was more difficult to be accessed by plants in the presence of the other two.

Table 3 shows the cadmium and zinc quantities, periodically accumulated in the aerial parts of the forage maize (*Zea mays* L.)

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Table 3. Cadmium and zinc quantities accumulated in the aerial parts of forage maize (*Zea mays L.*) in two successive phenophases

| Treatment | Soil category | Zinc (mg/kg of D.M.) | | Cadmium (mg/kg of D.M.) | |
|---|---|---|---|---|---|
| | | First phenophase | Second phenophase | First phenophase | Second phenophase |
| Without fertilization with biosolids | **M** - control | 4.20 | 4.20 | 0.025 * | 0.025* |
| | **P** - polluted | 14.2 | 10.5 | 0.380 | 0.500 |
| | **T** - polluted + amended | 9.65 | 14.7 | 0.320 | 0.380 |
| Fertilization with biosolids | **FM** - control | 2.80 | 8.63 | 0.570 | 0.700 |
| | **FP** - polluted | 12.8 | 14.50 | 1.300 | 1.470 |
| | **FT** - polluted + amended | 3.12 | 5.00 | 1.200 | 1.417 |

* the determined quantity of cadmium in plant tissues obtained on unpolluted soils can originate from atmospheric deposits, or from transport of the pollutant by the abundant rainfalls from the 2008 spring, from the plots with polluted soil in those unpolluted.

**Zinc** accumulates differently in the aerial parts, depending on the plant growth level and treatment type. In the variants without biosolids fertilization, zinc quantity remains constant (4.2 mg/kg) in plants grown on the control soil. In plants grown on polluted soil (P) the quantity of zinc in the second phenophase, at plant maturity, is lower (10.5 mg/kg) compared to the first phenophase when the plant is immature (14.2 mg/kg).

Addition of tuff-$Al_n$ in the variant of no-biosolids soil, reduced the bioaccumulation level of zinc with 32% in the first phenophase, from 14.2 mg/kg to 9.65 mg/kg.

Addition of biosolids had a synergetic effect in the variant of the treatment with biosolids-pillared tuff to decrease bioaccumulation, up to 75%, (from 12.8 mg/kg to 3.12 mg/kg) for zinc accumulation in plant tissue.

**Cadmium** is introduced in soil through biosolids addition. In time, it accumulates in the aerial parts of plants. Addition of biosolids will determine the increase of cadmium accumulation in plants up to 71% in the first phenophase (from 0.38 mg/kg to 1.3 mg/kg) and up to 66% in the second phenophase (from 0.50 mg/kg to 1.47 mg/kg). Addition of the pillared tuff-$Al_n$ in the experimental variant that doesn't use fertilization with biosolids, doesn't limit cadmium bioaccumulation in the aerial parts of plants, the quantitative values being similar (0.38 mg/kg; 0.32 mg/kg). This situation can be noticed in advanced phases of plant development, in the second phenophase, of maize harvest for forage, recording similar values ((0.50 mg/kg; 0.38 mg/kg).) When adding pillared tuff (tuff-$Al_n$) to the experimental plots, fertilized with biosolids, no effects on the bioaccumulation reduction could be noticed, values being similar (1.47 mg/kg in variant FP; 1.41 mg/kg in variant FT). Biosolids have components with no limitation effect for metal bioaccumulation in plant tissue.[6]. The forage maize biomass shows significant quantities of cadmium (1.2 mg/kg; 1.4 mg/kg), which makes it unusable as food for animals.

Tables 4, 5, and 6, show the values of the uptake coefficient of cadmium and zinc from polluted soils, unfertilized and fertilized with biosolids, with and without amendments that immobilize metals in soil of the Tuff-$Al_n$ type compared to control soils.

Table 4 shows the uptake coefficient for cadmium and zinc from polluted soils compared to the unpolluted soils (UC= $Q_P/Q_M$) for forage maize in the first phenophase, when the height of plants is of 20-30 cm. The uptake coefficient (UC) is reported to the quantity of metal accumulated in plants cultivated on common soils, unfertilized, unpolluted, and non-amended.

Table 4. Uptake coefficient of cadmium and zinc by forage maize (*Zea mays L.)*, in the first phenophase

| Treatment | Experimental variant | Uptake coefficients (UC) | |
|---|---|---|---|
| | | Cd | Zn |
| Without addition of biosolids | **P** – polluted soil | 14.4 | 3.80 |
| | **T** – polluted soil and treated with Tuff-$Al_n$ | 12.8 | 2.28 |
| With addition of biosolids | **FM –** normal soil | 22.8 | 0.70 |
| | **FP –** polluted soil | 33.0 | 3.16 |
| | **FT –** polluted soil and treated with Tuff-$Al_n$ | 24.0 | 0.65 |

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From the data presented in table 4, we can see that when grown on soil with significant quantities of metals (cadmium and zinc), the cultivated plants, under such conditions, will uptake, in the aerial tissues, higher quantities of metals than the plants cultivated on unpolluted, normal soils.

Thus, in the case of zinc, the uptake coefficient was of 2.28 – 3.80 and for cadmium it was ten times higher (UC= 33).

Biosolids addition needed to fertilize the soil, did not modify the uptake coefficient for zinc (UC=3.80 in variant P and UC=3.16 in variant FP) in plant tissues, but it also favored a higher accumulation of cadmium.

Thus, the uptake coefficient for cadmium increases twice (UC=33.0 in the variant FP) compared to the similar variant, of polluted and unfertilized soil (UC=14.4 in variant P).

Table 5 shows the uptake coefficient for cadmium and zinc from polluted soils compared to the unpolluted soils ($UC = Q_P/Q_M$ ) for forage maize in the second phenophase, when the height of plant is of 50-70 cm.

Table 5. The uptake coefficient for cadmium and zinc by the forage maize (*Zea mays L.)*, in the second phenophase

| Treatment | Experimental variant | Uptake coefficient (UC) | |
|---|---|---|---|
| | | Cd | Zn |
| Without addition of biosolids | **P** – polluted soil | 20.0 | 2.50 |
| | **T** – polluted soil and treated with Tuff-$Al_n$ | 15.2 | 3.50 |
| With addition of biosolids | **FM –** normal soil | 28.0 | 1.98 |
| | **FP –** polluted soil | 16.0 | 3.45 |
| | **FT –** polluted soil and treated with Tuff-$Al_n$ | 13.0 | 1.25 |

In the second phase of plant development, when forage maize is harvested, it can be observed that zinc is taken in the same proportion as in the first phase, reporting it to the plants cultivated on the control soil. For zinc bioaccumulation, in treatment variant without addition of biosolids UC is of 2.5 – 3.5, and in the ones with biosolids UC was of 3.45.

In the case of cadmium could be observed that, along with the plant growth, the plant will uptake from the polluted soil higher quantities of metal. The accumulation level in tissues increases over 20 times compared to the accumulation in the plant tissues cultivated on unfertilized, normal soils. Biosolids addition will not determine significant changes in the UC values.

Table 6 shows the values for the uptake coefficient for cadmium and zinc in the case of domestic volcanic tuff - Tuff-$Al_n$, type addition to polluted soils fertilized or unfertilized with biosolids, in the two growth phenophases of plants.

Table 6. Uptake coefficient for cadmium and zinc determined for the addition of Tuff-$Al_n$ to polluted soils, unfertilized (V1) and fertilized with biosolids (V2).

| Treatment | Experimental variant | Uptake coefficient (UC) | | | |
|---|---|---|---|---|---|
| | | First phenophase | | Second phenophase | |
| | | Cd | Zn | Cd | Zn |
| V1- Without addition of biosolids | T – soil polluted and treated with Tuff-$Al_n$* | 0.84 | 0.66 | 0.76 | 1.34 |
| V2- With addition of biosolids | FT – soil polluted and treated with Tuff-$Al_n$** | 0.75 | 0.2 | 0.27 | 0.34 |

*UC = quantity of metal from plants grown on polluted soil with addition of Tuff-$Al_n$ / quantity of metal from plants grown on polluted soil without addition of Tuff-$Al_n$.

**UC = quantity of metal from plants grown on polluted and fertilized soil with addition of Tuff-$Al_n$ / quantity of metal from plants grown on polluted and fertilized soil without addition of Tuff-$Al_n$.

Addition of Tuff-$Al_n$ to polluted soils, unfertilized with biosolids, determines the reduction of the uptake coefficient of metals by plants from soils polluted and treated with Tuff-$Al_n$, compared to those without addition of Tuff-$Al_n$ .

It can be observed that, in the first phenophase, both cadmium and zinc accumulate to a sub-unitary level of UC= 0.66 – 0.84 in the case of plants grown on areas polluted and treated with volcanic tuff. In the second phenophase, the cadmium accumulation maintains within the same range (UC= 0.76), but increases for the accumulation of zinc (UC= 1.34).

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In the second case, when the soil is polluted and fertilized with biosolids, the addition of pillared tuff determined at first the decrease of the accumulated metal quantity.

In the advanced phases of plant growth, the metal quantity uptake decreased, the uptake coefficient being only 0.27 – 0.34.

Sub-unitary value of UC demonstrates the efficiency of pillared domestic volcanic tuff - Tuff-$Al_n$, type, as amendment of soils polluted with heavy metals and fertilized or not with biosolids. It also demonstrates the difference between plants cultivated on amended soils with Tuff-$Al_n$, and those grown on similar soils untreated with the metal immobilization agent based on pillared domestic volcanic tuff - Tuff-$Al_n$ type.

## 4. CONCLUSIONS

The presented data are the result of an experiment regarding biosolids use as organic fertilizer and of the volcanic tuff - Tuff-$Al_n$ type as amendment to soils artificially polluted with cadmium, lead and zinc, in order to reduce their bioaccumulation in forage maize (*Zea mays L*).

Values of the obtained uptake coefficients (UC) for cadmium and zinc depend on the affinity of plants for a certain metal, of the metal mobility in soils and the variant of treatment compared to the control soil (unpolluted).

Addition of volcanic tuff - Tuff-$Al_n$ type, influenced the uptake coefficient for cadmium and zinc, compared to the control soil, especially when the polluted soil was associated with biosolids.

Generally, pillared material Tuff-$Al_n$, reduced cadmium and zinc transfer from soil to plant tissues, both in the first and second phenophases.

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# ANALYSIS OF PRECIPITATION QUANTITY IN VOJVODINA

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**Abstract:**
In view of the fact that the areas of arable soil in Vojvodina covered by irrigation systems are very small, and so are the possibilities to diminish the negative consequences of occasional droughts, our agricultural production is greatly dependent on the natural conditions. The natural meteorological processes, including also precipitation are of stochastic character, so that they can not be described by mathematical expressions in a simple way, and their future states can not be reliably predicted. On the example of precipitation data registered at the meteorological station R. Sancevi we demonstrated the application of several statistical methods to analyze the periodicity.

**Keywords**:
precipitation, changes, periodicity

## 1. INTRODUCTION

As a consequence of the insufficiently developed irrigation systems in Vojvodina, and relatively small areas of arable land where irrigation is possible, the atmospheric precipitation are still the major factor in providing water to the soil and crops. Lack of precipitation in one area in relation to average perennial value for specific period, leads to the occurrence of meteorological drought that can also cause substantial decrease of water quantities in aquatories and decline in ground water levels (hydrological drought), and thereafter it can also hinder proper growth and development of crops (agricultural drought). Hence, the phenomenon of droughts, as a time series of a stochastic character, deserves serious attention and thorough analyses.

The ever increasing water demands, and the simultaneously increasing danger of potential deterioration of water quality, have directed substantial research activities on the problems concerning the causes of drought occurrence. In view of the fact that in our present circumstances a decissive role in drought occurrence have the amount and time distriution of precipitation, i.e. their shortage, a need is evident for many-sided study and analyses of this complex phenomenon.

## 2. THE STUDY

The natural meteorological processes, including also precipitation, are of stochastic character, so that they can not be described by mathematical expressions in a simple way, and their future states can not be reliably predicted. Hence, for this purpose certain statistical methods are to be used. It is frequently the case, especially in the agricultural investigations and practice, that the description of precipitation is based only on the most elementary statistical indicators which, lacking the necessary application of all the preceding and accompanying analyses, may yield erroneous conclusions and predictions. Often, such analyses pay insufficient attention to the fact that the time series can have a certain cyclic component, so that it is of crucial importance to choose correctly the time period taken for the analysis. Depending on the nature of the variable, the duration of the period in which a process is developed and the effect of man and the environment, stochastic series can have, a more or less expressed deterministic component, which is manifested either through periodicity, abrupt changes, or trends.

It has been observed that the direct causes of hydrometeorological phenomena, solar activity, atmospheric processes, and the like, have marked elements of periodicity. Hence, it

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can be expected that their consequences also exhibit a certain degree of periodicity, although it is very difficult to prove direct partial cause-consequence relations [1,2]. A certain stochastic series is to be analyzed on the basis of the results of long-term measurements and registering of all the relevant hydro meteorological quantities in the past. In order to carry out the analyses in a correct way, and thus provide a better description of the phenomenon itself, it is necessary to ensure that the analyzed sample encompasses at least two full hydrologic, or meteorological cycles, one series of dry and one series of wet years [3,4,5].

The cyclic nature of a certain phenomenon which can be represented by a stochastic time series can be analyzed using one or more of the existing numerous methods, such as autocorrelation, moving average, periodogram, integral curve of modular deviations, etc. On the example of a series of monthly and annual precipitation sums registered at the meteorological station Rimski Sancevi near Novi Sad, in the 1948-2008 period for the monthly and annual values, by the presented analysis we demonstrated the applicability of some of the above meteorological and statistical methods for the analysis of droughts.

## 3. ANALISES AND DISCUSIONS

After establishing that they are representative and consistent, and on proving their independence by Anderson's autocorrelation test, the series of data on monthly and annual precipitation sums registered at the Rimski Sancevi meteorological station were analyzed for their homogeneity. For this purpose use was made of Student's T-test and normalized Z-test. In this way it was established the significance of the differences of the mean values and standard deviations between the series of data for the 1948-1994 period and the second series for encompassing the 1995-2008 period.

On the basis of the results presented in Table 1 it is evident that at the level of annual values, a inconsiderable precipitation increases occurred (the average value is higher by 31.7 mm), whereas for the monthly sums of precipitations the situation differs from one month to another. A largest increase of monthly precipitation in the analyzed period was registered in September and October (15.1 and 15.8 mm), as well as in some the other months (5-11.4 mm), whereas in February, June, August and December insignificant decreases in precipitation (0.2-9.4 mm) were observed. In all cases, the noticed differences for the significance level of $\alpha$=0.05 and the corresponding number of degrees of freedom, there were no statistically significant differences, i.e. the series can be considered as the homogeneous ones.

Table 1. Test of the homogeneity of monthly and annual precipitation. Criterion for the hypothesis acceptance at the significance level of a=0.05 and the corresponding number of degrees of freedom for T-test t=0±2.00, and for Z-test z=0±1.96.

| Statist. indicat. | Monthly values | | | | | | | | | | | | Years |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| Subseries 1: Period 1948 - 1994; N=47 | | | | | | | | | | | | | |
| Min. 1 | 5 | 3 | 3 | 15 | 15 | 20 | 2 | 8 | 2 | 0 | 9 | 3 | 384 |
| Max. 1 | 102 | 113 | 117 | 90 | 134 | 204 | 169 | 148 | 89 | 113 | 156 | 150 | 888 |
| Avg. 1 | 36 | 38 | 36 | 48 | 55 | 87 | 63 | 55 | 37 | 39 | 51 | 54 | 599 |
| Std. 1 | 23 | 29 | 24 | 17 | 31 | 41 | 41 | 34 | 22 | 33 | 29 | 32 | 113 |
| Subseries 2: Period 1995 - 2008; N=14 | | | | | | | | | | | | | |
| Min. 2 | 8 | 1 | 3 | 9 | 17 | 28 | 11 | 0 | 4 | 1 | 7 | 16 | 289 |
| Max. 2 | 75 | 64 | 95 | 156 | 176 | 237 | 209 | 125 | 160 | 143 | 143 | 138 | 999 |
| Avg. 2 | 41 | 29 | 36 | 54 | 67 | 79 | 68 | 50 | 53 | 55 | 57 | 45 | 631 |
| Std. 2 | 18 | 17 | 24 | 34 | 37 | 45 | 55 | 33 | 39 | 43 | 33 | 31 | 184 |
| $\Delta$ Avg. | -5.0 | 9.2 | 0.2 | -6.4 | -11.4 | 8.1 | -5.9 | 5.3 | -15.1 | -15.8 | -6.2 | 9.4 | -31.7 |
| t | -0.73 | 1.10 | 0.02 | -0.94 | -1.13 | 0.62 | -0.43 | 0.51 | -1.81 | -1.43 | -0.68 | 0.97 | -0.77 |
| Z | -0.85 | 1.45 | 0.02 | -0.68 | -1.04 | 0.61 | -0.37 | 0.53 | -1.38 | -1.26 | -0.63 | 1.00 | -0.61 |

The time variations of annual precipitation sums are presented in Fig. 1.a. However, only after carrying out the periodogram analysis (Fig. 1.b) it appeared that the most probable

durations of the identified cycles are about 14 years (maximum values of the periodogram peaks - halves of amplitude squares). The hydrological duration and the periodic sequence of dry and wet periods can be best observed on the integral curve of modular deviations. I this, the increasing values of this function denote precipitation surplus (the series of wet years) and decreases determine precipitation deficits (Fig. 1.c). On the integral curve of modular deviations is clearly evident the termination of an extremely dry and the beginning of another wetter period.

The periodicity of precipitation occurrence can also be followed on the basis of the moving average. It can be noticed that in respect of annual precipitation registered at the Rimski Sancevi meteorological station the period since 1982 to 1994 can be characterized as extremely dry. After that, started a extremely wet period (in 2001 annual precipitation sum where absolutely maximal - 999 mm)

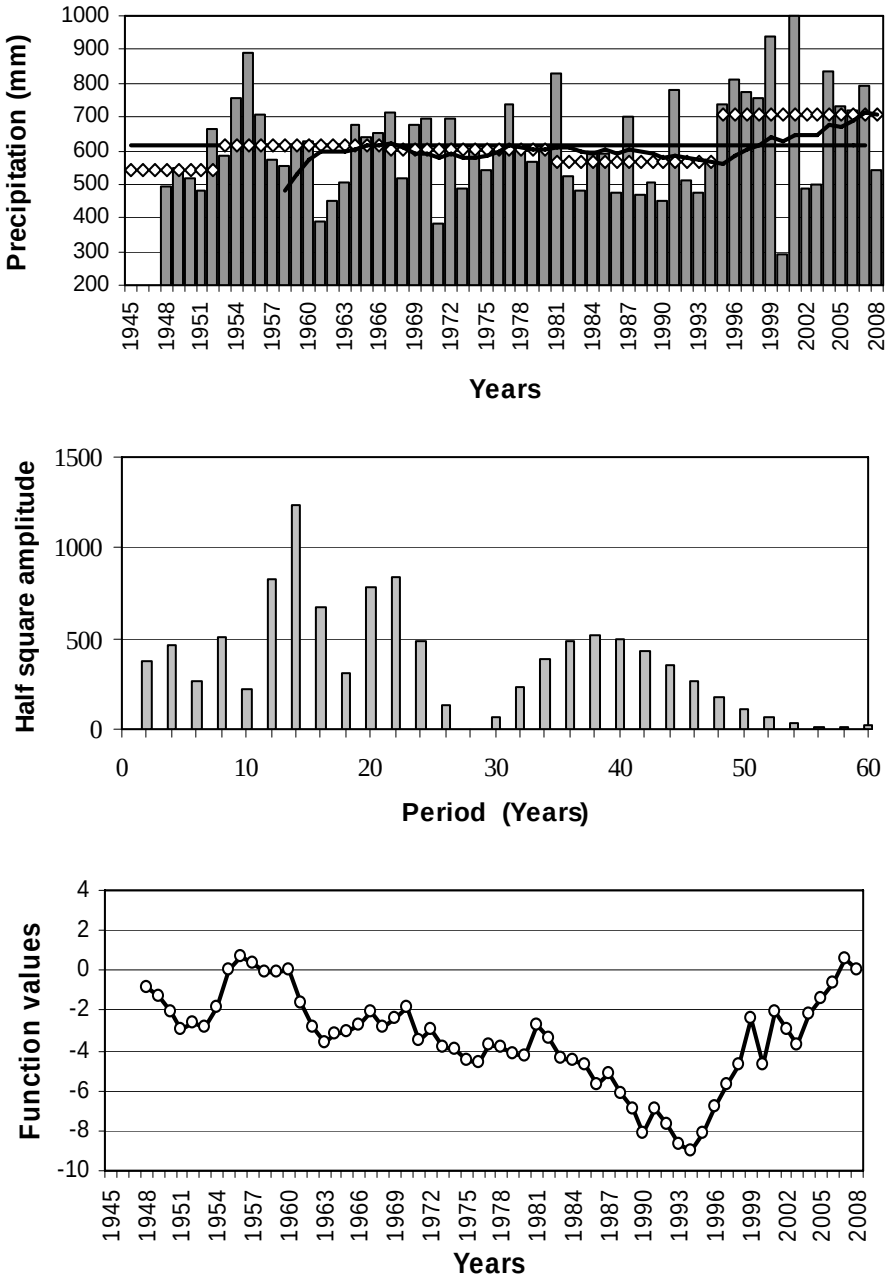



Fig. 1. a) Sum of annual precipitation, their average values and the 14-year moving average; b) Periodogram; c) Integral curve of modular deviations for the meteorological station Rimski Sancevi in the 1948-2008 period

## 4. CONCLUSIONS

The obtained results indicate that on the basis of data registered at the Rimski Sancevi meteorological station, a period 1982-1994 could be observed that is characterized by extreme deficiency of precipitation; in 1995 started a extremely wet period. This deficiency has been noticeably stronger than those registered in the past, but the differences are not so large to be statistically significant.

The precipitation distribution over a year has also undergone certain changes. A largest increase in precipitation has been observed for in September and October, and maximal decrease in February and June. This deficiency has been noticeably stronger than those registered in the past, but the differences are not so large to be statistically significant.

A certain regularity has been observed in the sequence of wet and dry years, so that appropriate longer or shorter cycles of changes could be noticed, as well as the termination of the one period with precipitation deficiency and the beginning of another considerable wetter period.

In view of the fact that in the previous time spans, droughts of similar character to the last one had been observed, it can be undoubtedly said that we do not deal with an unusual phenomenon. Only, the damages thus caused were this time very high because of the significant investments put into the intensification of agricultural production, and because of potentially higher yields, as well as in view of the unused possibilities to mitigate negative effects of such a drought.

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# ROMANIAN STEEL INDUSTRY THE THIRD YEAR OF EU INTEGRATION ENVIRONMENTAL ISSUE TO COMPLY THE EU STANDARDS AND REGULATIONS – BADISCHE STAHL-ENGINEERING "OFF GAS" CONCEPT

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**Abstract:**
This article presents Romanian steel industry production and environmental efforts in view to achieve the EU environmental standards and regulation and remain profitable. BSE – Badische Stahl Engineering - "off gas" concept means "High productivity and low emissions can go hand to hand"
**Keywords:**
Productivity, emissions, environmental standards, off gas,

## 1. INTRODUCTION

Environmental protection measures are very much shaped by the EU. The integral approach set forth in the Integrated Pollution Prevention and Control Directive (IPPC Directive) deserves special mention in this context. Best available techniques, subject to the conditions of the IPPC Directive, are described in a series of reference documents (BREF documents). The new development and improvement of available techniques also gives rise to changes in operating practice, not least as a result of new legislation and regulatory activities of the European Union and its member states

European Union has one of the most competitive steel industries of the world, Steel companies viable from an economic-financial point of view (restructured, modernized and revamped), complex fabrication structure with accent on the fabrication of high added value products; High technological level, innovation capacity, skilled labor force, organization, integration, most severe environment legislation in the world;

European Union represents the main action engine in the field of global policy of environment protection, including as concerns the climate changes.

Badische Stahlwerke GmbH (BSW), one of the most productive Mini Mills in the world, reached more than 2 million tons of good billets in 2007 operating with two conventional 90-ton electric arc furnaces (EAF). For more than 20 years BSW has been working hard to reduce their gaseous emissions with the focus on particulate matter, organic compounds and also carbon dioxide. BSE- Badische Stahl Engineering, belong to BSW, is little sister and all the research and experiment are done practically in BSW before becoming "products".

Operation of a steel plant on a very high productivity level is the basic for high efficiency and low cost. Beside the traditional key figures of a steelmaker we realize all over the world, that the stakeholders can no longer ignore the environmental standards. Especially the off-gas has a huge impact on a "clean" production. If we look at the present debates, it is clear for the industry that one of the challenges will be the reduction of global greenhouse gases.

This paper shows which level of emissions could be reached without having any disadvantage on productivity and gives an overview of various standards and practices in Europe and worldwide.

## 2. ROMANIA – MEMBER OF EU(27)

Main indicators of EU 27 steel industry for 2007 are presented in Table1.

| Crt. No | Indicator | Europe | Romania | % |
|---|---|---|---|---|
| 1 | Production capacities (crude steel) | 244 | 9.1 | 3.73 |
| 2 | Crude steel production | 210 | 6.2 | 2.95 |
| | - converter | | 4.4 | |
| | - electric | | 1.9 | |
| 3 | Continuous cast steel | 200 | 6.1 | 3.05 |
| 4 | Hot rolled production | 172 | 5.5 | 3.20 |
| | - flat | 103 | 1.9 | 1.84 |
| | - long | 69 | 3.7 | 5.36 |
| 5 | Steel tubes production | 32 | 0.8 | 2.50 |
| | - seamless | 49 | 0.6 | 1.22 |
| | - welded | | 0.2 | |
| 6 | Domestic consumption of steel products | 182 | 4.7 | 2.58 |

Table 1. Main indicators of EU 27 and Romania steel industry (2007)

Romanian Steel Industry in restructuring, modernizing and revamping, have the capacity to produce by two processes: converter 71% and electric 29% the structure and quantity (Table 2).

| Company | Production capacities - k tons - | Process | Production 2007 - % - |
|---|---|---|---|
| ArcelorMittal | 6950 | Converter | 75.9 |
| - Galati | 6000 | Electric | 71.1 |
| - Hunedoara | 950 | | 4.8 |
| MECHEL (Targoviste and Campia Turzii) | 1015 | Electric | 7.8 |
| MECHEL - DUCTIL STEEL (Otelu Rosu) | 300 | Electric | 5.6 |
| TMK (Resita) | 450 | Electric | 5.6 |
| TENARIS (Calarasi) | 400 | Electric | 5.1 |
| TOTAL | 9115 | | 100 |

Table 2. Romanian steel industry ownership and production (2007)

We must mention that 96.5 % of the weight was continuous cast steel.

European and worldwide recognition of Romanian steel industry with a capacity of 9.15 mil. Tons / year. 65.8% of capacity is converter steel making, especially for flat products. We must mentioned that all the companies have 100% capacities for continuous casting of crude steel.

The Romanian steel industry is owned by large international steel producing groups (Table 3.). ArcelorMittal and MECHEL possesses nowadays 93 % of steel making capacity and 89.3% of the crude steel production (2007).

After 1989 in the framework of restructuring process:

- were closed and dismantled over 8 mil. tons of crude steel making capacities;
- were closed and dismantled over 10 mil. tons of rolling capacities;
- the personnel number in steel industry diminished from 150 thousand persons up to 37 thousand persons in 2007;
- it increased the weight of continuous cast steel from 36.7% in 1989 up to 96.5% in 2007;
- the labor productivity was in 2007 of 326 t. steel/man

The crude steel production of Romanian steel industry, realized in the last years was of 6.2 mil. Tons, out of which cast steel production reached 6 mil. tons in 2007 and production of hot rolled products established in the last years at 5.5 mil. Tons (Figure 1.).

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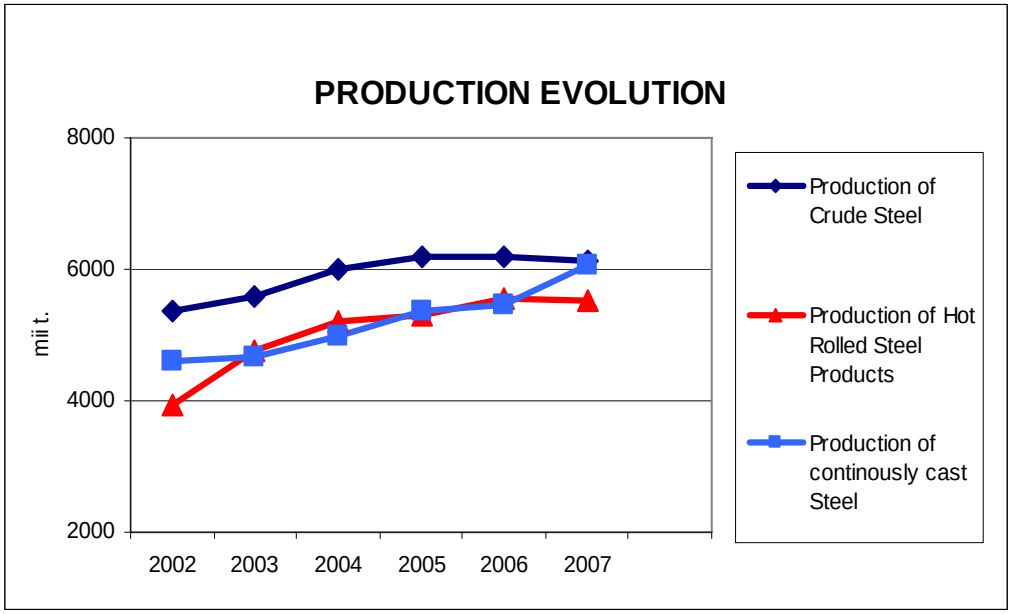



Figure 1. Main indicators of steel production

Romania transposed totally EU legislation in the field of environment. The IPPC Directive was transposed in the Romanian legislation by the GED no. 34/2002, approved by the Law no. 645/2002. Deadlines for conformation with The Romanian Steel Companies din Romania, develop investment programs to comply with IPPC requirements up to the deadline approved by the EC (IPPC Directive for the steel companies with transition periods accepted by EC between 31.12.2012-31.12.2015) inside the Conformity Programs negotiated with environment authorities

## 3. DESCRIPTION OF THE EXPERIMENTAL SETUP

### 3.1. Typical emissions from STEEL PLANTS

Emissions from EAF steel plants are linked to the input material. All organics and heavy metals are entering the process via the scrap and are therefore difficult to control.

Dust is generated during meltdown of scrap through vaporization of metals mainly in the electric arc. Inorganic gaze generation is linked to the process itself. Normally emissions from stacks are given in concentrations (mg/Nm$^3$). Since off-gas volume flow can vary significantly for different fume systems it is difficult to compare emissions from different installations. For this reason so called emission factors have been defined. An emission factor is the average emission rate of a given pollutant for a given source, relative to units of activity. For a steel plant this is for example the emitted weight of a pollutant per ton of steel produced like 100 g of EAF dust per ton of steel.

On the other hand the legal situation concerning limiting values for certain pollutants is very confusing. There is not a single limiting value for a pollutant which all industrialized countries in the world would have in common. The European Union is on the way to harmonize the environmental laws but is still far away from common limiting emission values.

The only way to get the full picture is to compare emission factors with the range of emission factors throughout the industry. The data basis so far is not very big but the IPPC office of the European Union is publishing emission factors in the so-called "Best available techniques reference document for the Iron and Steel industry" (BREF document).

3.2. Environmental performance and productivity of BSW

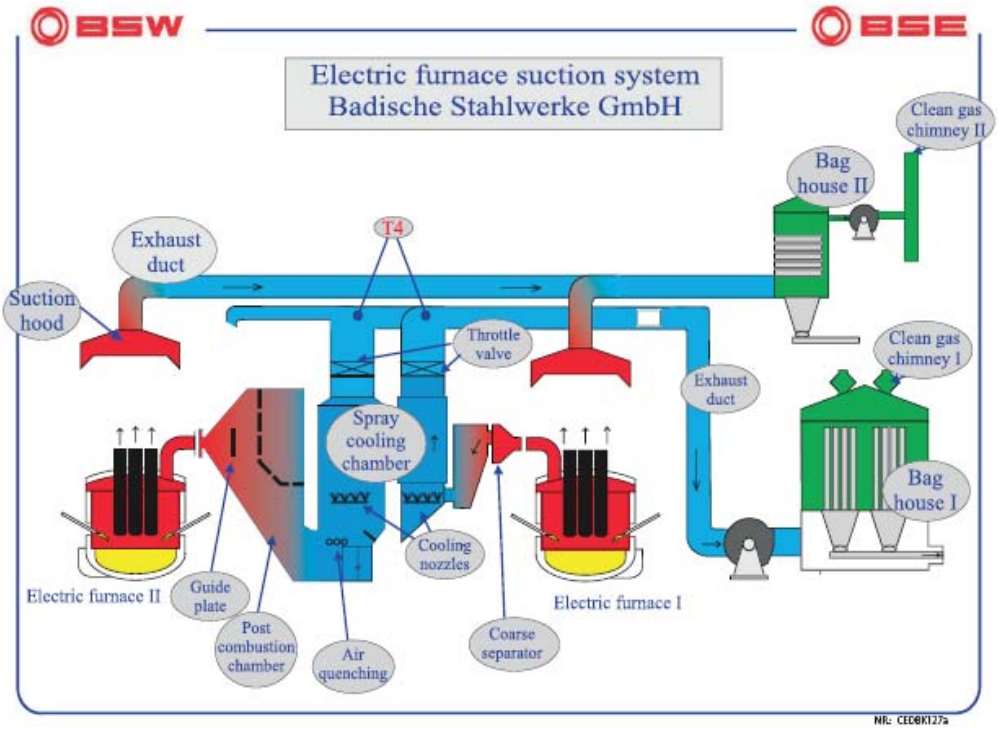



Figure 2: Schematic drawing of BSW's off-gas system

BSW – located at Kehl/Germany - is a so-called mini-mill founded 1968 by Willi Korff. The steelmaking facilities comprehend an EAF melt shop with two 90-t-EAF equipped with 90 MVA transformers, an average tap-to tap time in 2007 of 39.8 min and a productivity of 135 t/h, having produced 2.17 tons of billets in 2007. BSW is using state of the art equipment for their fume extraction systems. The generated off-gases are sucked off directly from the furnaces through the forth hole as well as by a melt shop ventilation system with a combined capacity of 1.8 million $Nm^3/h$ and cleaned in the de-dusting systems with a filter area of 38,000 $m^2$. Schematic drawing for off-gas system at BSW is shown in figure 2.

3.3. BSE "OFF GAS" concept

"OFF GAS" concept is optimal for our environment and companies efficiency, the necessary steps are:

- O Analysis and optimization of shop ventilation and off-gas treatment by fluid dynamic models and Computational Fluid Dynamics (CFD)
- O Concept, planning, supplier recommendation, quality control, implementation and supervision in a single source.

a). Fluid Dynamic Modeling

BSE throw this specialists, providing solution for optimal OFF-GAS treatment, making measurement in Steel Shop Melting building in representative points at different stages of steel production and with this dates analyze the emission quantity, intensity and directions, and base on fluid dynamic modeling methodology establish by Bender Corp of BSE group member (USA), establish the best concept and engineering for off gas system dedicated for each bay (Figure3. and Figure 4).



Figure 3. FLUID DYNAMIC MODELING- Charging



Figure 4. FLUID DYNAMIC MODELING –Taping

b). Computational Fluid Dynamics (CFD) - Simulation

The CFD simulation developed by BSE (Figure 5) means simulation of whole ductwork or single parts, temperature, velocity and flow parameters in view to determined the best technical solutions for off gas system. BSE developed:

"High Temperature Quenching (HTQ) System" (Figure 6):

- Most rapid off-gas cooling by atomized water
- Lower operation costs due to lowest pressure drop in the cooling system
- Low maintenance requirements
- Reduction of water-cooled ductwork

Main technological operations:

- Cooling of the gases from Direct Furnace Evacuation
- Injection of atomized water into water spray chamber
- Atomizing of the water by compressed air in spray lances
- Valve racks for water and compressed air

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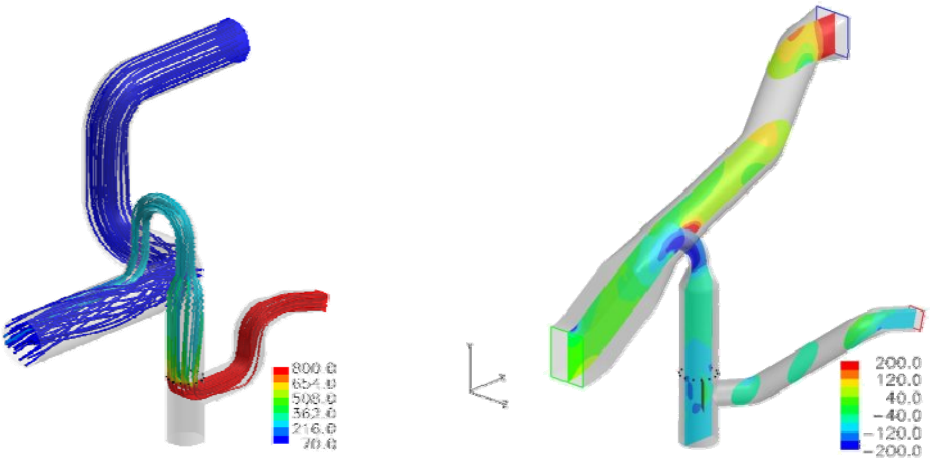



Figure 5. Simulation CFD – whole ductwork





Figure 6. High temperature quenching system

c). Filter technology

Baghouse specification is new and specific for each type of EAF and fan selection complete BSE's scope of off-gas concepts and engineering.

4.3. EMISSION OF PARTICULATE MATTER

In Germany the limiting value for dust emission for EAF plants is 5 mg/Nm$^3$ (0,0021 gr/scf). With today's filter technology it is no problem to comply with this rule. Nevertheless BSW is measuring continuously the dust emissions on both the stacks. The results are reported to the authorities in real time. An example of the results of one year is shown in figure 9.

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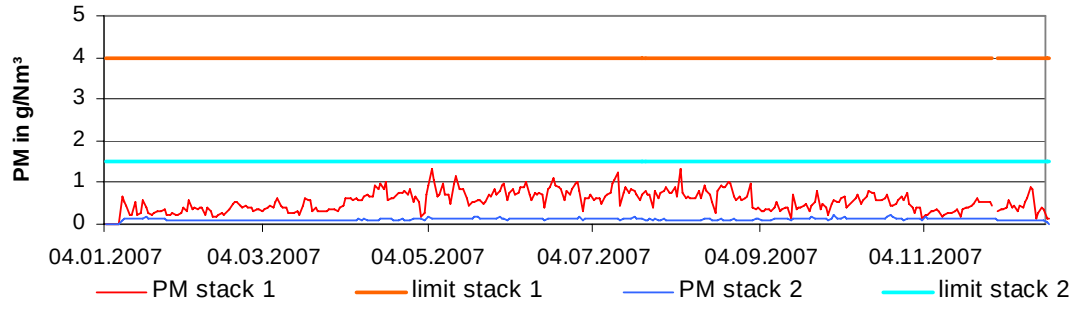



Figure 7. Continuous dust emissions of BSW at stack 1 & 2, 2007

The figures of BSW are far below any limiting values. In comparison with other steel plants BSW is again in the top flight of the emission factors. The comparison is shown in figure 10. The range of emission factors is very high. But with 0,008 mg/ton of steel BSW is very close to the minimum value.

The Romanian steel industry figures are between 20 to 30 mg/Nm$^3$ at stack emission, but the steel workshop emission are not solved yet in any Steel shop in Romania, the dead line for this is the ending of IPPC compliance program, Table 5.

Romanian Technological and Environmental investment program, was negotiated for each Company. In Figure ... are indicators for investment between 2004-2008.

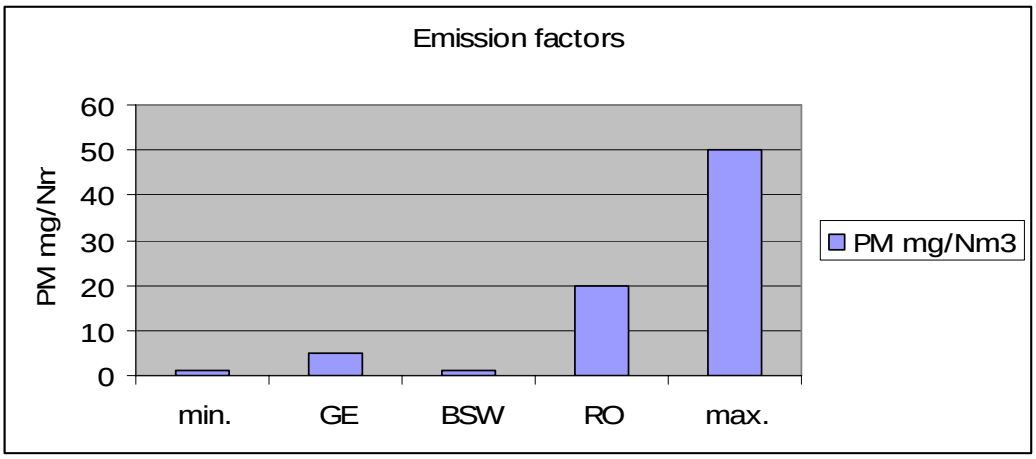



Figure 8: Comparison of emission factors for particulate matter

The Romanian Steel Companies from Romania, develop investment programs to comply with IPPC requirements up to the deadline approved by the EC, inside the Conformity Programs negotiated with environment authorities.

## 4. ANALYSIS OF RESULTS AND CONCLUSIONS

As shown in this paper high productivity of an EAF plant is possible without compromising on environmental performance, especially emissions. Of course some efforts and investments are necessary to operate today's technology in the right way especially in Eastern Europe. BSW is continuously investing in environment to be in compliance with latest rules and obligations. There are possibilities, however, to keep track of the costs for environmental efforts, and steel making can still be profitable in Europe.

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# CATEGORIZATION OF ALLUVIAL DEPOSITS FROM THE CONTENT OF IRON AND ALKALIZATION IN TOTAL SUSPENDED SOLIDS FROM HS DTD OF SOUTHERN BANAT REGION

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**ABSTRACT**

An increasingly agricultural region of Southern Banat was evaluated by the parameters of adsorption of alkaline metals and suspended particles of the rivers Tamis, Brzava, Karas, Nera and DTD canal water. Annual dynamics is categorized by statistical analyses, recognized trends of sodium adsorption ratio and a concentration of iron in total suspended solids. All these provide informational basis for irrigation, range of flood areas and transportation. Environmental protection of Carpatian waters is required because iron and sodium are present in fluvial deposits, and the sodium is gradually increasing. In the Danube-Tisza-Danube canal network in Banat region, the growing algae pointed out determination of suspended particles and changes in Ecological potential of the canalized DTD sector.

**Acknowledgements**

These studies were supported by the Ministry of Science and Technological development of the Republic of Serbia (project No 1945 and No 22006). We are grateful to Center for Electron Microscopy of University of Novi Sad for the SEM research.

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# THE INFLUENCE OF TRIBUTARIES ON LOWER RIVER TISA BASIN WATER SUPPLY NETWORK

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## ABSTRACT

The influence of dam and gates on water supply system- Danube-Tisza-Danube hydrosystem in Vojvodina province (HS DTD) in southern Banat was investigated. Annual dynamics of data represented in statistical BLOCK analyses from sulphates and alkalization (1997-2005) pointed out water supply condition of the River Tisza. The executive block is the control for conveyance system of water supply network and runoff. The obtained results from correlation matrices of SAR index was found to be in negative relation with the iron content in boundary stretch St Martonos while at the dammed stretch St Novi Becej neutral phosphatase enzyme activities were positively correlated with the iron content. The occurrence of brackish water diatom *Entomoneis paludosa* and small centric algae *Cyclotella meneghiniana* downstream the Bega River pointed to considerable problems of detailed canal network usage supplied by the impounded stretch of the river Tisa.



Figure 1. SEM magnification correlate diatom communities of Prominent diatom *Cyclotella meneginiana* (a) of the River Tisa (b) and irrigation/drainage canals (c)

**Acknowledgements**

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# OBTAINING INFORMATION FOR THE RIVER DANUBE ECOLOGICAL STATUS FROM THE CITY OF NOVI SAD

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**Abstract**

Obtaining information of the Danube River (1997-2005) pointed out degradation of four river stretches. Integrating data were represented in the block of phosphatase enzyme activities and dynamics of iron depositing bacteria. The Scanning Electron Microscope (SEM) and Energy Dispersive Spectroscopy (EDS) detection of bacteria *Gallionella* in water samples of alluvium and biofilm of the Novi Sad drinking water resources indicated heavy metals in groundwater. The SEM observations shows that at those groundwater where the iron increasing in oil contaminated wells the activity of alkaline ions resulted in characteristic depositional environment of the Novi Sad City. There, the potassium, aluminum, titanium and zinc are consumed in same relation, and their elemental dispersion is very similiar. The biological activity pointed out stabilization of iron and phosphorus in drainage wells.

**Key words:**

model to study, PAI, Iron-depositing bacteria, SEM & EDS, particles, The Danube River

## 1. INTRODUCTION

As a step forward substantial progress in harmonization and implementation the EU water policies of The Danube River and improvement of the Ecological status of the infrastructure of the city of Novi Sad, the research of bio-activities concerning metal deposits was investigated from un-treated water samples.

## 2. MATERIAL AND METHODS

Hydrological network of the River Danube in Novi Sad is sustained of two small slack-water areas, small streams entering from Fruska Gora mountain, Danube-Tisza-Danube (DTD) Canal entering to the main river's channel. It also includes waste water disposal systems as well as drinking water transportation system of the Danube abstraction wells supply for the more then 200 000 citizens of Novi Sad. The research was made on four urban river stretches concerning river banks and middle current of the river when the samples were collected from the three bridges (1997-2007): stretch I from 1262 to 1259 r km (L1, R1); stretch II 1257 r km (L2, M2, R2); stretch III 1254-5 r km (L3, M3, R3), L3- municipal waste water discharges; stretch IV from 1253 to 1245 r km (L4, M4, R4). During the research, the ruining of three bridges and Oil-refinery in 1999 and the drought 2003 year unfavorably occurred. Several oil contaminated drainage wells in the vicinity of the drinking water wells and deep drainage well located at the stretch four, upstream the piezometer Danubius of the second urban river stretch (left riverbank) and biofilm of drinking water pipe represent our investigated water-deposit samples. The phosphatase enzyme reaction took place at 30°C by the use of substrate p-nitrophenylphosphate [1]. The reaction mixture contained of 3 ml of water was contained of 0.3 ml buffer solution (0.33 M Tris, 0.33 M TES), pH of un-filtered water samples was adjusted for acid (pH 5), neutral (pH 7) and alkaline (pH 9) conditions of water; 0.3 ml of 5 % w/v of substrate p-nitrophenylphosphate and 2.4 ml of untreated water sample. The concentration of p-nitrophenol was determined by measurement of absorption at 420 nm; the average values of three phosphatase activities were described as PAI index

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[4]. Deposit analysis of the groundwater drainage wells was made by the use of Scanning Electron Microscope (SEM) JEOL JSM-6460 L. The EDS pattern of elemental composition (total wt %) were recorded on an OXFORD INCA Microanalyses suite and presented in diagram and categorized graph. The particule size analyses was made by MASTERSIZER 2000, Malvern instruments UK. A spatial framework for collecting, storing, and classifying information on the character of urban river network was proposed using the software Stat.soft Statistica 8.

## 3. RESULTS AND DISCUSSION

The implementation of the Water Framework Directives in the monitoring requirements of large rivers requires serious steps which are proposed in the Directives, and should be applied to the water remediation for the achievement of good Ecological status of protected areas [2, 6]. As an important step, the urban river network research [5] concerning changes of phosphorus availability is represented in BLOCK- (box-plot) integrating data of activity of phosphatases enzymes in season succession when we compared river banks and middle current of the river. Nevertheless, increased activities appeared from municipial waste water discharges (river stretch L III) (Figure 1).

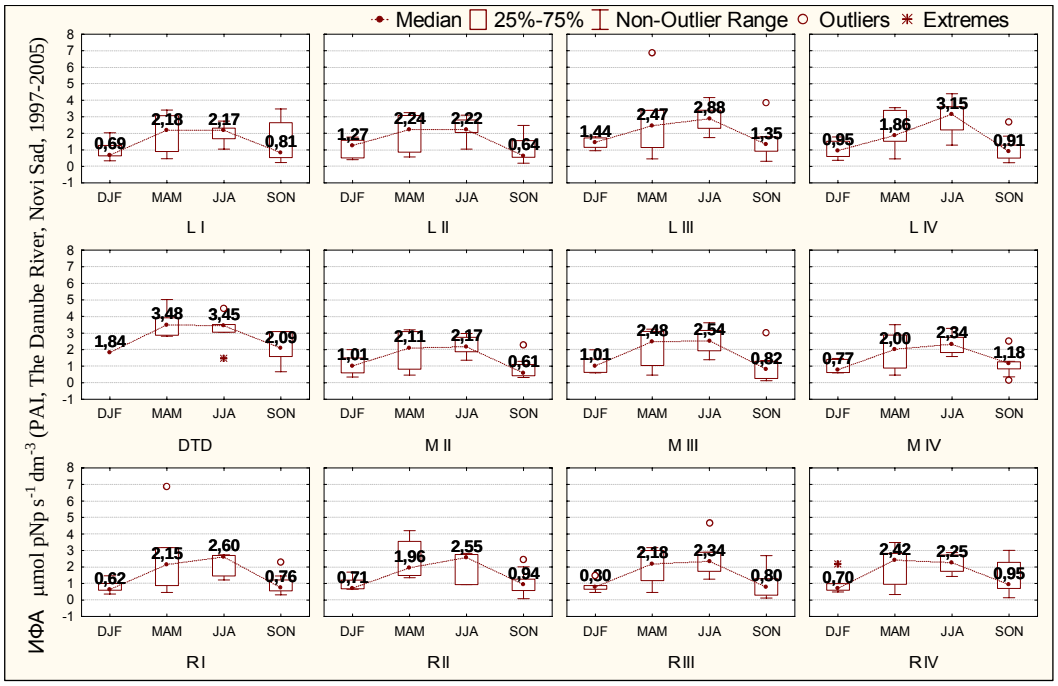



Figure 1. Box-plot: seasonal dynamics of phosphatase activity index of the surface water of The Danube in the City of Novi Sad ($PAI_{NS}$) (left riverbank, DTD canal, middle current, right riverbank of The Danube; river km 1262–1245).

In conformity with results of piped water, phosphatase activities after the period of closing the water suggested the sensitivity of parameter for hydrodynamic conditions of piped water (Figure 2). It was also noted that in hot water from electric boiler (>70 °C) the phosphatase enzyme activities were detected, too (sample 13). In this system, neutral phosphatase are active when they are compared with the depositional environment of the most contaminated piezometer 9 contributed by acid phosphatase enzyme activities. The acid phosphatase enzyme activity is shown in the most microbiologically contaminated ground water, where the oil and its derivatives has its highest concentration (Figure 2).

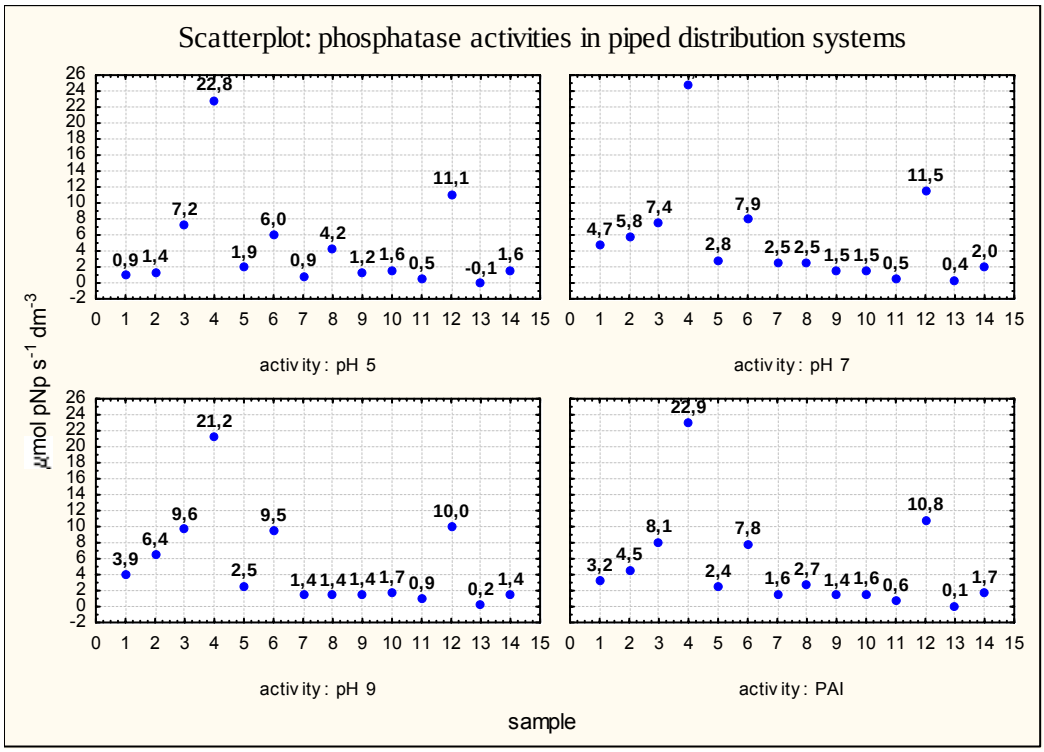



Figure 2. Scatterplot: categorization of phosphatase enzyme activities (µmol pNP $s^{-1}$ $dm^{-3}$) in piped systems in Novi Sad. Water samples: 1) Danubius piezometer 7, 2) Danubius piezometer 7 unfiltered, 3) Danubius piezoemeter 9, unfiltered, 4) Danubius piezometer 15, unfiltered, 5) Piezometer 1 in the vicinity of river bank- stretch 4 of the Danube River, unfiltered, 6) Drainage well 5 in the vicinity of oil rafinery- unfiltered, 7) Drainage well 9 filtered, 8) Drainage well 9- unfiltered, 9) Raw drinking water 1, 10) Raw drinking water 2, 11) Liman: sector I - cold water, 12) Liman residential area: sector IV- cold water- pipe deposit, 13) Liman: sector I- hot water (boiler), 14) Liman: sector IV, hot water.

The high portion of amorphous content throughout the drainage system of The Danube River alluvium reveals the growth of iron-oxidizing (iron-depositing) bacteria. Scanning electron micrographs demonstrate that Fe- depositing microbial mat sampled in oil polluted drainage wells is primarily composed of granules and several types od bacteria with the predominant species being described as *Gallionella feruginea*, *Lepthothrix ochracea* and *Chrenothrix polispora* (Figure 3). Increasing mineralization [3] was a contributing factor for infrastructure degradation because of iron-depositing bacteria occurence detected in 2004-2008 (Figure 3). The water of drainage wells located one km from the left riverbank is highly contaminated with the iron-depositing bacteria in water and there oil derivative- benzene was mostly determined in concentration of 1 µg/l (well 8, well 9, well 10) and maximum conc. of 9.4 µg/l was measured in November, and there was found extreme conc. (23 µg/l) in drainage well 9.

In drinking water distribution system of the Novi Sad city, the physico-chemical parameters belong to rarer unsatisfactory quality due to the 40 % of changed collor, 40 % of manganese increased, 30 % of residual chlor, increased concentration of iron and chloroform in 20% [9]. Neverthelless, there has been paid attention in alkalization processes; decreasing of pH was also detected in Novi Sad [8]. It is important to mention that at the sector of The upper Danube at the river km 1300 and nearby The Novi Sad city, an increase in the concentration of aluminium and iron was followed by more or less constant values in the Danube Delta and on the way to it [7]. From the electromagnetic method geosolar for the assessment of diffuse pollutants, ammonia was continually detected at contaminated area [10], an important nutrient for movement of groundwater microorganism (in prepare).

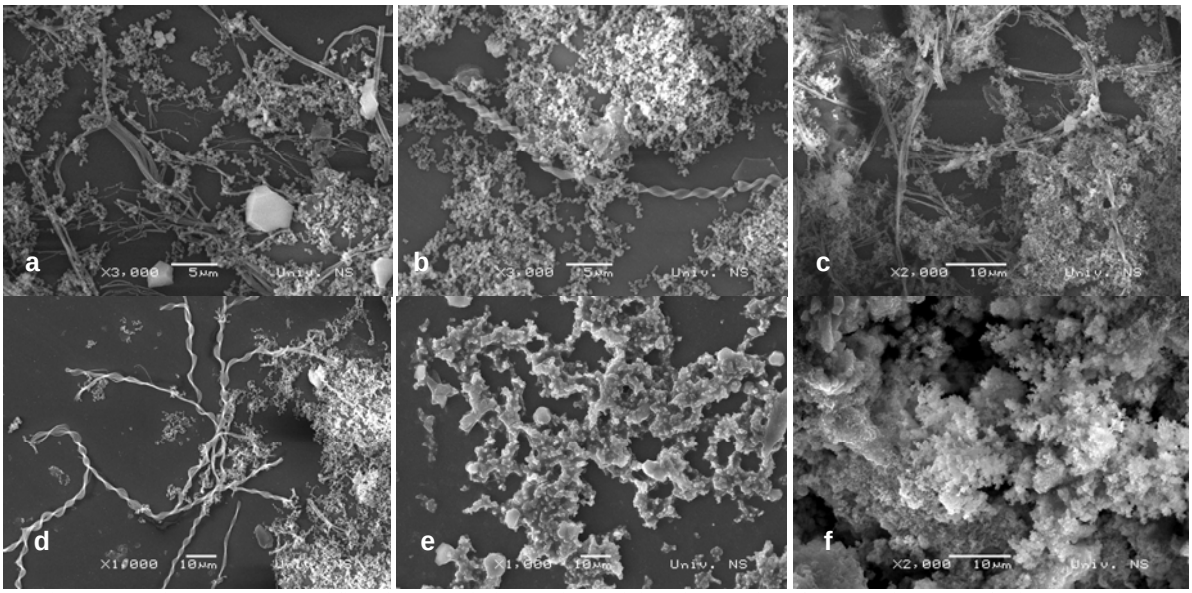



Figure 3. The SEM magnification: a-d) iron-depositing bacteria of groundwater of The Danube drainage well nearby The City of Novi Sad sampled in 2007 (left river bank, fourth river stretch), e) silted material of piezometer Danubius from the second river stretch, f) biofilm of piped drinking water.

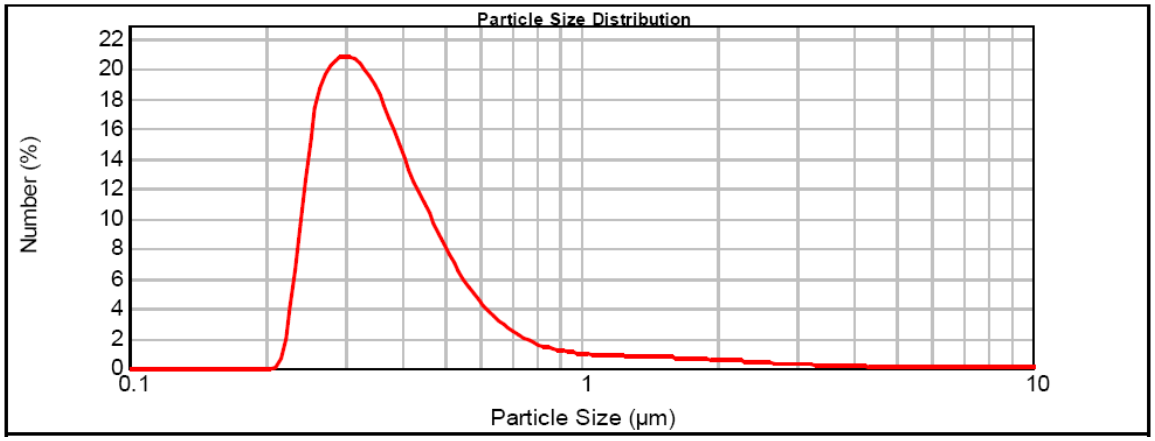



Figure 4. Particle size distribution analyses of groundwater deposit of The Danube River carried by Mastersizer 2000.

Particles of the sample of groundwater deposit are in diameter range from 0.2 µm to 8 µm. Predominant particles have diameter of about 0.3 µm (Figure 4). About 90 percent of all particles belong to range from 0.2 µm to 0.65 µm. The particle distribution is comparable to SEM research of particles size showing grains in diameter range about 160 – 196 nm, but braided stalks probably belong to larger particle size of active microorganisms.

Considering the dynamics of iron-oxidizing/depositing bacteria, similiar elemental composition of the grains and stalks in drainage wells and pipes were recorded (Figure 5,6). Potassium, titanium and zinc are microbiologically consumed equally, and their elemental dynamics is similiar in silicon, dependent on content of aqueous calcites and chlorides. Therefore, the movement of particles and their relative error of weight fraction indicated contamination and degradation of river sector Ecological status nearby residential areas.

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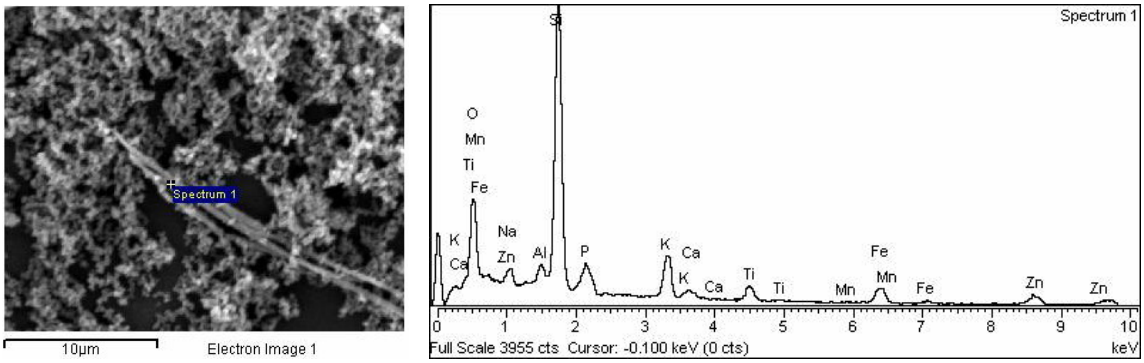



Figure 5. SEM and EDS diagram of spectrum point analyses (Oxford Instrument INCA-X-sight software) of the groundwater deposits shown by the X- ray spectra from the spectrum point of the fourth river stretch (The Danube in Novi Sad). Mineral identification of feldspar is assested with the X-ray microanalyses by standards.

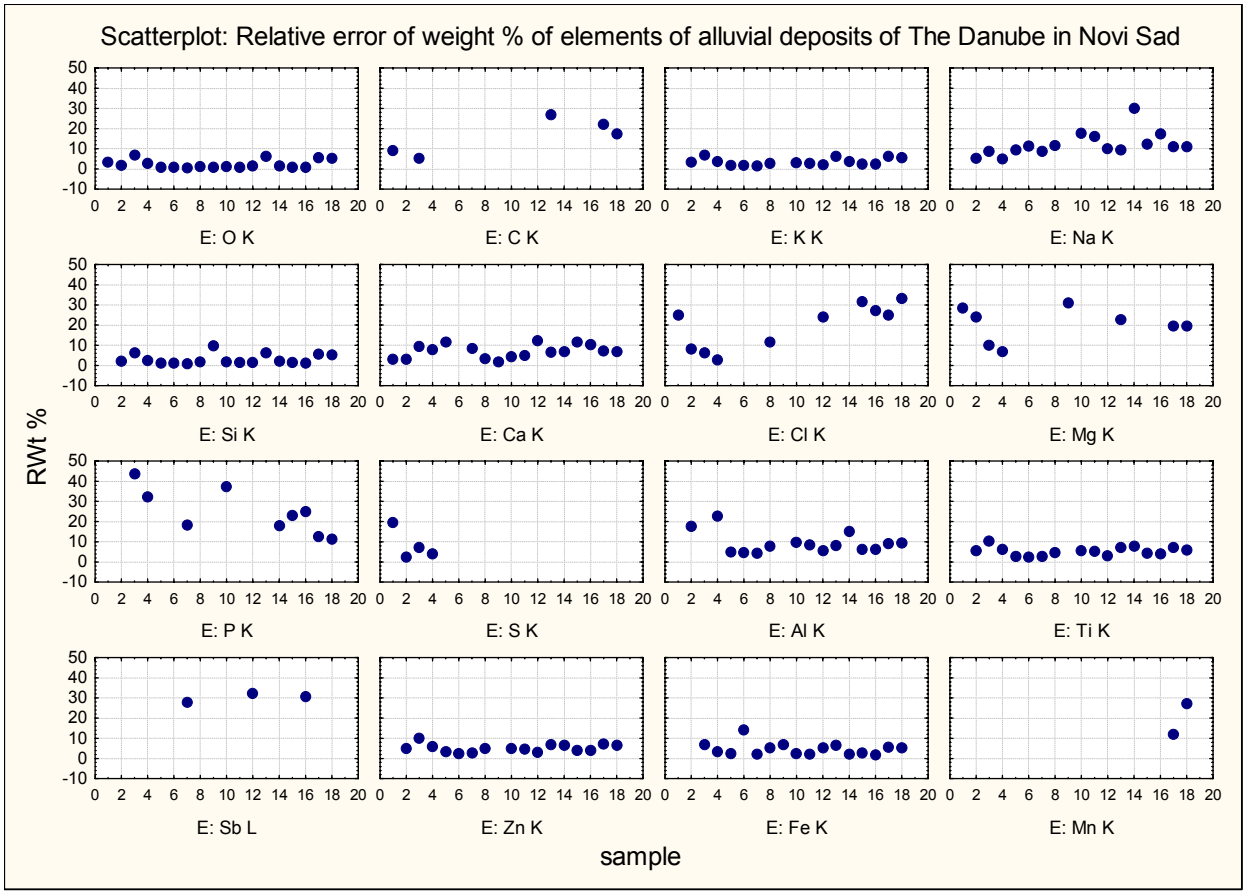



**Figure 6.** Categorized graphs of relative error of weight fraction (%) of different elements in groundwater drainage deposits. Relative weight (sigma weight (%)/weight (%)) was presented by the categorized scatterplot graph (Statistica 8) in order to provide systematization of EDS analyzed parameters of spectrum point analyses (Oxford Instrument INCA-X-sight software). The elemental composition analyses was carried out in piezometers Danubius located on left riverbank of second river stretch (sample 1—4) and downstream on the fouth river stretch- left riverbank in deep water well in 2007 (5-7) and the one collected from 2008 (8), drainage well 1 (9-11) sampled in 2007, drainage well 6 (12-13), drainage well 7 (14), drainage well 9 (15-16), drainage well 10 (17-18). The drainage wells are located between the Oil Refinery and Drinking water wells of The City of Novi Sad. Mineral identification of feldspar by standards is assested from the X-ray microanalyses.

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## 4. CONCLUSION

Obtaining information of urban river sector of The Danube, indicated that at those groundwater where the contamination with the iron-depositing bacteria occured, the movement of phosphorus, particles and their elemental composition resulted in characteristic depositional environment of the groundwater of the Novi Sad Capital City of Vojvodina Province.

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# ENVIRONMENTAL IMPACTS OF NITRATE AND NITRITE

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**Abstract:**
The natural nitrogen cycle is significantly influenced by the human activity – principally by agriculture and transport. The excessive fertilizing, the organic matter content of sewage waters, and the emission of nitrogen oxides to the atmosphere – caused by vehicles and industrial activities – are unsettling the biosphere's nitrogen balance. The anthropogenic nitrogen surplus in soils, water bases and atmosphere means great problem, and its indirect effect is observable in our environment and daily life. Nitrite and nitrate pollutions are important and serious risks in spite of being relegated to the background in global environmental protection.

**Keywords:**
nitrate, nitrite, fertilizer, eutrophication, methemoglobin

## 1. SIGNIFICANCE OF NITROGEN

The nitrogen is present in the environment in many various forms and considerable amount. Nitrogen compounds are especially important from environmental, ecological and physiological aspect because they are indispensable constituents of e.g. proteins, nucleic acids or humus; they can be found in the atmosphere, in soils or in any living organism. The wide interval of nitrogen's oxidation state (-3 - +5) indicates the high number of the – essential, toxic, neutral or anthropogenic - components nitrogen can form. Among these numerous compounds nitrate and nitrite mean significant environmental risk and can cause long-term natural damages.

## 2. THE NITROGEN CYCLE

The elemental nitrogen of the atmosphere – because of its inert structure – highly resists chemical reactions; hence the most of organisms are disable to use it for biological processes. Only some microorganisms (e. g. Rhizobium, Azotobacter, Clostridium) can fix and convert nitrogen to accessible form for plants (ammonia, ammonium). Ammonia is oxidized by Nitrosomonas and Nitrococcus bacteria to nitrite which is converted to nitrate by Nitrococcus and Nitrobacter species during the nitrification process. These nitrogen forms are also available for the flora. Nitrogen compounds of organic residues are converted to ammonia in the course of ammonification then nitrified as well. A part of nitrite/nitrate content of the soil is returned to the atmosphere as elemental nitrogen and dinitrogen oxide by the activities of e.g. Pseudomonas, Paracoccus species (denitrification) (Figure 1).

Accordingly the presence of nitrate and nitrite in the soil is evident; these forms are the main nitrogen sources of plants and indirectly animals and mankind too. However natural nitrogen cycle is significantly influenced by human activities – principally by traffic and agriculture. The biosphere's nitrogen balance is affected by the overfertilizing, the high organic matter content of sewage or nitrogen oxide emissions of traffic and industry. Anthropogenic nitrogen surplus in the soils, water bases and atmosphere are both sources of environmental problems; the impact to the nature is clearly noticeable.

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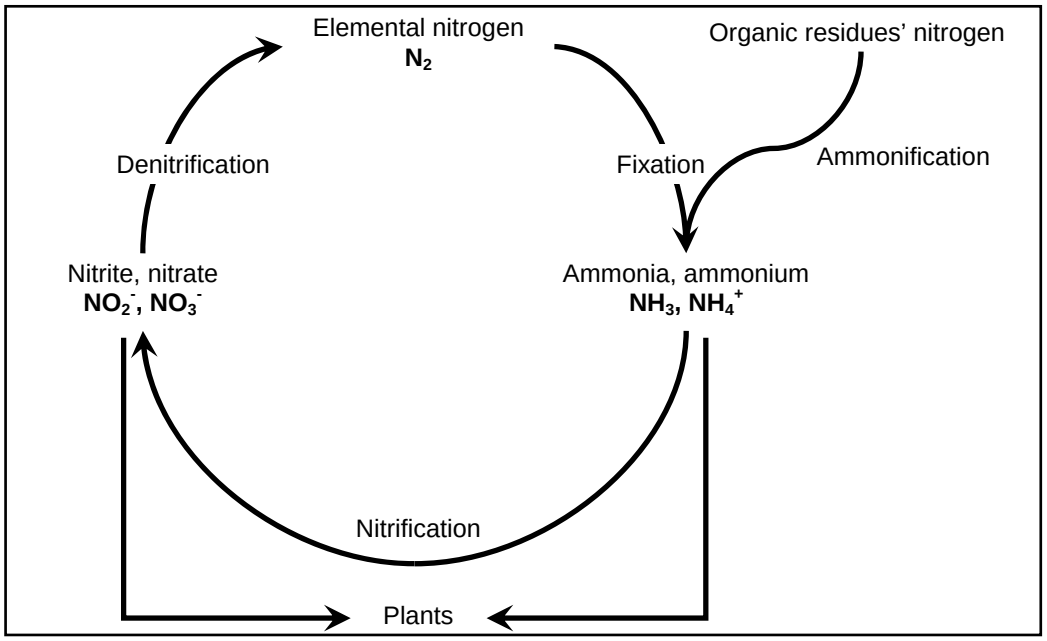



**Figure 1.** The nitrogen cycle

## 3. FERTILIZERS

Usually the nutrient content of soils does not correspond with the demands of cultivated plants; hence fertilizers are basic materials in nowadays' agriculture to increase the crop yields. However added nutrients influence the ion mobility and chemical attributes in soils and the components of soil water, the considered and responsible application of fertilizers not necessarily endangers the environment. Besides proportional nutrient supply can be ensured for the plants with fertilizers, some soil parameters can be optimized, such as alkalinity or structure.

However the irresponsible usage of fertilizers can entail serious environmental and financial risks; incorrect dosaging can disturb the existing balance of nutrients, can cause the elements' immobilization and might reduce the product's quality and yield. Soil accepts and stores nutrients only in limited rate; if it is encumbered with fertilizers beyond this limit, nutrients will concentrate in the soil solution, soil water will be polluted and even salt accumulations will evolve. The surplus of organic matter might reach the drinking water bases by erosion, leaking of groundwater or surface runoff and threatens their quality and causes eutrophication.

Nitrogen fertilizers can be especially harmful because of their possibly high solubility; leaching rate of fertilizers' nitrogen content can reach 80% depending on weather, characteristics of soil, amount of fertilizer and vegetation.

Further risk of soil's high nitrogen level is the nitrate accumulation in vegetables. Under optimal circumstances organic acids – derived from oxidation of carbohydrates – form amino acids with ammonia enzymatically reduced from nitrate. These amino acids are essential components of vegetal proteins. If the nitrogen metabolism suffers disturbance, biosynthesis of proteins will slow down and nitrates and amino acids will accumulate in the plant organism. The accumulated nitrate can worsen the vegetable's tissue attributes, lasting and even its taste. High nitrate levels can be measured in e.g. lettuce, kohlrabi, radish, colewort and spinach.

## 4. NITRATE IN WATERS

Eutrophication of surface waters is caused by increased organic matter content – basically nitrogen and phosphorus compounds – originated from sewage or leaking from fertilized agricultural areas. Great amount of nutrients offsets the balance between photosynthesis and plant breathing: the water's oxygen concentration rises and the flora

starts to proliferate. The multiplied species of fitoplanctons and algae further increase the nutrient amount of water however during their degradation processes the water's dissolved oxygen resource is consumed. Finally the lack of oxygen leads to almost complete disappearance of flora and fauna, decreasing biodiversity and the water loses its self-cleaning capability (Figure 2). Under natural conditions eutrophication occurs much more slowly (e.g. lake succession); the intensive organic matter input significantly speeds up the process.

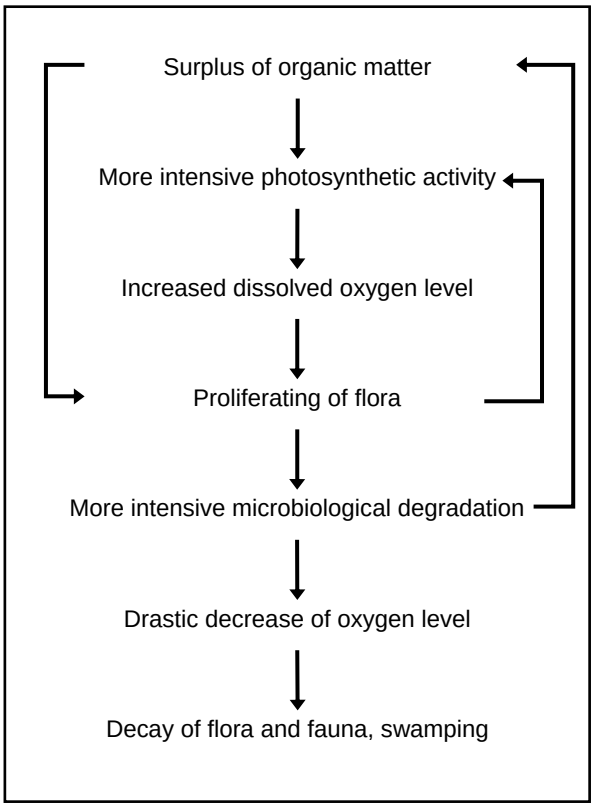



**Figure 2.** Process of eutrophication

High nitrite and nitrate content means direct risk where drinking water is supplied from polluted water bases. Leaked to groundwater, nitrogen compounds of fertilizers endanger the water quality of drilled wells and other water sources. The amount of nitrate ions stays unchanged during the conventional water cleaning processes; hence the nitrate content of consumed water is equivalent with the water base's.

## 5. NITROGEN COMPOUNDS AS AIR POLLUTANTS

Besides elemental nitrogen other nitrogen compounds are formed in the course of denitrification that harm the atmosphere. The gas phase losses of fertilizers can get to the atmosphere as nitrogen oxides (e.g. $N_2O$, $NO_x$) and take part in generating acid rains and tropospheric smog and thinning ozone layer. The great amount of organic matter can make the denitrification more intensive and considerable part of the fertilizer's nitrogen amount can get in the air. Flue gases are main sources of these types of air pollutions; the magnitude of fertilizer's impact is minor, but confirmed and not negligible.

## 6. NITRATES AND NITRITES IN FOODS

Nitrite and nitrate get in foods partly as a result of not suitable producing or handling processes and partly as additives. Food industry applies nitrite and nitrate components (e.g. E249 – $KNO_2$, E250 – $NaNO_2$, E251 – $NaNO_3$, E252 – $KNO_3$) primarily with conservation purpose. Most of meat products contain added nitrate and/or nitrite preventing appearance of pathogen microorganisms and ensuring the bright color of the meat. As mentioned, some vegetables' nitrate content can be high as well such as dairy products, cheeses, wines or flour.

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## 7. PHYSIOLOGICAL EFFECTS

Nitrate and nitrite content of foods and drinking water can induce various medical problems – however most of these components usually leave human organism fast and without evolving any deleterious effect. Nitrite – reduced from nitrate mainly in stomach and small intense – can transform to nitrous acid that oxidizes the ferro-ion of hemoglobin and causing methemoglobinaemia. In the case of methemoglobinaemia blood's oxygen carrying capability decreases and even death can occur. Under normal circumstances 1-2% of human organism's hemoglobin is present in methemoglobin form; if this scale is about 10% symptoms of languor and concentration disturbance will be observable; 50% of methemoglobin is lethal. Nitrite poisoning is really rare in adult population because a special enzyme transforms back the methemoglobin to hemoglobin (Figure 3); however babies are highly endangered because in early age the methemoglobin reductase is not working adequately yet. Therefore the babies' nutriments and drinking water must not include nitrate or nitrite in even trace amount because in lack of medical help anoxic state ("blue baby" disease) is probably deadly.

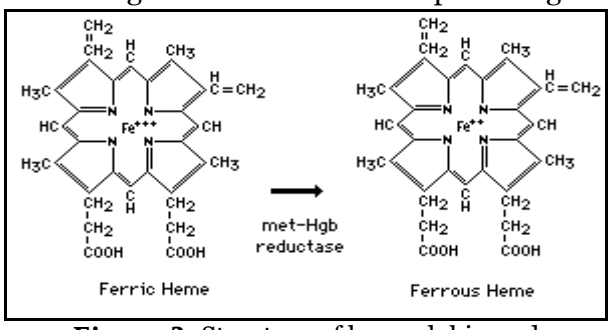



**Figure 3.** Structure of hemoglobin and methemoglobin [6]

Another problem related with nitrite presence is the formation of nitrosamines and nitrosamides. These carcinogen N-nitroso compounds are particularly evolved in the acidic media of stomach through reactions of amides and amines with nitrite [2].

## 8. REGULATIONS

Because of the above environmental and physiological dangers controlling the nitrate and nitrite emissions and monitoring their concentration in foods and waters is important and required. Regulations, decrees and limit values exist to avoid the unnecessary, dangerous or harmful application of these compounds. The directives and regulations of the EU assign fertilizing parameters, limit values for drinking waters, vegetables, meat products etc., and lay emphasis on the protection of nitrate sensitive regions (areas where nitrates can easily reach drinking water bases). Unfortunately national rules not always correspond to the international requirements.

## 9. CONCLUSIONS

Fast and effective solving of environmental problems caused by anthropogenic nitrite and nitrate is difficult task because of its complexity. The only long-term solutions seem to be the reasonable fertilizing and the adequate wastewater treatment. The environmental and medical risk can only be reduced with controlled emissions and international co-operation. Nitrate and nitrite pollutions are critical however often hidden problems of nowadays that should be taken much more serious.

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# SUPPORTING THE REASONABLE AGRICULTURAL PRODUCTION WITH A NEWLY FOUNDED ENVIRONMENTAL LABORATORY IN THE SOUTH EASTERN REGION OF HUNGARY

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**Abstract:**
An agricultural and environmental laboratory was founded within the framework of Baross Gábor Program in the summer of 2008 in Mórahalom, South-East Hungary, South Great Plain region. The primary aim of this initiative is making the countryside's agriculture more effective and environmentally aware, and assisting the dynamic development of the region. The laboratory helps agricultural production – the primary financial source of the region's villages – with analytical measures of soil and water samples, counseling about nutrient dosing, organized presentations, and cooperating with local enterprises and with another laboratory analyzing chemical residues in the produced crops. One significant deficiency was compensated by the establishment of SoilChem Laboratory – meeting the conditions set forth by directives of the European Union –, due to the lack of environmental laboratories in the region.

**Keywords:**
soil and water analyzing laboratory, agriculture, environmentally aware,
food safety and technology network

## 1. INTRODUCTION

With the help of the Baross Gábor Program, conducted by the Homokkert Small-regional Integration Public Company consortium a research and development network and a food safety and food technological subcenter has been set up in the South Great Plain region in Hungary. It is structured around up-to-date technological and metrological solutions and results cooperation of scientific institutions, researcher non-profit organizations and the entrepreneur sector.

The micronetwork and the soil- and water analysis laboratory – coordinated by the Homokkert Public Company – provides agro-innovative services for the cooperatives and partner organizations (DATÉSZ Rt., Mórakert Cooperative). By doing so it improves the local products' competitiveness and the standard of nutrition and quality assurance.

## 2. THE IMPORTANCE OF AGRICULTURE IN THE REGION

45,000 people live in the area of Mórahalom, which is considered the center of the Homokhát Small-region. Most of the people work in agriculture, thus their living is exposed to the competitiveness of the vegetable and fruit grown by them. Agriculture uses 72% of the small-region's land. The rate of forests is high, resulted by the afforestation in the beginning of the last century. The rate of lawns is also high because of the previously existing vast meadows and mowing fields. However vegetable growing is typical in arable farming and in the garden cultivation branches and its economical importance is unquestionable, it occupies relatively small area from the region's land. The volume of land used for pomology and vineyards shows the characteristics of sand farming. Non-cultivated lands and waste lands are the signs of uncertainty of farming and marketing and the disarrays about the ownership of the tenures (Figure 1).

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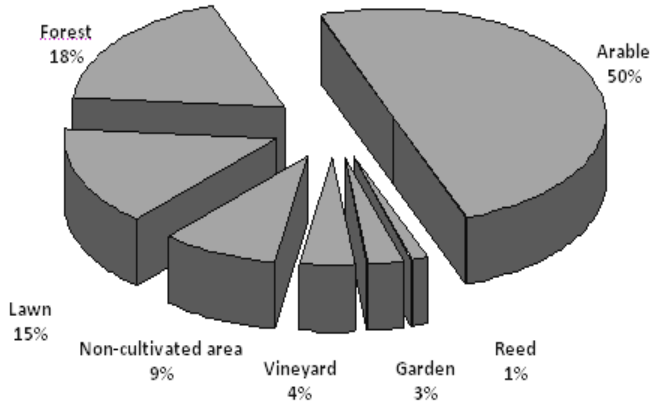



**Figure 1.** Distribution of cultivation branches of the small-region's area

The integrators, the cooperatives and other significant economic operators have to make sure the compliance with the market requirements, which means producing clear, healthy and high quality products. The most significant such integrator is Mórakert Cooperative founded in 1995 and declared as the first fruit and vegetable producer realizer organization by the Ministry of Agriculture and Rural Development in 2002. Its turnover and number of members has increased significantly in the last 10 years (Figure 2).

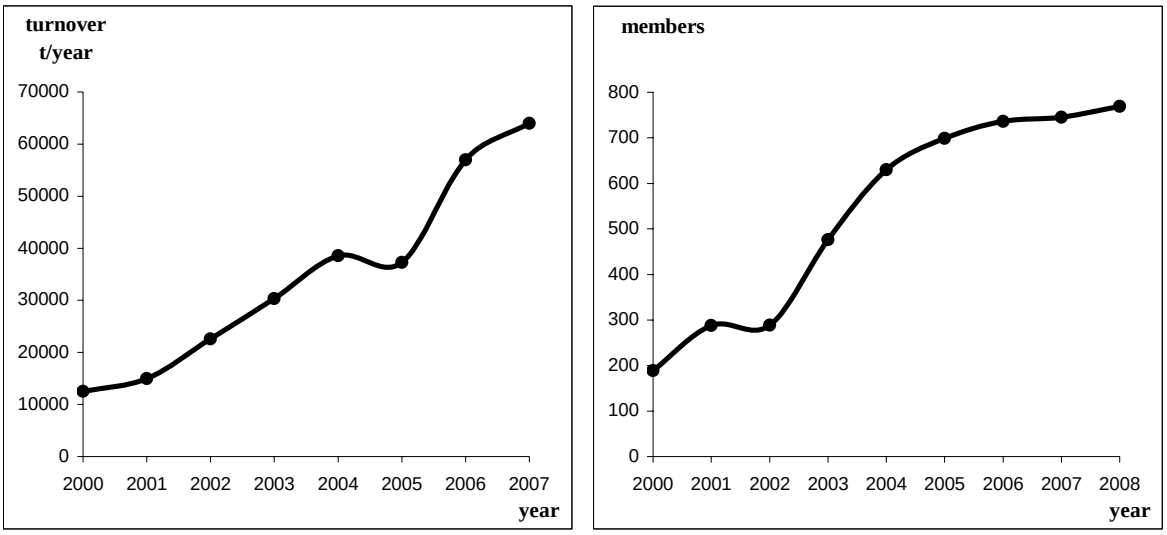



**Figure 2.** Growth of turnover and number of members of Mórakert Cooperative

## 3. HOMOKKERT PUBLIC COMPANY

The Hommokkert Small-regional Integration Public Company was corporated in 2000 by 9 agrarian cooperatives and the local authority of Mórahalom. The company was comprising producer and marketing cooperatives until the conversion in 2004 when the main profile of the company changed and two strategical directions were developed in connection with the agricultural priorities. These focus on the improvement of the living and income conditions of the rural population.

**International connections**

The Homokkert Public Company cultivates good relations with international partners. Seeking the possibility of cooperation with neighboring countries and participating in common projects are important parts of the company's activity. A recent collaboration was the establishment of a Borderland Commercial Center with Topolya and Temerin, two towns in Vojvodina, within the framework of an inter-regional project in 2008. The primary aim of this center is helping the cross-border trade of the agricultural products in the region.

**Profiles of the Homokkert Public Company**

On the one hand the main profile of the Company is encouraging alternative income activities – the so-called Renewable Energy Information Center was built in support of this objective – and on the other hand the research and development, innovation and innovation intermediation services. The Regional Food Safety and Technological Micronetwork needs to be highlighted here, which was set up in the framework of the Baross Program. The Network was evolved by the partnership of the Homokkert Public Company and Mórakert Cooperative

in Mórahalom, the DABIC Public Company in Szentes and the College of Kecskemét (Figure 3). Its goal is to establish an accredited institute complying with the international standards and placed near big producer-realizer cooperatives (e.g. Mórakert Cooperative).




**Figure 3.** Centers of the Regional Food Safety and Technological Micronetwork

**Aims of regional food safety and technological micronetwork**

a) establishing a regional food safety and technological subcenter with the utilization of results and experiences of the regional center and network maintained by DABIC Public Utility Company
b) founding an agrarian research workshop with the collaboration of acknowledged researcher-teachers with scientific degree and local experts, and developing an academic practicing section in connection with garden cultures and the safety of horticultural products
c) establishing an experimental soil and water analyzing laboratory and the publication of results
d) achieving experimental developments in relation with product innovation and changing production structure in vegetable, fruit and ornamental plant growing
e) starting continuous horticultural research and development activity based on regional demands
f) evolving a research and development and innovation micronetwork – with thousands of members - considering the specifics of producer-realizer cooperatives (TÉSZ) and the conditions of local product structure
g) establishing a consultant network and educational activity
h) experimental developing of analytical methods, e.g. for fast determination of chemical residues
i) founding an agrarian research workshop that conduces to the production of high added-value or new products (bioproducts, functional foods) with developing growing methods and technologies

## 4. REASONABILITY OF MICRONETWORK

### Directives of the EU – Food safety

Establishing and maintaining the Regional Food Safety and Technological Micronetwork is reasoned by directives and regulations of the EU. In hygienic overseeing of food producing, the European Union put emphasis on supervision of producing environment instead of the former final product checking in the last years. Therefore application of new analytical methods is required. SoilChem Laboratory – part of Regional Food Safety and Technological Micronetwork – wishes to keep pace with this continuous vocational improvement. Developing analytical procedures to support the development of new technologies – that result healthy and safe food – is one of SoilChem Laborarory's primary goals. Nowadays food safety is number one priority of agrarian economy: organizations in agriculture and food industry must correspond to the higher and higher requirements of food safety and environmental protection, and must meet the consumers' increasing demands.

Considering food safety regulation of the European Union, configuring quality insurance systems and helping producing activity at agrarian small and medium enterprises became indispensably necessary by now. In the interest of competitiveness of these enterprises preventive self-checking food safety systems must function effectively „from field to table", ensuring the transparency of food chain. Successful food politic demands the absolute traceability of crops, food and their components. This enables the enterprises to

withdraw hazardous forage or food from the market in case of consumers' health is endangered. Healthy and safe food can only be ensured by continuous monitoring of critical points of the producing process and by running quality insurance systems. It is reasonable to establish and upkeep accredited food safety and technological centers and subcenters, placed near farmers in the interest of quantitative and qualitative determinations of health-damaging chemical and microbiological compounds.

**Functions of centers:**

Instrumental tests are indispensable to obtain knowledge of environmental factors and their impacts. Thus we can collect data that help us to intervene in the process of cultivation. Precision nutrition replenishment can be attained only in possession of the knowledge on the soil's current nutrition level. Therefore soil analysis is necessary both before and during every single cultivation process. More detailed information is needed of soil and irrigation water in case of horticultural crops (nutrient rate and quantity, harmful elements).

a) monitoring chemical residues (pesticides, pharmaceutics etc.) of crops and food
b) detection of metal pollutants (lead, cadmium, mercury, arsenic, aluminium, copper, zinc, nickel) in food of plant and animal origin
c) determination of nitrate in vegetables susceptible for nitrate accumulation
d) complete analysis of soil and water
e) microbiological monitoring to increase the hygiene of food processing technologies
f) forage-safety monitoring
g) issue accredited certificates

**Economic advantages**

The building up of the Micronetwork is appropriate concerning its economic advantages as well. The current international and domestic consumer habits seem to prefer products with known origin; customers appreciate the value derived from the specific circumstances of the production. Thus the quality advantages in the production lead to market advantages. With the characterization of agricultural and food industrial products grown on excellent soil, using adequate technology and defining the relating quality features and with the conscious perpetuation of these benefits these products can obtain market advantages.

## 5. CONCLUSIONS

The whole sector and region profits from the database of materials endangering food safety, building up and operation of preventive indication systems, meeting the requirements of identification and traceability, and applying new, conventional sampling methods. The Micronetwork's indirect economic effects can be measured in the improvement of competitiveness of the analyzed products, the prevention of the damages caused by loss of consumer trust, and the recognition of the network's trademark.

The operation of SoilChem Laboratory as a service provider, accredited institute makes the non-profit investment self-supporting in the future.

**ACKNOWLEDGEMENTS**

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# ARSENIC PROBLEM AND POSSIBLE SOLUTION FOR DRINKING WATER

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**Abstract**

Aim of this research was the removal of toxic and carcinogenic arsenate ($AsO_4^{3-}$) ions from drinking water on different metals (Mg, Mn, Al, Fe) content layered double hydroxides (LDH). The efficiency of the MgAl LDHs in the arsenic removal is increased with increasing nitrate content in LDH. The basal spacing of LDH was decreasing with 0.085 nm after the ion-exchange. The calcinated form of each adsorbent resulted less arsenic removal, but less dissolution of metal from the oxide compared to the uncalcinated LDH. Increasing the manganese content in the MnFe LDH resulted enhanced arsenic removal efficiency.

**Keywords:**

arsenic removal, drinking water, layered double hydroxide, adsorption, calcination

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# SLAG – UTILISATION IN ROAD CONSTRUCTION – EXPERIENCE AND SOLUTIONS

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**Keywords:**
Steel slag, waste recycling, by-product, road construction

## 1. INTRODUCTION

As the world population grows, so do the amount and type of waste being generated. Many of the wastes produced today will remain in the environment for hundreds, perhaps thousands, of years. The creation of nondecaying waste materials, combined with a growing consumer population, has resulted in a waste disposal crisis. One solution to this crisis lies in recycling waste into useful products. One answer to all of these problems lies in the ability of society to develop beneficial uses for these waste products.
The road-highway construction industry can effectively use large quantities of diverse materials. The use of waste by-products in lieu of virgin materials for instance, would relieve some of the burden associated with disposal and may provide an inexpensive and advantageous construction product. Current research on the beneficial use of waste byproducts as road-highway construction materials has identified several promising uses for these materials. Some of these materials include: Blast furnace and steel slags.

## 2. STEEL SLAG IN EUROPE

In Europe are produced annually around 15 Mil tones of steel slag, resulting from different type of steel technology (Figure 1),

More than 75 % of steel slag was recycled in Europe (Figure 2.) in different kind of utilization in especial like raw materials.

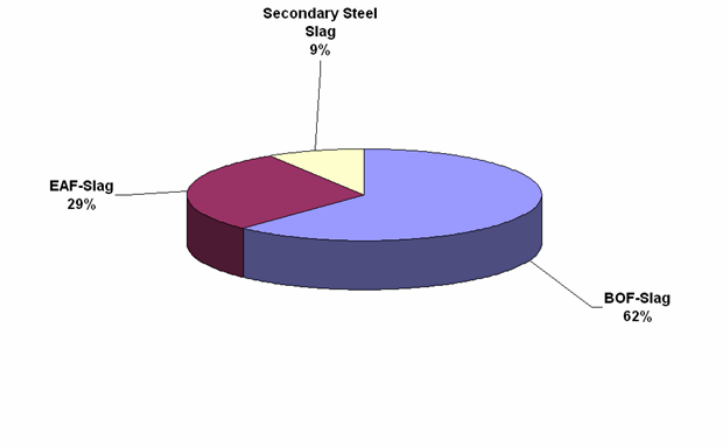



Figure 1. Type of steel slag

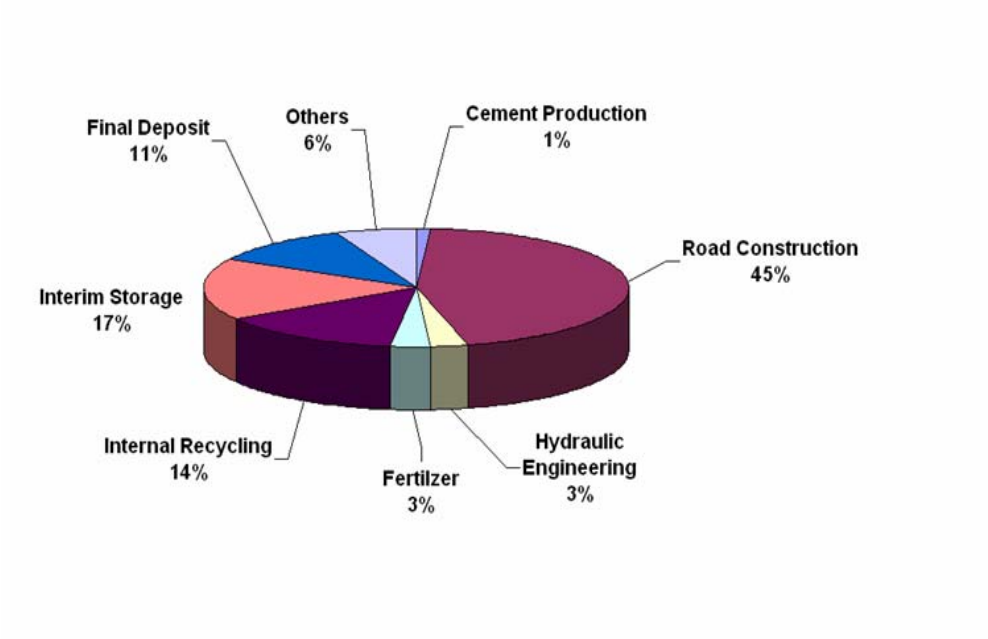



Figure 2. Slag utilization in Europe

2.1. European waste framework Directive

Present situation in the steel industry on material management give as an overview on the legal situation regarding the dealings with by-products such as slag and secondary raw materials on the basis of the European waste framework directive. Further on it describe the existing frameworks nebulous differentiation between waste and non waste (by products, when ceases waste to be waste) that lead to a flood of court procedures and to a discrimination of by-products and products made of recycled materials. Metallurgical slag is given as an example for a purposeful produced by-product in the steel industry which replaced primary raw materials and thus saving resources. Typical product criteria are described. Finally the proposal on the revision of the waste framework directive of the European Commission and those presently discussed in Parliament and Council is evaluated regarding the necessary clarification

- when a substance is excluded from the waste legislation as (by-)product, or
- when it creases to be secondary row material

A discrimination of by-products and products made of recycling material compared to products made of virgin material is not acceptable and contrary to the aim of sustainable management. On the contrary the usage of by-products and secondary row-materials must have priority.

European Waste Catalogue does only name unprocessed slag as a waste, European Waste Shipment Regulation (NO 259/93) - GREEN LIST, GC 070 exclude processed slag from the waste list:

"Slags arising from the manufacture of iron and steel (including low alloy steel) excluding those slags which have been specifically produced to meet both national and relevant international requirements and standards."

Green list substances shall be generally excluded from control procedures of the regulation since such waste should normally not present a risk to environment.

Principles of European Waste management say that steel slag has to be recycled (Figure 3.).




Figure 3. Waste management hierarchy

## 3. DESCRIPTION OF THE EXPERIMENTAL SETUP

3.1. Steel slag treatment process

| Steel slag type | Treatment | |
|---|---|---|
| Hot slag from EAF | Cooling by water spraying | Quick cooling is important for technical and environmental properties (Figure 4) |
| Raw slag with steel | Iron separation | Steel recovery pays for the slag treatment (Figure 5) |
| Raw slag | Crushing and screening | Crushing and screening gives different products (Figure 5) |
| Slag products | Road aggregates rip rap chippings | Products differ only in grain size distribution (Figure 6.) |

Table 1. Main slag processing

Main slag processing is mechanical treatment of cold slag, the principle of slag processing are in Table 1.



Figure 4. Cooling area with water spraying



Figure 5. Instalation of slag treatment SPS Hunedoara



50-150 mm 2-5 mm

Figure 6. Slag products

3.2. Steel slag in Road construction

CLOOS Luxemburg had more than 100 years experience in utilization of slag in road construction, an examples of road layers (Figure 6.)

Slag crushing aggregates can be used in all layers of the road, in Romania; SPS homologated the shape, foundation, basic and binder layers and are in course of homologation the utilization of slag in asphalt layer. Here will be used cold slag treatment procedure for obtain good results.

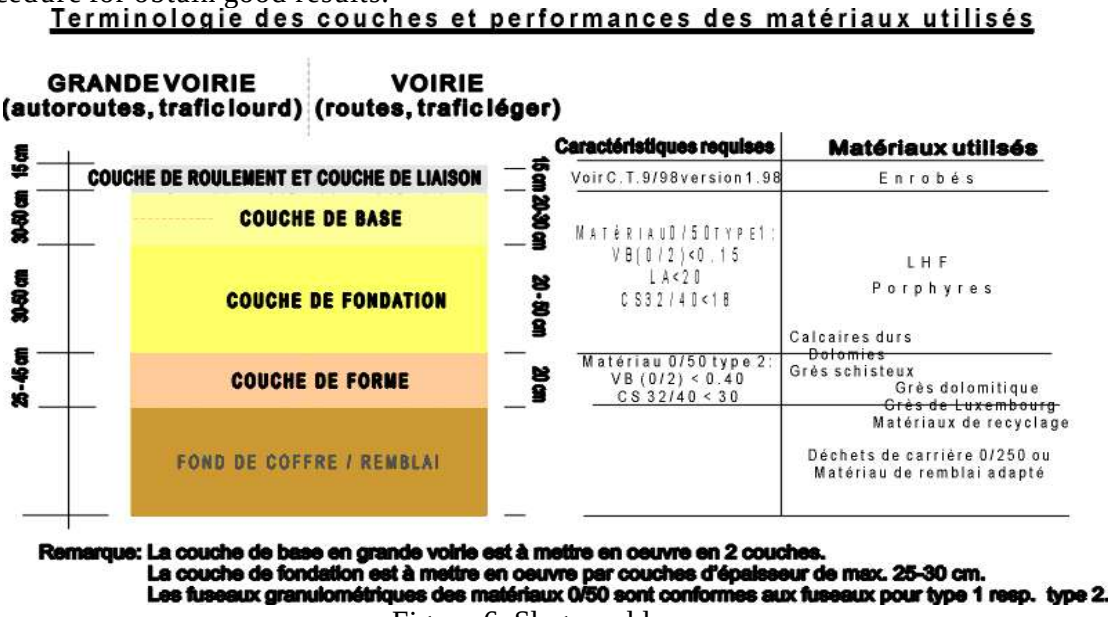



Figure 6. Slag road layers

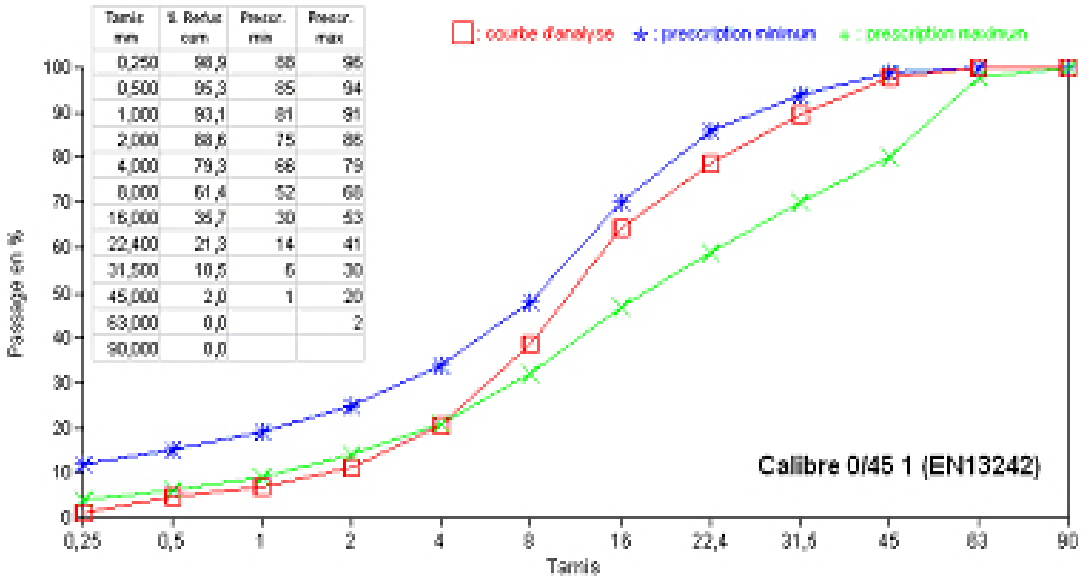



Figure 7. Slag aggregate 0/45

In Figure 7. we can see red line, property of slag product 0-45; and minimum and maximum requirement of EN 13242,

Example of slag utilization in road construction in Hinedoara is the 4 bands road between Deva and Hunedoara (Figure 8), where the basic, foundation and binder was made from slag aggregates from Buituri Slag Dump, processing by SPS. Unfortunately the Romanian road designers and constructors don't understand yet to use this waste; by-products existing in Hunedoara in Slag Dump in quantity of 70 Mill. Tones.

SPS continue the researches regarding slag utilization in road construction with University "Politehnica" Timisoara – Road Construction Department, now in researches of Slag roads comportment in different charges starting with County roads, Villages roads, technological roads, and sure Highway.



Figure 8. Slag road construction; Hunedoara - Deva

## 4. ANALYSIS OF RESULTS AND CONCLUSIONS

### 4.1. Product Certification and Quality Control

Steel slag has to undergo a quality control process like any other process (Table 2.), steel slag is an artificial stone, with the request property for road construction, and other utilizations: concrete production, fertilization, hydraulic construction, building foundation, etc.

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| No. | INDICATORS | VALUE |
|---|---|---|
| 1 | Bulk density according to DIN 52110 | Average value: 2,06 g/cm3 for grain size mixture 0/32 and 0/45 |
| 2 | Proctor density according to DIN 18127 | Average value: 2,47 g/cm3 for grain size mixture 0/32 and 0/45 |
| 3 | Fines | In grain size range 0,0 – 0,063 mm from 0,2 to 0,4 weight.-%. |
| 4 | Destruction by beating SZ 8/12 | Desired value 18,0 weight-% for chippings |
| 5 | Destruction by beating SD 10 | Desired value 26,0 weight-% |
| 6 | Polished stone value (PSV) | PSV 60, chippings for asphalt |
| 7 | Frost resistance | Limit value 3,0 weight.-% |
| 8 | Volume stability | Limit value 5,0 vol.-% |
| 9 | Inner angle of incline | Average value 40 ° |

Table 2. List of technical test

Slag Processing Service SA Hunedoara (CLOOS Luxemburg is main shareholders with 80% of shares), start the work in ArcelorMittal Hunedoara Slag Dump, with chemical and physical tests of the slag, make in Luxemburg (80 tones of samples taken from different places from slag dump was send with tracks). After this was start the treatments of old slag: crushing and screening, iron separation, aggregates rip rap chippings, with 500.000 tones/year capacity Installation.


QUALITY CERT

CE - CERTIFICAT DE CONFORMITATE

Sistem de atestare a conformității 2+
NB 1870-DPC-98/598/EC-0484-07

AGREGATE CONCASATE DIN ZGURĂ DE FURNAL

S.C. SLAG PROCESING SERVICE S.A. București
Str. General Berthelot, Nr. 84, Ap. 3, Sector 1
Tel.:021/410.39.42, Fax: 021/323.53.73

Halda de zgura Buituri
Jud. Hunedoara

EN 12620/2002
EN 13242:2002/AC:2004

PRESEDINTE
QUALITY CERT
Ing. BURTEA IOAN

PRESEDINTE
CONSILIU DE CERTIFICARE
Ing. STAN GHEORGHE

Figure 9. Conformity Certificate

Conformity Certificate for slag aggregates utilization in Romania (Figure 5.), was obtain by SPS in 2006, was certificate that the products "Crashing Aggregates from Steel Slag" 0-4; 4-8; 8-16; 16-31,5; 31,5-63; si 0-63, produces by SPS in Slag Dump Buituri Hunedoara, are in accordance with: EN 12620/2002, EN 13242: 2002/AC:2004, Utilization domain: construction of: roads, civil and industrial buildings, hydraulic and earth construction.

4.2. Comparatives cost of slag roads and virgin materials roads

We analyze comparatives structure of road layers; classic and two alternatives for basic and foundation layers, (Figure10.) mentioned that wear layer in all three situations remain the same asphalt mixture and the existing shape also.

| Thickness | Layer – **CLASSIC** |
|---|---|
| 5 mm | **Wear - asphalt mixture** |
| 20 mm | **Basic - natural crash stone** |
| 30 mm | **Foundation -Ballast 0-63 mm** |
| X mm | **Shape - existing** |

| Thickness | Layer- **Alternative 1** | Layer- **Alternative 2** |
|---|---|---|
| 4 mm | **Wear - asphalt mixture** | **Wear - asphalt mixture** |
| 15 mm | **Basic - slag 0-63 mm** | **Slag - optimal mixture stabilizated with: 0.5 ciment and 8% water** |
| 20 mm | **Foundation -Slag 0-150** | |
| X mm | **Shape - existing** | **Shape - existing** |

Figure 10. Comparative layers classic-slag roads

The comparative costs in "LEI" of all three variants (Figure 11.):

1. Classic system road (virgin materials)
2. Alternative 1 road system with slag
3. Alternative 2 road system with slag and cement

Sow as that the partial slag roads analyze are with 24% chipper that classic roads. If the road will be executed integrally by slag products like in Luxemburg, Germany, France, etc. the cost reduction is around 40%.

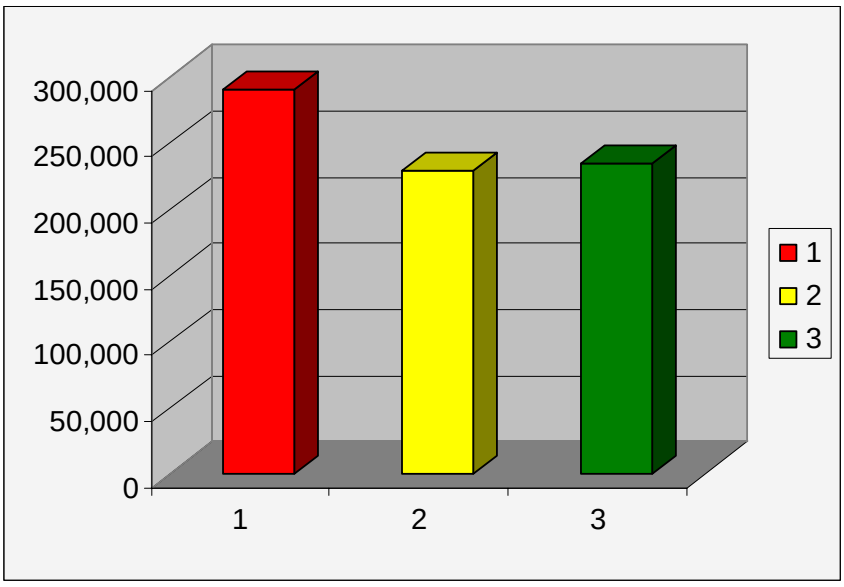



Figure 11. Comparatives cost of the roads

Conclusions: We can construct with the same amount 140% more roads.

This is not the single reason for using slag, the durability, stability of the roads is better and not the last we save virgin materials, recycling the slag and ensuring the slag dump disappear.

Use of steel slag is absolutely necessary in Europe to reduce costs and to comply with environmental laws

- Slag use in Europe has a long tradition.
- European law asks for recycling of steel slag.
- European legislation makes it sometimes difficult to bring slag products to the market.
- Process technology is known and proven.
- Slag products can be certified and have to undergo a quality control procedure.

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# PROBLEMS IN THE PROCESS OF WASTE WATER TREATMENT ON THE SUBOTICA WASTE WATER TREATMENT PLANT (WWTP)

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**Abstract**

The waste water treatment plant (WWTP) in Subotica has continuously been operating for 33 years. The Plant was designed for mechanical and biological treatment of municipal waste waters. The major issue in the functioning of the plant is its low hydraulic capacity and the inflow of waste waters other than municipal, and not pre-treated industrial and technological effluents respectively. Massive organic matter surges, as well as waters with toxic effect have negative impact on the micro world of the active sludge, modify the character and ability of sludge sedimentation, condition oxygen deficit in aeration tanks, which aggravate the treatment process management and result in the effluent's poor quality. The aim of this paper is to present the effects of the Subotica WWTP operation, and also the quality of technological effluents by the major industries in the city, and their impact on the treatment process in 2008.

**Key words:**

waste water treatment process, effects of the WWTP's operation, industrial effluents.

## 1. INTRODUCTION

The city's WWTP is located on the southern part of the city of Subotica, while the recipient for treated wastewaters is Lake Palic. The sewage network in Subotica is built up according to a general sewage system, meaning that the same system takes off stormwater and wastewater alike. The public sewage network comprises drains of different shape, size and material. The city is divided into eight major collection point, and the whole sewage system is gravitation-based. The lowest point in the city is its WWTP. The WWTP was commissioned late 1975 and since then it has been operating continually. The reason behind building a WWTP was a special ecological disaster in Lake Palic in 1971 with a massive pestilence of fishes. Parallel with the building of the WWTP, the lake recovery was implemented as well (desiccation and desludge of the lake-bottom), whereupon the lake was divided by dikes into four sectors. The aim of dividing the lake in such a manner was to provide a more efficient and intensive process of autopurification of the water and thus to provide the highest possible quality of water in the 4th sector, i.e. the tourist part of Lake Palic. Lake Palic is an aeolic, eutrophic lake with maximum depth of about 2.5 meters. Sufficient water quantity in the lake is provided by the inflow of treated waste water from the Plant. Excess water is evacuated through lake Omladinsko jezero via a canal to Ludas Lake, from where it is taken by the Keres streamlet to the Tisa River (Fig 1).

An imperative in the Plant's operation is the best possible quality of effluent, first and foremost, due to the recipient's high sensitivity and eutrophic character. The WWTP was designed to treat municipal wastewaters with a designed hydraulic load of 30000 $m^3$/day and 45000 $m^3$/day respectively in times of heavy stormwater, while the designed BOD of influents is 250 mg/l $O_2$. Waste water undergoes primary and secondary treatment, which comprise mechanical (coarse and fine screen, aerated sand trap and primary sedimentation tank) and biological (aeration tank) treatment of waste waters (Figure 2) [4]. Biological treatment is implemented by activated sludge method. Water is taken from the aeration tanks to secondary sedimentation tanks, where sludge is separated from the treated water.

The problem in the operation of the Plant and achieving water quality, which will not impair and additionally accelerate the eutrophication process of the recipient, is the lack of tertial treatment within waste water treatment (removal of nitrogen and phosphorous compounds), massive hydraulic load of the Plant and the inflow of not treated industrial effluents.

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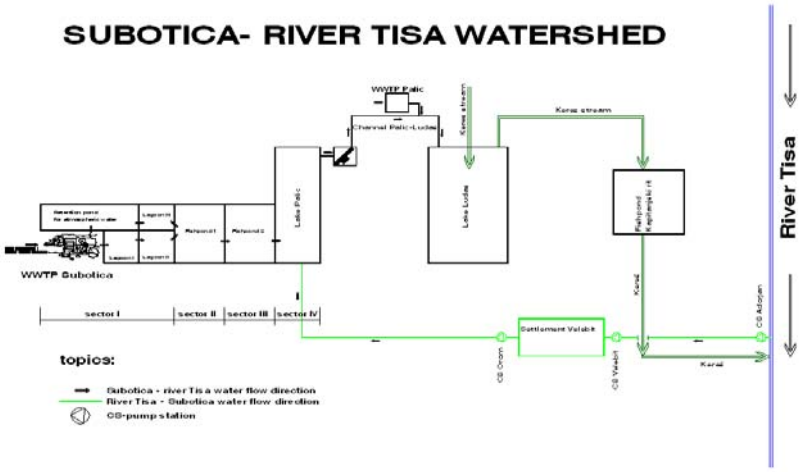



Figure 1. Subotica-River Tisa Watershed

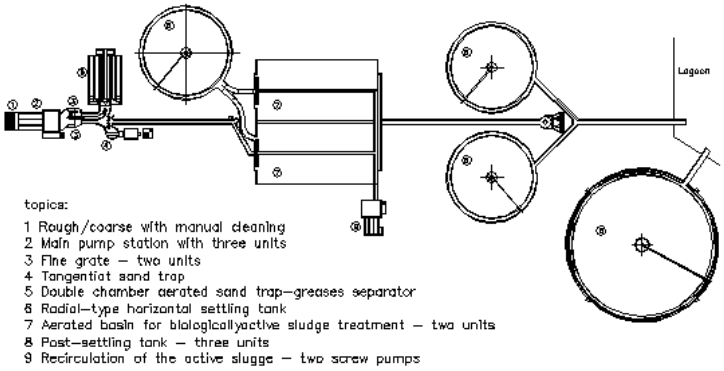



Figure 2. The Wastewater Treatment Plant of the City of Subotica

The aim of this paper is to present the effects of the Subotica WWTP operation, and also the quality of technological effluents by the major industries in the city, and their impact on the treatment process in 2008.

## 2. MATERIAL AND METHOD OF WORK

Analyses of the Plant's operation are permanently made by the internal laboratory for the quality control of waste and surface waters in the Subotica Waterworks PUC. The laboratory is equipped for physical, chemical and hydro biological analyses. Physical and chemical analyses cover a set of relevant parameters, first pH, organic load, oxygen concentration, total nitrogen and phosphor content in the waste and treated water, as well as dry matter content and sedimentation volume of the bioactivated sludge, and are defined by the recommended standard methodology. Instantaneous and 24-hour composite samples are processed per each treatment phase. Samples of industrial effluents are taken once or twice a month. The selection of parameter volumes for the analyses of industrial effluents is made depending on the type of industry, and mostly, it includes basic parameters.

Biological analyses include microscopic quality control of the bioactivated sludge according to the recommended methodology [3]. Analyses are made on a daily basis, while samples are taken from the aeration tanks and the recirculating sludge. Fresh, native and coloured preparations are analysed. Photos of the samples are taken daily, and data are kept in a database. Toxicological tests of industrial effluents are also made. Toxicity level is determined by standard short (24h) tests on aquarium fish *Lebistes reticuatus*. LC-50 is defined (concentration of chemicals which kills 50% of the organisms in a specific time). Results are expressed in %Tlm which is conversely proportional to toxicity level, and in Dil. Tlm indicates indicates the number of times the water is to be diluted in order to achieve LC-50.

## 3. RESULTS AND DISCUSSION

The operation of the WWTP

The average quantity of intake water on the Plant was 39155 m$^3$/day, while an average quantity of 32375 m$^3$/day of waste waters was treated in 2008 [2].

The quality of intake water was varied over the year. Moderate content of organic matters, with time-to-time surges of organically highly loaded waters was characteristic for the raw waste water. The tendencies of average and maximum organic load values for the raw and treated waste water are shown in Table 1.

Table 1: Organic load values of influent and effluent waste waters and Sludge Volume Index

| Parameters | BOD (mg/l) | BOD (mg/l) | BOD (mg/l) | BOD (ml/g) | SVI (ml/g) |
|---|---|---|---|---|---|
| | Influent average | Influent max. | Effluent average | Effluent max. | |
| January | 228 | 390 | 16 | | 228 |
| Febr. | 207 | 332 | 14 | | 240 |
| March | 208 | 332 | 17 | | 279 |
| April | 197 | 233 | 7 | | 261 |
| May | 219 | 318 | 20 | | 326 |
| June | 161 | 282 | 14 | | 354 |
| July | 205 | 302 | 22 | | 555 |
| Aug. | 211 | 341 | 11 | | 378 |
| Sept. | 232 | 382 | 16 | | 368 |
| Oct. | 260 | 352 | 34 | | 519 |
| Nov. | 248 | 347 | 31 | | 452 |
| Dec. | 203 | 424 | 15 | | 325 |

From the aspect of impact on the aquatic eco-system of Lake Palic, it is essential to emphasise that there is a relatively high nitrogen and phosphor content in the city's waste waters. In the total nitrogen content its ammonium form is dominant. The average concentration of total nitrogen in inlet water was 44,2 mg/l. Thereof ammonium nitrogen made up 29,2 mg/l or 66%. The total nitrogen concentration in treated water was 30,7 mg/l , and 23,5 mg/l, or 76% of this was ammonium nitrogen. The effect of total nitrogen decrease was 30% in the Plant. The total nitrogen concentration in treated water was 6,61 mg/l , and 3,41 mg/l of this was ammonium nitrogen. The effect of total phosphor decrease was 50% in the Plant [2].

Microscopic sludge analyses serve system status assessment based on quality of floc and microorganism composition. High hydraulic load and frequent surges of high concentrations of organic matters condition system overload and oxygen drop in aeration tanks, which are reflected in the qualitative and quantitative composition of microbe community in the activadet sludge [1]. Filamentation index [3] (total number of filamentous bacteria) was increased over the whole year (FI=6). *Thiothrix* spp., was dominant, and it is a sulphuric bacterium, which, with the contexture of its long and thick filaments changes sludge characteristics and aggravates sludge sedimentation and it is reflected in increased SVI over the whole year (Figure 3b). Frequent occurrence and higher number of type 1863 was recorded as well, since it grows on hydrophobic substrates (grease) and, due to its morphology, it floats up and creates foam. The size, shape, structure and stability of flocs were satisfactory most of the year, yet sludge age was constantly old with frequent occurrences of sludge decay signs (Figure 3a). Numerous low diversity colonies (as a consequence of uniform substrate) occurred during the year as well. The number of free cells in supernatant was constantly increased (indicating system overload) From the protozoa, flagellates (indicators of overload) also occurred frequently, while amoebae were recorded infrequently and in smaller number. Free-living ciliates occurred sporadically, mostly *Colpidium* spp. and *Euplotes* spp. From the crawling ciliates, *Aspidisca costata* was dominant, which was permanently present and sometimes achieved high numbers.

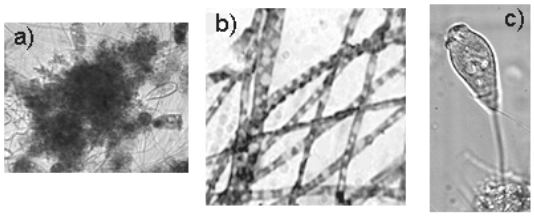



Figure 3. Activated sludge microorganisams: a) sludge floc, b) Thiothrix spp., c) Vorticella microstoma

Most frequently, the total number of fixed ciliates was higher than 20000/ml, sometimes reaching a value over 120000/ml (which also indicates sludge ageing). During May, June and July, the number of this indicator groups of organisms dropped (to below 10000/ml), due to the toxic influence of the influent water quality. Dominant were *Vorticella microstoma* (Figure 3c), *Opercularia* spp. and *Vorticella convalaria*.

Industrial Effluent Analysis

A total of 104 wastewater samples of industrial origin were analysed in the wastewater quality control laboratory. Quality incompliance of effluents to the prescribed values is determined on the base of permitted maximum concentration (PMC) set in Article 18 of the Decision on Public Sewage (the Official Journal of the Subotica Municipality no. 39/2001). The effluent quality of controlled industrial polluters deviated from the prescribed PMC values in the following parameters: low and high pH values, high organic load, grease and oil, sedimentary matters, inorganic soluble salts, total nitrogen and phosphor and AA detergents [2]. Effluents coming from process industry (milk processing, flour and fruit processing, beverage production) had the most significant negative impact on the Plant's operation. (Table 2).

About 70% of the analysed samples showed satisfactory quality in view of toxicity (atoxic or oligotoxic water levels I and II) and did not disturb the Plant's operation [2]. In average, the highest toxicity level over the year was in food processing industries, i.e. dairy and flour processing (farina production) and in the textile industry, while maximum toxicity level was also recorded in fruit processing industry and beverage production, where it amounted to %Tlm=1,41, which corresponds to mesotoxic water level V. If %Tlm value is lower (>100), the analysed sample is of higher toxicity level (Table 2).

Table 2. Demonstrated maximum values of critical physical and chemical parameters and toxicity level of dominant industries in Subotica in 2008

| Sampling spot-industrija / Parameters | Flour Processing Industry | Milk processing Industry | Fruit Processing and Beverage Production | PMC |
|---|---|---|---|---|
| max. pH | 6,31 | 7,85 | 10,12 | 8,5 |
| min. pH | 3,58 | 4,48 | 1,52 | 6,5 |
| $BPK_5$ (mg/l) | 13900 | 65668 | 2082 | - |
| Total N (mg/l) | 334 | 873 | 28,8 | 50 |
| Total P (mg/l) | 142 | 71 | 1,90 | 12 |
| Grease (mg/l) | - | 7177 | - | 30 |
| Total Sedimentary Matters (mg/l) | 12520 | 1380 | 110 | 100 |
| %Tlm | 3,17 | 3,17 | 1,41 | 100 |
| Toxicity Level | Mesotoxic Level V | Mesotoxic Level V | Mesotoxic Level V | - |

## 4. CONCLUSION

WWTP in Subotica received higher quantities of water than the designed ones during 2008.

Unlike municipal wastewaters, which are mostly uniform in their physical and chemical composition, the character of industrial effluents significantly varies in quality and quantity. The WTTP cannot treat adequately the diverse composition of industrial effluents, hence these aggravate the treatment process by making it slower and more expensive.

The lack of tertial water treatment is the cause of high total nitrogen and phosphor concentration in the effluent over the whole year.

Due to the above indicated, effluent quality during 2008 was not always satisfactory, yet treatment effects, express through the decrease in total organic load of the water, amounted to 92%.

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# THE METHOD OF RISK ASSESSMENT AT WORKPLACE AND WORKING ENVIRONMENT IN AN EXAMPLE OF A METAL MECHANICAL PROCESSING SECTION OF A FACTORY

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**ABSTRACT**

The aim of this work is to show, with due respect to the existing methodologies, the implementation of an original method of risk assessment at workplace and working environment. The example represented here is based on implementation of this method in a section of a factory where mechanical processing of metal is performed. The risk assessment procedure is conducted through implementation of our own method. It is ensured that the project is conducted thoroughly, from the defining of technological process – system, to implementation of measures for control of ("emergency") risk.

The method is of quantitative character with possibility to determine and compare all risks, at every workplace and including all participants who take part in working environment on every basis.

## 1. INTRODUCTION

Risk assessment is based on systematic record keeping and tracking of all factors, vulnerability and hazards in a working process. Therefore, it is crucial to recognize organization of work, working process, means of work, material and raw material used in working process, means and equipment for personal protection and other relevant elements. A precondition to this has to be the recognition of existent facts. This is a basic and starting point and it is also required by the Code of Practice (1), made in compliance with Directives of the European Union. Apparently, the true answer and primary task of any method is: to determine risk arising at any workplace and regarding any worker, to determine all risks and to allocate the risks to individuals, working space and working environment.

Risk assessment methodology has to be clear and unambiguous in order to enable a complete analysis of risk assessment to be conducted. A methodological way of risk analysis, according to the method of High School from Novi Sad is the following:

Defining of system – defining assessment levels (company, facilities, floors, premises, work-rooms, workplace, work activity etc.) – identifying hazards and vulnerability – evaluation of risk – measures for elimination, prevention and reduction of risk – re-evaluation of risk – conclusion on risk – measures for maintenance of risk control.

## 2. THE STUDY

### 2.1 Input data. Technological setting

In our example, an engine hall and working process of metal processing are used as a model. In this section of a factory, steel material is processed through grinding, perforating, milling, welding etc. It is a standard section of a factory with typical and recognizable hazards.

There are N workplaces in this factory section where it is likely that hazards and vulnerability for workers at those workplaces may occur. The workers in the engine hall are exposed to shared hazards and vulnerability arising from workplaces in the environment all the time during their working hours. The workers whose workplace is not the engine hall, but who are frequently present there during their working hours (such as section managers, maintenance workers, controllers and alike) are also exposed to the same hazards. Also, all

those who every now and then enter the hall are exposed to the same hazards (directors, trainees etc.). Naturally, risks relating to each of these categories of employees are different because of their different frequency of exposure to hazards and vulnerability.

### 2.2 About the method

The method of the School is formed to meet the following requirements:

- to include all workplaces by making a selection of them out of technological process together with important hazards and vulnerability and to determine risks for each of them
- to determine risks at all levels (the engine hall);

By meeting the given requirements it is ensured that risks for each of the workers are determined, i.e. for all those who are present in the company (the engine hall)

- the method for all risk parameters is based on numerical, quantitative values, independent of a level at which the risk is determined, thus enabling presentation of all risks together and their uniform observation
- the measures for elimination, reduction and prevention of risks are clearly defined, as well as the measures for maintenance of risk control level. The represented system of risk management makes way to implementation of quality systems in health and safety at workplace.

Characteristics of the method:

a) Risk calculation of a workplace based on a table determination of all risk parameters; likelihood of accidents, damage size, frequency and number of people exposed to hazards and vulnerability

$$R_i = V*F*S_i*N$$

$R_i$, $S_i$ – risks and damage size for different categories of employees, depending on the frequency of their exposure to hazards and vulnerability.

b) risk assessment of working environment based on determining likelihood of accident occurrence which is based on values of safety conditions in the working environment and accordingly developed mathematical equation

$$R_i = f(x)*F*S_i*N$$

where

$$f(x) = 16.46\ x^{2.7}$$

$$x = n/N,$$

n – is the number of negative values of safety conditions

N – is the total number of evaluated values of safety conditions

The evaluated values of safety conditions have to be in compliance with legislation and technical regulations.

### 2.3 Output data

There are several key points in the risk assessment procedure, of which every represents an interest evaluated from various points of view. One of them is a table of remaining risk for all workplaces, working environment and for each of the workers. The significance of this table is to the advantage of an employer and, naturally, to the advantage of an employee. According to the results of this work, the table has to determine the following risks for each of the workplaces:

- the risk of a workplace
- the risk of the engine hall
- the "somebody else's" risk

The "somebody else's risk" relates to the activities of some other workplace, which a worker sometimes has to perform. The example is a job of a driver, a work which we sometimes have to do. The risk is considerably lower compared to a driver's risk, since the frequency of exposure to hazards and vulnerability is also lower, but positively this risk exists.

Only a risk assessment conducted in such a way can provide answers regarding size and types of risks which a worker is exposed to during the working hours.

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Table 1: Risk table

| | WORKPLACE | | QUANTITATIVE ASSESSSMENT OF REMAINING RISK | | | | | | | QUALITATIVE RISK ASSESSMENT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Primary risk | | | | | Secondary risk | | |
| | Occupation (job) | Code number | Company, facility | facility part, plant | Plant, working room | workplace | source | value | Source (activity, workplace, ...) | |
| 1. | Counselor | 112 | 0 | 0,3 | 0,05 | | Company Headquarters | | | |
| 2. | Technical secretary | | 0 | 0,5 | 0,32 | | Company Headquarters | | | |
| 3. | Operational engineering | | | | | | Company Headquarters | | | |
| 4. | Qualified worker | | | | | | Company Headquarters | | | |
| 5. | Coordinator | | | | | | Centre for ambrosia suppression | | | |
| 6. | Section manager | | 2,7 | 0,52 | 0,36 | | Plantation | | | |
| 7. | Assistant | | 2,7 | 0,52 | 0,36 | | Plantation | | | |
| 8. | Non-qualified worker | | | | | | Plantation | | | |
| 9. | Driver | | | | | 37,5 | Form 4/23 Company Headquarters | | | |

## 3. ANALISES, DISCUSION, INTERPRETATIONS

### 3.1 The example for mechanical processing on a lathe:

**IDENTIFICATION OF HAZARDS AND VULNERABILITY**

| 1 No. | 2 Code of hazards and vulneradility | 3 The descriptive analysis of hazards and vulnerability including data regarding easier and more precise determination of likelihood, frequency and damage size |
|---|---|---|
| 1 | 05 | When grinding fragile material with low speed of cutting or with particular geometry of cutting tools, there occur torn parings whose temperature might go even up to 800$^0$C, and which are likely to hit a worker in the eye thus causing a severe injury. As a worker does this type of work during a whole working day, it is possible that a worker sustains eye injuries often and it is more than likely that injuries occur every day |

**QUANTITATIVE RISK ASSESSMENT**

| 4 Likelihood lavel | 5 Frequency | 6 Damage size | 7 No. of peple – coeff. | 8 Risk | 9 Risk lavel |
|---|---|---|---|---|---|
| 5 | 4 | 2 | 1 | 40 | Low but present |

**THE MEASURES FOR REDUCTION, PREVENTION AND ELIMINATION OF RISK**

| 10 Safetyain | 11 Organizacioal | 12 Constructive | 13 Safety | 14 Personal safety means | 15 Other |
|---|---|---|---|---|---|
| Protection of eyes | | | | Protective spectacles | |

**ADDITIONAL RISK ASSESSMENT**

| 16 Likelihood lavel | 17 Frequency | 18 Damage size | 19 No. of peple – coeff. | 20 Risk | 21 Risk lavel |
|---|---|---|---|---|---|
| 0,033 | 4 | 2 | 1 | 0,264 | Negligible |

**RISK MANAGEMENT**

| 22 Who implements | 23 Time frame for implementation measures | 24 Procedure within quality systems | 25 Conslusion | 26 Measures for control of the remaining risk |
|---|---|---|---|---|
| Safety officer | Immediately | IQ2.f... | Rislk is low and tolerated | Drawing up and strict implementation of code of personal means of protection |

### 3.2 The example of working environment risk assessment

According to the Code of general measures for buildings whose purpose is to be used for working or subsidiary premises and Code of keeping records, values that characterize the safety conditions of the engine hall can be determined. Those values are:

- Clear height of the work-room
- Clear area of the work-room per worker
- Clear volume of the work-room per worker
- floor of the work-room
- inner surface of ceiling and walls
- opening of windows of the work-room
- door of the work-room
- lighting of the work-room
- corridors, availability of staircase
- passages and access
- protective fence
- handy warehouse
- rotating and mobile parts
- free movement of parts
- indoor transport
- exposure to being blocked (shut), covered by something and alike
- hazardous surfaces
- work at height and depth
- cramped, limited
- hazardous space
- wet and slippery surfaces
- physical instability of the work-room
- inappropriate and not adapted working methods
- contact of elements at voltage
- indirect contact
- thermal effect of electrical source
- thunderbolt
- electrostatic charge
- work in low/ high pressure atmosphere
- radiation
- work in the open air
- use of hazardous material
- work with animals
- water surfaces

In comparison with the procedure for the workplace, we determined hazards and vulnerability in this way (columns 1, 2 and 3); other columns are identical to risk assessment of a workplace

## 4. CONCLUSION

In compliance with the set aims of the work, the conclusions have completely met and justified the expectations. Basically, the conclusions are:

- the established methodology and formed method of risk assessment make risk analysis simple
- the method implemented in engine hall for metal processing gives completely precise answers to all arising risks
- two risk levels are distinctive: the level of engine hall and the level of workplace, evaluation within these two levels gives all information;
- quantitative nature of the method enables comparison of all obtained values;
- the method presented in this work can be completely applied to any engine hall that is basically used for mechanical processing;
- the same method, but with a change to values evaluating safety conditions, can be used for any working environment, which can differ.

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# METHODOLOGICAL FRAMEWORK FOR THE STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT (SEIA) OF SPATIAL PLANS IN AUTONOMOUS PROVINCE OF VOJVODINA

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**Abstract:**
This paper provides a methodological framework for conducting Strategic Environmental Assessment (SEA) of spatial plans in Autonomous Province of Vojvodina. The main objective of Strategic Environmental Impact Assessment is to ensure environmental protection and the establishment of sustainable development by integrating the basic principles of environmental protection in the process of preparation, drafting and adoption of a Plan.

**Keywords:**
Strategic Impact Assesstment, environmental protection

## 1. INTRODUCTION

Planned solutions defined in the planning documentation may have some impact on certain segments of the environment, positive and negative. In planning and organizing the space, it is necessary to pay special attention to the aspect of environmental protection as an integral part of the process taking place or will take place on the areas embraced in the plan.

Such an approach is the unique optimal way for the realization of active environmental protection, monitoring and management of certain areas in accordance with the basic principles of sustainable development [6].

The realization of this approach in accordance with the tendency of harmonization legislation in the territory of the Republic of Serbia and the Autonomous Province of Vojvodina with the legislation of the European Union, Strategic Environmental Impact Assessment (SEIA) of planning documents have the important role, as a separate instrument for implementation of environmental protection in all segments of development. This instrument is an integral part of sustainable development strategy, by which a comprehensive estimate the possible impacts of the prescribed planning solutions.

In the Republic of Serbia, a Strategic Enviromental Impact Assessment is an important document, which is an integral part of planning documents, that gain legal dimension by adopting a set of the Law on Protection of the Environment in December 2004. Strategic Enviromenal Impact Assessment is not only important measure, but an instrument that makes the plans, programmes and policies related to the area of spatial and urban planning, agriculture, forestry, water, etc.

However, after five years of application of the Law on Strategic Environmental Impact Assessment ("Official Gazette of the Republic of Serbia", no. 135/04), experts who work on these elaborats meet with a large number of problems, especially due to the lack of established methodology and insufficient definition of current state environmental indicators and indicators of effects on the territory of the Republic of Serbia and the Province of

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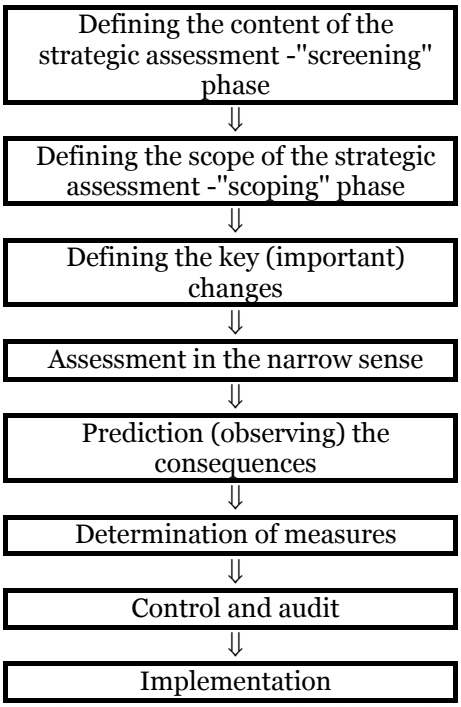



Figure 1. General methodological process of SEIA

Vojvodina, so that today there is a great diversity and unevenness. Major problem is the fact that current state environmental monitoring in our country was established only in the last few years, and only in few locations, insufficient in number, so it's often difficult to adequately define and comment the indicators of current state of the environment because of the lack of data.

## 2. METHODOLOGY OF STRATEGIC ENVIRONMENTAL IMPACT ASSESSTMENT

Experiences of the countries, members of the European Union, point to the importance of the planning process and the process of Strategic Impact Assessment of planning documentation. Strategic Impact Assessment is partially integrated into the plans and programmes if they are made in separate stages. The general methodological procedure that is used for preparing the strategic assessment consists of several general phases, as it's showed in Figure 1.

To be completely integrated, process of SEIA should be intertwined with the procedure of plans or programmes.

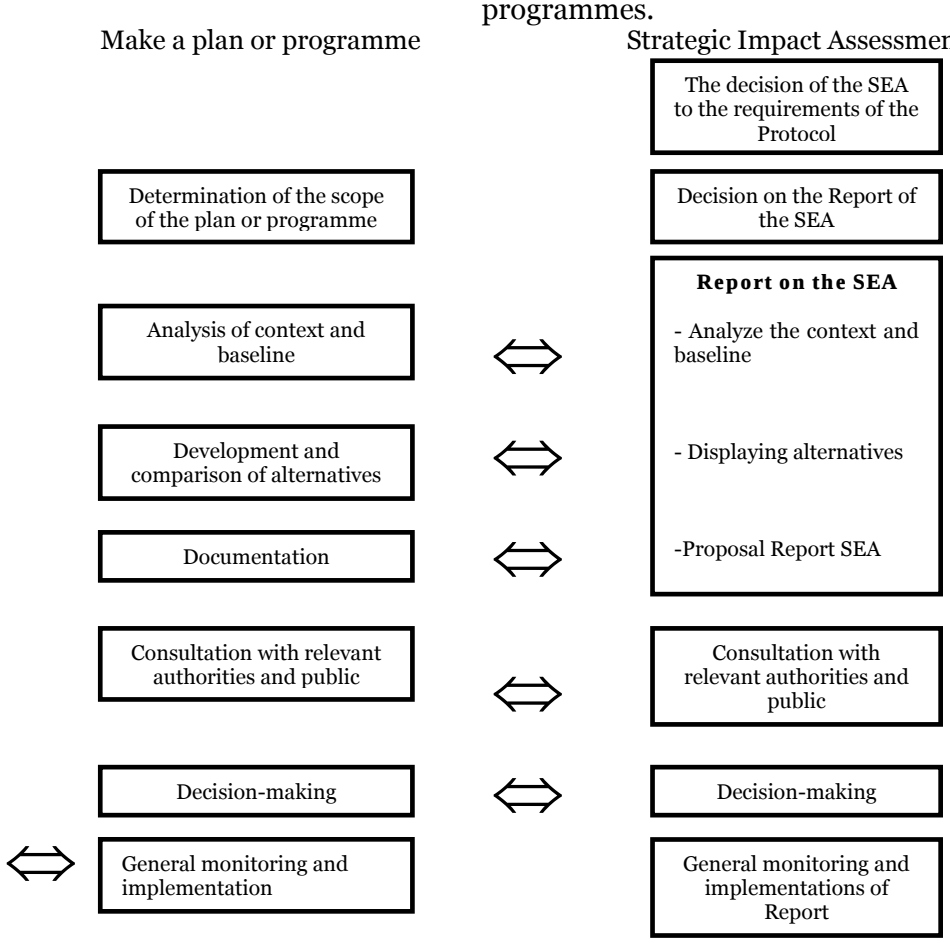



Figure 2. Links between the creating stages of plans and strategic impact assessment [5]

In terms of methodology of the Strategic Assessment Report of plans, it is necessary to note that there are several different methodological approaches regarding the way of constituting.

The main task of the SEIA in Serbia, as a developing country, is to facilitate timely and systematic consideration of the possible environmental impact at the level of strategic decision-making in plans and programmes, considering the principles of sustainable development. Integrating the process of SIA in the process of preparation and decision making, in spatial plans, allows the efficient evaluation of the instrumentalization of the strategic environmental impact in spatial and urban planning.

Content of Strategic Assessment Report, and also the basic methodological approach are defined by the Law on Strategic Environmental Impact Assessment ("Official Gazette RS", no. 135/04) and the Law on the Enviromental Protection ("Official Gazette RS", no. 135/04). Strategic evaluation became important by adoption of EU Directive 2001/42/EC on the environmental assessment effects of plans and programmes, that began to implement in 2004. in Serbia, by adoption of the Law on Strategic Environmental Impact Assessment, and has started the implementation in 2005.

The Strategic Assessment Report is the document that describes, evaluates and assesses the potential significant impact on the environment, which could result by implementation of plans and programmes. It shall also define measures for reduction of adverse effects on the environment.

Report's content is in accordance with the provisions of Article 12 of Law on Strategic Environmental Impact Assessment, and shall include the following in particular:

1. The bases of the strategic assessment;
2. The general and specific objectives of the strategic assessment and selection of indicators;
3. The evaluation of likely impact with the description of measures planned for reduction of adverse effects on the environment;
4. The guidelines for elaboration of lower level strategic assessments and Assessments of environmental impact of projects;
5. The programme of monitoring of environmental status during the execution of plans and programmes (monitoring); and programmes that have already been realized are considered qualified for elaboration of the strategic assessment report;
6. The programme of monitoring of environmental status during the execution of plans and programmes (monitoring);
7. The outline of methodology applied and difficulties encountered during the strategic assessment elaboration;
8. The outline of decision making methods, description of reasons vital for selection of the given plan and programme from the aspect of alternative solutions considered and the outline of methods in which the environmental issues have been included in plans and programmes;
9. The conclusions reached in the process of strategic assessment report elaboration presented in the way understandable for public;
10. Other data of relevance for the strategic assessment [4].

## 3. GENERAL METHODOLOGICAL FRAMEWORK FOR STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Analysis of methodological framework is useful to make a comparative analysis with the methodology used for the purpose of the strategic impact report and methodological bases, which are proclaimed in the general legal framework that regulates the issues, analized in the Law on Strategic Environmental Impact Assessment. The main goal is consisted in efforts for adaptation the general methodology of Strategic Environmental Impact Assessment to the specific of each analyzed plan.

Strategic assessment of impact of certain plans and programmes is a new discipline and it is the result of evaluation of the environmental impact. Environmental Impact Assessment of Projects and facilities on the environment has shown insufficiency in the system of environmental protection, so Strategic Environmental Impact Assessment was developed to examined cumulative impacts on the environment.

Strategic Environmental Impact Assessment integrate ecological, socio-economic and cumulative impacts, so that it:

1. Includes maintenance on the source of environmental problems in planning stage and reduces the consequences of rehabilitation;
2. Allows to determine the need and justification from the environmental protection point of view;
3. Processing wider importance issues, and
4. Determines the context and set policies for a hierarchical framework of future Assessment of Environmental Impact of plans and projects.

The strategic assessment procedure shall be composed of the following stages:

1. The Preparation stage that shall include:
   a) The decision on the strategic assessment elaboration;
   b) The selection of the strategic assessment developer;
   c) The participation of authorities and organizations concerned;
2. The strategic assessment report;
3. The decision making procedure that shall include:
   a) The participation of authorities and organizations concerned;
   b) The participation of the public concerned;
   c) The report on the results of participation of authorities and organizations;
   d) Public concerned;
   e) The evaluation of the strategic assessment report;
   f) The approval of the strategic assessment report. [4]

## 4. METHODOLOGICAL FRAMEWORK FOR THE STRATEGIC ASSESSMENT OF SPATIAL PLANS IN AUTONOMOUS PROVINCE OF VOJVODINA

Analyzing the process of Strategic assessment Report for spatial plans consists of four phases:

1. Basic, analysis and evaluation of the present situation (Land use defined in Spatial Plan and main environmental issues);
2. Possible environmental impact assessment;
3. Environmental protection measures;
4. Environmental monitoring programme.

Without detailed consideration of any single phase, it is necessary to emphasize that each phase has its own peculiarities and should not be neglected in the integrated planning of the environment.

The way of evaluation of the possible impacts of planning decisions on the environment in the Republic of Serbia is not yet sufficiently developed and methodologically confirmed. According to the generally adopted model, the significance of the impact can be compared to assess the size, i.e. intensity of the impact and spatial scale in which the impact can be made. The following table shows that planning decisions can, according to size of their impacts, be divided into one with the: higher impact, smaller impact and non important impacts. Also planning decisions can be divided to one with: positive impacts, good impacts and very good impacts. According to the intensity, planning decisions can be presented as one with: a strong negative impact, a negative impact, less negative impact, less positive impact, a positive impact and a strong positive impact, and there are also some planning decisions with a lack of data in some cases, so it cannot be said how big their impact can be. [2]

Table 1. Size evaluation of planning decisions impact on the environment

| The size of the impact | Label | Description |
|---|---|---|
| Critical | - 3 | Strong negative impact |
| Larger | - 2 | Larger negative impact |
| Lower | - 1 | Minor negative impact |
| No impact | 0 | No data |
| Positive | + 1 | Smaller positive impact |
| Favorable | + 2 | Larger positive impact |
| Very favorable | + 3 | Strong positive impact |

On the other hand, according to the size of the impact, spatial planning solutions can be divided to the one with the: global impact, national impact and regional impact, and also to impacts that have municipal and local character (Table 2).

Table 2. Spatial scale evaluation of planning decisions impact on the environment

| The importance of the impact | Label | Description |
|---|---|---|
| Global | G | Possible global impact |
| National | N | Possible impact on the national level |
| Regional | R | Possible impact in the region |
| Municipality | M | Possible impact in the municipality |
| Local | L | Possible impact in a zone or part of the municipality |

Table 3. Probability scale for the assessment of impact

| Probability | Label | Description |
|---|---|---|
| 100% | W | Predictable impact |
| more than 50% | V | Probable impact |
| less than 50% | M | Possible impact |
| less than 1% | N | No probable impact |

It is also possible to state the probability that some estimated impact can take place in the present, and sometimes it is an important criterion for decision-making procedure in the phases of plan creating. Probability of impact in this case can be determined by the following scale (Table 3).

As additional criteria, by which evaluation is done in Strategic Impact Assessment, some estimation is made using the duration of impact and its consequences. In this case, a temporary-periodic (P) and long (D) effects are defined. That is how are defined the important impacts for the Plan, as well as for Impact Assessment.

It is important to consider the positive impact on the environment because the emphasis is always only on the negative impacts on the environment [3]

As already noted, there is no unique methodology for Impact Assessment, in the world and also in our country, and the decision on the usage of certain methodology framework and techniques are left to experts.

In the third phase, the appropriate measures of environmental protection are prescribed in order to decrease the negative impact and improve the environment. In this phase the guidelines for plans on different hierarchy levels are defined, as well as the guidelines for Strategic Environmental Impact Assessment and Assessment of Enviromental Impact of projects.

Finally, there is the phase in which the monitoring programme is defined, which includes proposed state indicators for environmental monitoring. Also, it is very important to monitor the implementation and effectiveness of the prescribed measures of protection defined in plan, and whether defined safeguards provide relevant results.

The applied technique is based on the continuous process of harmonization of the planning process with the identification of problems, the solutions for the prevention, and proposal of measures for environmental protection in all phases of design and implementation of spatial plans.

## 5. ENVIRONMENTAL INDICATORS

Environmental indicators are very suitable for measuring and evaluating of planning decisions, from the possible negative impact on the environment point of view, and for the determination of negative impact that is necessary to reduce or eliminate. Environmental indicators are one of the instruments for the systematic identification, assessment and monitoring, processes and environmental conditions, and consideration of the consequences. In the process of defining of environmental indicators, Serbian experts evaluated environmental indicators of sustainable development defined by European Union [6].

## 6. CONCLUSIONS

Strategic Environmental Impact Assessment of plans and programmes is a complex process that considers not only the preparation of the Strategic Assessment Report, but also includes the implementation of several stages that must be integrated in the appropriate procedures of creating, decision-making and adoption of plans and programmes.

The unique methodological approach for Strategic Environmental Impact Assessment is still not defined. Content of the strategic assessment of impact of certain plans and programmes and Strategic Assessment Report is defined by law, but it is not possible to identify the content and unique methodology, because the elements that define the content of

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the document should contain the way in which the methodology leads to specific goals and results [6].

Table 4. Specific objectives and environmental indicators in SEA [1]

| No. | SPECIFIC OBJECTIVES SEA | INDICATORS |
|---|---|---|
| 1. | Reduction of emissions harmful substances in the air | Emissions of particles of dust, $SO_2$, NOx |
| 2. | Reduce exposure of inhabitants to high noise levels | Number of buildings in the zone of increased noise |
| 3 | The development of organized water supply | Increase the capacity for water supply |
| 4 | Preservation of the quality of surface and underground water | Biological oxygen for five days BPK5 |
| 5 | Reduce the risk of flooding | % reduction of vulnerable land area jeopardized by floods |
| 6 | Conserving arable agricultural land | Conversion of soil arable surface (%) |
| 7 | Preservation of area under the meadows and pastures | Conversion of area under the meadows and pastures (%) |
| 8 | Improvement of state forests and increase the areas under forest | Conversion of forest land area |
| 9 | Detention of erosion processes | Reduction of erosion soil (%) |
| 10 | The introduction of the collection, treatment and storage of municipal waste | % of households involved in the system<br>% of waste that is stored |
| 11 | Conserving biodiversity - to avoid losses | % permanently lost species in relation to the region |
| 12 | Preserve and avoid damage of protected natural resources | The number of the important protected area and natural resources that are damaged |
| 13 | Reclamation of degraded areas | % recultivation area |
| 14 | Preserve and protect the cultural important areas | The number and importance of vulnerable buildings and cultural heritage |
| 15 | Raising the quality of the areas | Provide infrastructure at the area (public transport and infrastructure, public facilities, standards, etc.) |
| 16 | Preservation of population- stop emigration | % reduction of population |
| 17 | The growth of employment-creating the conditions for the return of working-age population | % of employees and unemployed |
| 18 | Promote and develop the infrastructure | The number and the quality of new infrastructure elements |
| 19 | Improve public information on environmental information issues | Amount of information about the environment |

Due to the complexity and the lack of a unique methodology for the Strategic Environmental Impact Assessment, particularly the assessment of possible impact on the environment in the Strategic Assessment Report, in the Republic of Serbia is still present diversity in the manner and methodology.

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# POLYCHLORINATED BIPHENYLS (PCBs), IN SOUTH BAČKA – FROM THE ENVIRONMENT TO HUMAN MILK

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**Abstract:**
Measurements of PCBs congeners (PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153, PCB 180, PCB 209) in 16 samples of 3rd day human colostrum were performed in 2006, using GC-ECD (HP 5890) supplied with a Quadrex fused silica column 5% Ph for PCBs. Concentrations of PCB congeners – 52, 138, 153 and 180, measured in 2006 were 2-5 times higher than concentrations of the same congeners measured in 2003 in the same region. Human milk, was once again a mirror of environmental pollution.

**Keywords:**
polychlorinated byphenyls, human milk, environment

## 1. INTRODUCTION

Our environment is under constant influence of various human activities – seldom beneficial to it, often harmful, sometimes even highly dangerous. Many chemicals are hazardous for human health. Among these, due to their ealier extensive production and worldwide use, are organochlorine contaminants (OCC). Pesticide residues and polychlorinated biphenyls (PCB) still keep the prominent position on OCC list related to human health potential hazards.

Persistent organic polutants (POPs), due to their perzistence, long live and presence in all environmental macroecosystems (soil, water, air, and their macrobiota), and in particular due to their bioaccumulation and biomagnification through the food chain, have made humans particularly exposed [9]. More than 90% of POPs daily intake in humans is via food, and of that amount, around 90% are from animal sources [4].

Breastfed human newborn, nutritionally relying only upon mothers milk, is the ultimate ring in the food chain, on our planet. As such, its level of exposure is highest for humans [12]. Therefore, continuous monitoring of POPs in human milk could point, not only to the level of exposure of very young children, but also to changes in the the environment [11].

PCBs were manufactured from 1930 around the world continued. They were extensively and broadly used in many fields of industry and it was easy for these chemicals to find their way into the environment, in the course of innumerable accidents of various levels. In spite of their restricted use which started gradually in industrialized countries since their potential hazard was anticipated, inadequate storage and disposal, even leakage and spill incidents, continued their environmental inlet. Great chemical stability, physical and chemical inertness, results in a very slow degradation, with their persistence in the environment. This, together with high mobility in the atmosphere, has put PCBs on the list of global environmental pollutants. PCBs bioaccumulated and biomagnified in a wide range of plants and animals consumed by humans, with the net effect of the greatest toxic risk for animals and humans on the end of food chain. As highly lipid soluble substances, with the $K_{ow}$ >5, PCBs are deposited primarily in adipose tissue. In mammals, the only way to excrete in significant amounts liposoluble substances, such as PCBs, is via milk, during lactation. Since milk is the only food during

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the first months of life, the exposure of breastfed neonates might be the highest of all macroorganisms, with superimposed postnatal, over prenatal exposure.

Throughout fifteen years, a series of ecologically very unfavorable events [5] - possible atmospheric transport of PCBs from UN bombarded targets in Bosnia and weeks of incinerations and fires after NATO bombardment of oil refinery and other industries in Serbia (e.g. 100 000 ng ITEQ/kg and 70-74 g/kg of PCBs in samples of soil on one location in central Serbia), not only soil and waters, were contaminated, but inevitably plants, animals and humans, amplifying its historical presence. UNEP task groups in summer 1999. identified four hot spots in the territory of Serbia, one of these being the city of Novi Sad [1].

PCBs are bioaccumulated in plants and animals consumed by humans. During delivery, a period of short term starvation, lipsoluble substances mobilized from fat reserves into the blood reach the mammary gland. Since milk is the only way for their excretion, the neonate, relying fully on mother's milk, as the only source of nutrients, may be at greatest risk of all mammals, particularly in the earliest neonatal period. Studies on PCB in early human milk (colostrum) are few [2, 3 , 7, 11].

Pollution of early human milk with POPs is being monitored in the region of South Backa since 1982 [10].

## 2. MATERIAL AND METHODS

### Samples of colostrums

Donors of colostrum (early milk) were 16 healthy mothers living in and around the city of Novi Sad, age 28.81±4.29 years (range 23-39). They gave birth to healthy babies after a normal pregnancy and normal delivery in 2006. Questionnaires related to demographic data on mothers and their babies, as well as dietary habits, smoking and occupational and other exposure to chemicals of mothers were filled on entry into the study, when each mother consented examination of her colostrum. Mothers expressed colostrum in the amount of 21.87± 13.53 mL ( $\overline{X} \pm SD$) , range 7-55 mL, into specially prepared glass containers, on the 3rd postpartal day, after the 2nd morning breastfeed. Samples were frozen at -20°C until analyzed.

### Preparation of samples

PCBs were extracted from human milk using modified method of Jan [6] as described earlier [10].

### PCB congeners determination

All analytical determinations of 8 key PCB congeners in human milk samples were performed at the Institute of Occupational Health in Novi Sad. Samples were analyzed using GC-ECD (HP 5890 supplied with a Quadrex fused silica column 5% Ph for PCBs (PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153, PCB 180, PCB 209)

### Standards used

The system was calibrated using Pesticide Mix 33 with individual EPA standard mixture of 7 PCB congeners PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153, PCB 180, PCB 209 (Dr Ehrenstorfer Laboratories, Augsburg, Germany).

### Statistical analysis

Statistical analyses were performed using Statistica for Windows, version 7.1, from StatSoft (Tulsa, OK, USA). Concentrations of 8 PCB congeners in human milk were summarized using arithmetic means, standard deviation, median, minimum and maximum values. Pearson correlation was used to assess association between age of mothers and of PCB congeners in their milk.

## 3. RESULTS

PCB congener 138 was the only one detected in all examined samples; congeners 52 and 153 and 180 were detected in all but one sample (153 and 180 in the same sample, 52 in diferent sample); congener 209 was detected in two samples; and 101 in only one sample; while congeners 28 and 118 were not detected in any of 16 examined samples of colostrum (Table 1). Average values of 5 PCB congeners, detected in more than one of 16 examined human colostrum samples are presented in Table 2.

## 4. DISCUSSION

Concentrations of 4 PCB congeners – 52, 138, 153 and 180, measured in 2006 were 2-5 times higher than concentrations of the same congeners measured in 2003 in the same region [6]. To our knowledge, no ecological accident occurred in this region at the time of pregnancy of these mothers or earlier.

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Table 1. Concentrations (ng/g wet) of 8 EPA PCB congeners in 16 individual samples of human colostrum

| Sample of colostrum | Age of mothers | Parity of mothers | PCB congeners | | | | | | Sum of congeners |
|---|---|---|---|---|---|---|---|---|---|
| | | | 52 | 101 | 138 | 153 | 180 | 209 | |
| 1 | 23 | 1 | 0.19 | - | 0.14 | 0.20 | 0.10 | - | 0.63 |
| 2 | 33 | 2 | 0.42 | 0.12 | 1.27 | 1.27 | 1.94 | 0.12 | 5.14 |
| 3 | 39 | 7 | 0.17 | - | 0.07 | 0.09 | 0.05 | - | 0.38 |
| 4 | 23 | 1 | 0.3 | - | 0.11 | 0.16 | 0.15 | - | 0.72 |
| 5 | 30 | 1 | 0.23 | - | 0.27 | 0.29 | 0.48 | - | 1.27 |
| 6 | 31 | 4 | 0.05 | - | 0.03 | 0.04 | 0.03 | - | 0.15 |
| 7 | 24 | 2 | 0.19 | - | 0.14 | - | - | - | 0.33 |
| 8 | 25 | 1 | 0.57 | - | 0.58 | 0.7 | 1.12 | - | 2.97 |
| 9 | 26 | 2 | 0.83 | - | 0.22 | 0.34 | 0.4 | - | 1.79 |
| 10 | 29 | 2 | - | - | 0.04 | 0.06 | 0.06 | - | 0.16 |
| 11 | 25 | 1 | 0.39 | - | 0.14 | 0.14 | 0.07 | - | 0.74 |
| 12 | 32 | 3 | 0.29 | - | 0.11 | 0.15 | 0.13 | - | 0.68 |
| 13 | 29 | 1 | 0.11 | - | 0.04 | 0.04 | 0.03 | - | 0.22 |
| 14 | 30 | 3 | 0.25 | - | 0.06 | 0.08 | 0.05 | - | 0.44 |
| 15 | 31 | 3 | 0.07 | - | 0.03 | 0.04 | 0.02 | - | 0.16 |
| 16 | 31 | 3 | 0.21 | - | 0.05 | 0.21 | 0.16 | 0.12 | 0.75 |

- not detected

Table 2. Concentrations (ng/mL) of 5 EPA PCB conegeners detected in more than 1 of 16 samples of 3rd day human colostrum. $\overline{X} \pm SD$, median value, range.

| | PCB congeners | | | | | |
|---|---|---|---|---|---|---|
| | 52 | 138 | 153 | 180 | 209 | Sum |
| Mean | 0.29 | 0.21 | 0.26 | 0.32 | 0.09 | 1.17 |
| SD | 0.20 | 0.32 | 0.33 | 0.53 | 0.04 | 1.42 |
| Median | 0.23 | 0.11 | 0.15 | 0.10 | 0.09 | 0.68 |
| Range | 0.05 - 0.83 | 0.03 - 1.27 | 0.04 - 1.27 | 0.03 - 1.94 | 0.07 - 0.12 | 0.05 -5.43 |

Correlation of organochlorine contaminants in milk and age of mothers, together with higher levels in milk of primiparous than of multiparous mothers, was found by others [13]. In this study, the only correlation was found between PCB congener 153 and the age of mothers (p=0.019). This could be attributed to greater proportion of multiparous than primiparous mothers (10:6) than in previous study (7:11) on the same territory, in which no correlation was found [13]. Occupation and dietary habits of mothers did not imply any known exposure to chemicals.

Comparing these latest results with the results from the earlier periods [11] for the same geographic area, the fall of total PCBs in early human milk from 1982 (mean value 40.08 μg/L whole milk) till 1993 (mean value 10.95 μg/L whole milk), was observed. The assumed total PCBs in 2003 (10.25 ng/g whole milk) suggest that their unchanged levels in early human milk over 10 years are the result of continued inlet into the environment. These determinations in Serbia are very scarce and till now, performed only by this group of authors.

## 5. CONCLUSIONS

Last measurements of PCBs congeners (PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153, PCB 180, PCB 209) in 16 samples of 3rd day human colostrum were performed in 2006, using GC-ECD (HP 5890) supplied with a Quadrex fused silica column 5% Ph for PCBs.

PCB congener 138 (0.21±0.32, $\overline{X} \pm SD$) was detected in all examined samples; congeners 52 (0.29±0.20), 153 (0.26±0.33) and 180 (0.32±0.53) in all but one sample; congener 209 (0.09±0.04) in two samples; and 101 in only one sample; while congeners 28 and 118 were not detected in any of 16 examined samples. The only correlation found was between PCB congener 153 and the age of mothers (p=0.019). Mothers, donors of colostrums, did not have any known occupational or dietary exposure to chemicals.

Concentrations of PCB congeners – 52, 138, 153 and 180, measured in 2006 were 2 - 5 times higher than concentrations of the same congeners measured in 2003 in the same region. Total PCBs in human colostrums, in the same region, showed a four time decrease from 1982 till 1993; mostly

unchanged levels till 2003; followed by the rise in this last measurements. Human milk, was once again a mirror of environmental pollution.

**Acknowledgements**

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# VARIABILITY OF GAS-PARTICLE PARTITIONING OF POLYCYCLIC AROMATIC HYDROCARBONS IN A PILOT AREA OF VOJVODINA

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**Abstract:**
Polycyclic aromatic hydrocarbons consist of two to eight condensed aromatic rings and they are produced during incomplete combustion of organic materials. High atmospheric levels of polycyclic aromatic hydrocarbons are associated with industrial activities, energy production, and any type of combustion and traffic. In the atmosphere, PAHs are distributed between gaseous and particulate phase. Distribution of PAHs in the atmosphere controls removal processes and atmospheric degradation. During the June and July 2004 air sampling campaign was conducted in the region of Vojvodina, and concentration levels of 16 PAHs in gaseous and particulate phases were determined.

**Keywords**:
Polycyclic aromatic hydrocarbons; Gas-particle partitioning; Atmospheric distribution; Active air sampling

## 1. INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are the comlex group of organic compounds with planar structure, with C and H atoms organized in circlet structure with at least two aromatic rings. Primary natural sources of PAHs are fires and volcanic eruptions. The most important anthropogenic sources of PAHs in the atmosphere are wood combustion, energy production, and production of aluminium, incineration, catalytic cracking and exhaust gases from vehicles. Concentration levels and behavior of polycyclic aromatic hydrocarbons in the environment have been frequently monitored because of their long-term transport, global distribution and high toxicity [1, 2, 3, 4, 5].

In the atmospheric environment, PAHs are found in the gaseous phase or sorbed at the solid particles, depending mainly on ambient temperature and vapor pressures. Gas-particle partitioning process can be described using partitioning coefficient $K_P$:

$$K_P = \frac{1}{K_V} = \frac{\frac{F}{TSP}}{A} \quad (1)$$

where:
$K_P$ –partition coefficient between particle and gaseous phase in atmosphere ($m^3\ \mu g^{-1}$)
$K_V$ – partition coefficient between gaseous and particle phase in atmosphere ($\mu g\ m^{-3}$)
$A$ i $F$ – compound concentration associated with the gaseous and particle phase, respectively (ng $m^{-3}$ air)
$TSP$ – total suspended particulate matter concentration ($\mu g$ aerosol $m^{-3}$ air)

Atmospheric distribution of PAHs, can also be described with total amount of supstance proportion sorbed on atmospheric particles, $\phi$:

$$\phi = \frac{F}{A+F} = \frac{K_P \cdot TSP}{1 + K_P \cdot TSP} \quad (2)$$

During the period from June - July 2004, air sampling campaign was conducted in the region of Vojvodina, Serbia, and concentration levels of 16 US EPA PAHs were determined.

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## 2. MATERIALS AND METHODS

Concentration levels of selected polycyclic aromatic hydrocarbons have been determined in accordance with the sampling procedure and analysis of organic pollutants in ambient air, adopted by EPA [6, 7]. Active air sampling method is realized through flowing of definite quantity of air, controlled by compressor, through the sampler. In the first step, air is released through the horizontally placed single layer filter made of glass fiber (GF), which holds atmospheric particles over 0.1 μm in diameter. Air, then, passes through the sorbent made of polyurethane foam (PUF), placed behind GF, which collects gaseous phase of PAHs molecules.

The sampler used for the active sampling of air was GV2360 Thermo Andersen TSP, made of stainless steel boxes and equipped with 20.32 x 25.4 cm filter holder and PUF holder (9 cm in diameter and 30 cm long). Air was passed through using a 1200 watt motor controlled by an inverter (Hitachi L100-015NPE) and flow was measured by a Sierra 620 fast flow insertion mass flow meter with a totaliser. The average total sampled air was 1200 $m^3$/day. For each sampling period, per one Whatman grade G653 glass fiber filter (dimension: 20.32 x 25.4cm) and two polyurethane foam filters (dimension: 9 cm diameter and 5 cm long) were used.

Prior the sampling, glass fiber filters were burned in 400°C for 5 hours and polyurethane foam filters were Soxhlet extracted by 1:1 acetone/hexane (Merk suprasolv) by a Foss Tecator Soxtec 1045 HT-2 apparatus for 4 hours to 120°C.

After the sampling period (3 x 24h), GFs and PUFs were extracted and analzyed using GC/MS method. Analytical determination of 16 EPA PAHs in all samples was carried out in laboratories of Research Centre for Environmental Chemistry and Ecotoxicology (RECETOX), Masaryk University in Brno, Czech Republic.

## 3. RESULTS

Three 24-hour high volume samples were collected from each of three sampling sites in in the town of Pančevo, Vojvodina, Serbia. Air sampling campaign in Pančevo was conducted during the period from 27th – 30th June, 2004. Two samplers were placed within the industrial area, in the yard of the oil refinery and petrochemical complex (localities P1 and P2, respectively). The third HiVol sampler was placed in the city center, on the top of the Pančevo city hall (locality P3). Detailed information on the three sampling spots is presented in Table 1. Concentration levels of 16 EPA PAHs are presented in Table 2.

Table 1. Detailed information on the sampling sites

| Site ID | Latitude | Longitude | Elevation (m a.s.l.) |
|---|---|---|---|
| P1 | N 44°49' 56.3" | E 20°41' 25.4" | 82 |
| P2 | N 44°49' 57.0" | E 20°40' 17.0" | 85 |
| P3 | N 44°52' 12.8" | E 20°38' 24.1" | 130 |

Table 2. Average concentrations of PAHs in gaseous and particulate phase (ng/$m^3$)

| Sample type | PUF | GF | PUF | GF | PUF | GF |
|---|---|---|---|---|---|---|
| Locality | P1 | | P2 | | P3 | |
| Sampling period | 27-30th June 2004 | | | | | |
| Nap | 1.195 | 0.010 | 0.811 | 0.016 | 0.454 | 0.010 |
| Acy | 0.065 | 0.003 | 0.050 | 0.001 | 0.044 | 0.001 |
| Ace | 0.063 | 0.006 | 0.054 | 0.006 | 0.027 | 0.002 |
| Flo | 1.454 | 0.003 | 1.497 | 0.009 | 0.171 | 0.002 |
| Phe | 18.309 | 0.041 | 27.364 | 0.144 | 3.659 | 0.030 |
| Ant | 0.679 | 0.001 | 1.152 | 0.007 | 0.187 | 0.002 |
| Flu | 2.133 | 0.024 | 10.997 | 0.167 | 2.160 | 0.071 |
| Pyr | 1.521 | 0.020 | 3.773 | 0.095 | 1.831 | 0.077 |
| B(a)A | 0.023 | 0.008 | 0.017 | 0.018 | 0.070 | 0.028 |
| Chr | 0.120 | 0.018 | 0.146 | 0.066 | 0.206 | 0.088 |
| B(b)F | 0.041 | 0.045 | 0.019 | 0.220 | 0.029 | 0.380 |
| B(k)F | 0.022 | 0.030 | 0.010 | 0.122 | 0.012 | 0.144 |
| B(a)P | 0.021 | 0.016 | 0.006 | 0.102 | 0.000 | 0.130 |
| I(1,2,3-cd)P | 0.021 | 0.046 | 0.005 | 0.240 | 0.000 | 0.365 |
| D(ah)A | 0.000 | 0.002 | 0.000 | 0.013 | 0.000 | 0.024 |
| B(ghi)P | 0.035 | 0.066 | 0.009 | 0.320 | 0.000 | 0.500 |
| Total | 5.700 | 0.336 | 45.909 | 1.547 | 8.849 | 1.853 |

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Estimated distribution of polycyclic aromatic hydrocarbons between gaseous and particulate phase in the ambient air of Pancevo is shown in Figures 1 – 3.

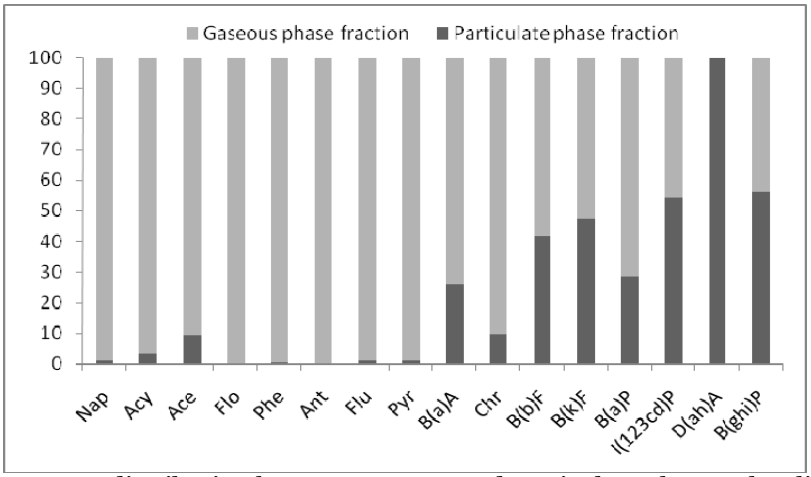



Figure 1. PAH distribution between gaseous and particulate phase at locality P1

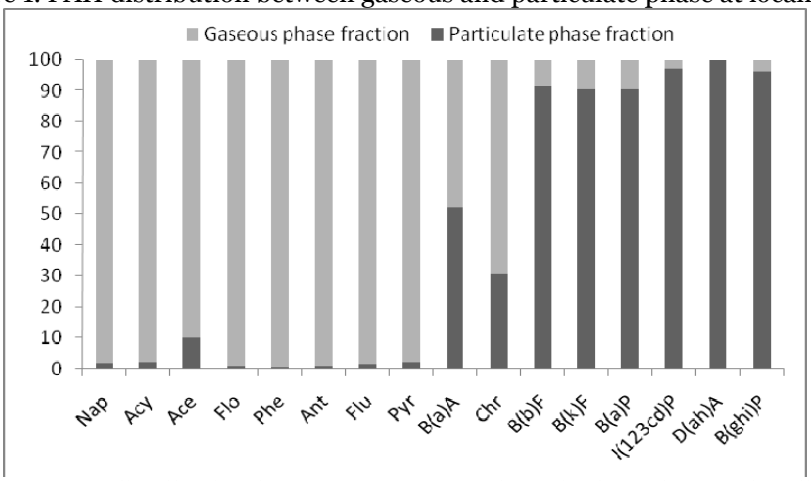



Figure 2. PAH distribution between gaseous and particulate phase at locality P2

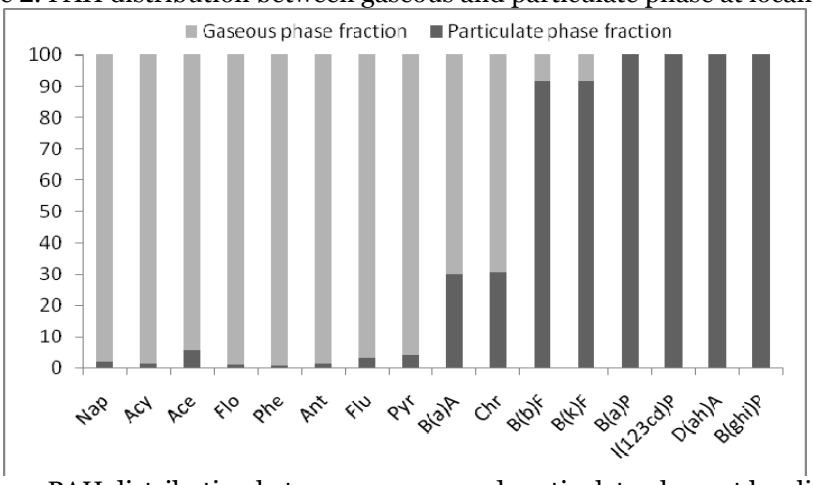



Figure 3. PAH distribution between gaseous and particulate phase at locality P3

In the city of Novi Sad, the highest total concetraton level of examined PAHs was detected on the locality P2 (Petrochemical complex Pancevo) and equals ΣPAH=47.456 ng/m$^3$. Total concentration of PAHs at the localities P1 (oil refinery) and P3 (city center) are ΣPAH=26.036 ng/m$^3$ and ΣPAH=10.747 ng/m$^3$, respectively.

In national legislation, maximum allowed concentration of examined group of persistent organic pollutants has not been defined, therefore comparison with legallly adopted values was not possible. Threshold value of ambient air quality for benzo(a)pyrene for 24-hour sample, 0.1 ng/m$^3$, has been

exceeded at the localities P2 and P3, with value 0.108 ng/m$^3$ for locality P2 and 0.130 ng/m$^3$ for locality P3.

Obtained experimental results point out on almost complete particle sorption of pollutants B(b)F, B(k)F, B(a)P, I(1,2,3-cd)P, D(ah)A i B(ghi)P, with exception of sampling site P1 (Oil Refinery Pancevo), where foregoing PAHs fractions, beside D(ah)A, are about 50%. Specific distribution of polycyclic aromatic hydrocarbons at oil refinery, does not manifest, apriory, low concentration of total suspended particles in the atmosphere. Increased concentration levels of PAHs in gasous phase or sorbed at ultrafine particles which can not be collected at glass fibre filters, issued from refinery, are probably responsible for atmospheric distribution of PAHs at site P1.

## 4. CONCLUSIONS

Results of analysis point out on the presence of residual quantities of PAHs in air samples from three localities in the town of Pančevo.

The highest concentrations of examined polycyclic aromatic hydrocarbons was detected at the petrochemical complex (47.456 ng/m$^3$).

Regulation defines limit value of ambient air quality only for benzo(a)pyrene (0,1 ng/m$^3$ for 24-hour sample). Limit value was exceeded at two selected localities in Pančevo – petrochemical complex (0.108 ng/m$^3$) and city center (0.130 ng/m$^3$).

Direct influence of atmospheric distribution on wet and dry deposition processes, long-range transport, as well as potential reactions of degradation of PAHs in the atmosphere, points out on an extreme importance of examination and determination of concentration levels and partition of pollutants in the atmosphere.

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# SNAIL MEAT, ROLE AND PLACE IN HUMANS DIET

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**ABSTRACT**

The present study aims to establish the differences between the chemical compositions of snail meat and pork meat used for making snail pate and liver pate.
Snail meat as fish meat also is high-protein and low-fat (0,5–0,8%), low-calories (60-80 cal/100g.), high biological proteins content (12-16%), minerals (1,5%) and nitrogen (2,5%).

Chemical Composition of Snail Meat

| SPECIE | COMPONENT | | | |
|---|---|---|---|---|
| | WATER (%) | PROTEIN (%) | FAT (%) | MINERALES (%) |
| SNAIL | 79,35 | 16,10 | 1,08 | 1,50 |
| CHIKEN | 70,00 | 19,00 | 8,50 | 1,00 |
| TURKEY | 67,00 | 23,40 | 7,60 | 1,10 |
| CARP | 76,00 | 18,50 | 2,40 | 1,20 |
| WALLER | 63,50 | 16,80 | 17,40 | 1,10 |
| VEAL | 78,00 | 20,00 | 1,00 | 0,70 |
| RABBIT | 71,40 | 21,30 | 5,50 | 1,15 |
| PORC | 65,00 | 18,00 | 16,20 | 0,80 |
| BEEF | 65,50 | 17,90 | 15,70 | 0,90 |

After some laboratory tests, the results are even better for Helix Pomatia : water -75,09%, protein - 18,46%, fat -0,25 %, ashes – 1,62%, carbohydrates – 1,01%

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# ADVANTAGE OF THE SUBSTITUTION ETHYLMERCAPTAN, COMPOUND FOR ODORIZATION NATURAL GAS, WITH TETRAHYDROTHIOPHEN

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**Abstract:**
This paper presents the advantage of substitution ethylmercaptan, compound for odorization natural gas, with other compound for odorization, tetrahydrothiophen. The physical - chemical properties of both compounds, ecological - toxic characteristics, odorization properties and evaluation of annual consumption odorization compounds in Serbia are discussed. The comparative analysis of these two odorization compounds from the aspect of chemical stability in the system of gas installations and economic acceptability have been described.

**Keywords:**
Ethylmercaptan, tetrahydrothiophen, odorization, substitution

## 1. INTRODUCTION

Natural gas, in particular, which is distributed for consumer goods, must be odorized up to level of one fifth of the lower flammable limit for security and health safety reasons.

Odorization compound with their physical - chemical properties should ensure first of all recognizable strong smell from a small portion of evaporation, or in a low concentration level to be detected leakage of gas and prevent unwanted consequences.

In Serbia as odorant, almost exclusively, used ethylmercaptan characterized with the best ability odorization, are no longer used in most European countries.

One of the main reasons for the termination of the use of ethylmercaptan as odorant its chemical instability (in the reaction with air and iron-oxide), which causes loss of smell intensity, as well as changes characteristic strong unpleasant smell.

Most frequently used compound for odorization natural gas is tetrahydrothiophen which has recognized intensive smell. It is the most stable of all gas odorants. Tetrahydrothiophen not react with iron oxides and bases and it does not change, nor the intensity or character of smell, for the most causes of loss of smell.

Unlike ethylmercaptan, which is extremely toxic to flora and fauna biosystem and the environment, tetrahydrothiophen belongs to the middle toxic group pollutant and there is no label danger for the environment according to the German classification for surface water pollutants. [4]

## 2. ETHYLMERCAPTAN (EM)

**Physical - chemical characteristics:**

- Chemical formula: $C_2H_6S$
- Appearance and the smell: colourless liquid – reminiscent of the smell of garlic
- Melting point: -148 °C
- Boiling point: 35 °C
- Density (g $cm^{-3}$): 0.839
- Flash point: -45 °C
- Explosion limits: 2.8 - 18.2 %
- Water solubility: slight

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**Other properties of ethylmercaptan:**

- In normal circumstances, a stable, but extremely flammable liquid;
- Incompatible materials: oxidans (can lead to flammable), strong acid (reaction can be violent), calcium chloride (react violently), corrosive effect on metals, reacts violently with alkaline metals;
- Classification, belongs to the 3rd group of toxins and is extremely toxic to flora and fauna and surface water;
- UN number 2363;
- Additional tag 336; [5]

**Ethylmercaptan as natural gas odorant**

Ethylmercaptan has a very strong and unpleasant smell reminiscent of the smell of garlic. Threshold of low sensitivity of smell defined EM, based on its odorization capacity, as the best odorization compound for the natural gas. However, the big problem is nonstability of ethylmercaptan because it easily reacts with oxides and bases giving disulfide, and in that case loosing smell properties.

In addition, irreversible adsorption of ethylmercaptan on the walls of steel and polyethylene gas pipes increases ethylmercaptan consumption.

Low flammablity and extreme toxicity, associate with environmental and contamination aspect are the problems, because increase the cost of transport and storage. For these reasons ethylmercaptan as odorant need to replace with other substances with a higher chemical stability and less or slightly toxicity for the environment. [4]

**Assessment of consumption ethylmercaptan in Serbia**

According to company for natural gas odorization "OD – JU" from Ruma, the total amount of odorized gas in 2007. year was about 517,500,000 $Sm^3$. Total consumption of ethylmercaptan was about 6700kg, with the average achieved concentration about 12.95 mg/$Sm^3$ of natural gas. [3]

## 3. TETRAHYDROTHIOPHEN (THT)

**Physical - chemical characteristics:**

- Chemical formula: $C_4H_8S$
- Physical state and appearance: Liquid.
- Odor: strong unpleasant
- Molecular Weight: 120.11 g/mole
- Color: Clear Colorless.
- Boiling Point: 284.5°C
- Melting Point: 27.4°C
- Density: 1.26 (Water = 1)

**Information about toxicity:**

- Acute oral LD50 (in rats) 2450mg/kg
- Acute inhalation LC50 (in mice) 27g/$Sm^3$ (2 hours)

**Environmental information:**

Information about toxicity for aquatic organisms: No data available

Toxicity to Animals:

Acute oral toxicity (LD50): 1900 mg/kg [Mouse].

Acute dermal toxicity (LD50): >3800 mg/kg [Rat].

**Tetrahydrothiophen as natural gas odorant**

Tetrahydrothiophen has recognizable characteristic strong smell that is different from other spices impurities that may appear in the natural gas. THT shows very small deviations from own specific fragrance and is very difficult to overdose.

Tetrahydrothiophen is the most stable of all gas odorants, as a result of heterocyclic chemical structure, what is unusual for other common odorants. Tetrahydrothiophen not react with iron oxides and bases, and is imperceptible to most of the causes of pad smell.

Adsorption of tetrahydrothiophen on the walls of the new pipe is almost completely reversible so that the amount of THT is a reserve of odorant. In the case of changes in the dosage THT, dynamic equilibrium adsorption and desorption are disturbing and THT is desorbed from the wall of pipes back into the gas.

THT is in the middle group of pollutants according to the German classification of pollutants surface water (W6K2) and not wearing the label of danger for the environment, which makes it easier for packaging, storage and transport. [1, 4]

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## 4. COMPARATIVE ANALYSIS OF ETHYLMERCAPTAN AND TETRAHYDROTHIOPHEN AS ODORANTS

**Stability**

The difference in stability ethylmercaptan and tetrahydrothiophen in the presence of corrosion on the walls of pipes is a significant benefit for the THT, which could be displayed in the chart (Figure 1).

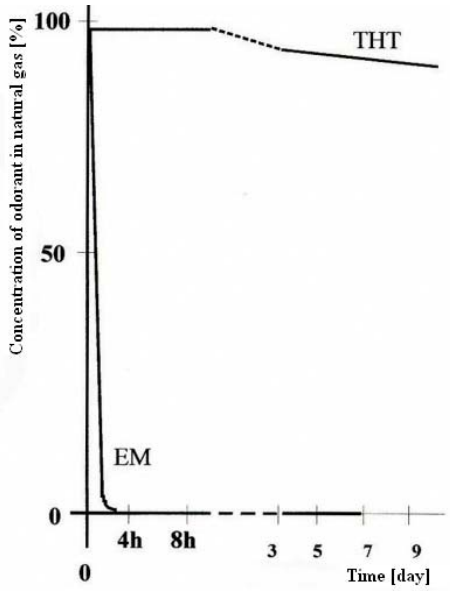



Figure 1. Graphic display depending on the concentration of odorant in function of time, in the natural gas in the presence of corrosion [4]

From the diagram it could be seen that the concentration of THT in the gas begins to decline significantly after the third day, while the concentration of EM decline in the "0" for about 2 hours. This means that the EM is totaly spent in the chemical reaction of oxidation, loosing completely smell in a very short time. [4]

**Economic effects**

Comparative analysis of the costs of the odorization with EM and THT in the following text is calculated for concentrations of odorant in the natural gas of 12.95 mg/Sm$^3$ for odorization 517.500.000Sm$^3$/yr, the average distance from odorants storage is about 80km.

**Odorant ethylmercaptan**

Total amount of required odorant is 517.500.000 Sm$^3$/yr • 0.00001295 kg/Sm$^3$ = 6700 kg/yr.
Price of charging for EM is 16.10 €/kg, (or 0.000241 €/Sm$^3$).
The annual price for EM is 16.10 €/kg • 6700 kg/god = 107,850 €/yr.

**Odorant tetrahydrothiophen**

Total amount of required odorant is 517.500.000 Sm$^3$/yr • 0.00001295 kg/Sm$^3$ = 6700 kg/yr.
Price of charging for THT is 31.02 €/kg, (or 0.000465 €/Sm$^3$).
The annual price for THT is 31.02 €/kg • 6700 kg/god = 207,850 €/yr. [3]

## 5. CONCLUSION

Replacement and substitution of ethylmercaptan by THT as the odorant for natural gas, is obviously required for the following reasons:

- For the protection of the environment bearing in mind its outstanding cumulative and biocumulativ toxic effect for flora, fauna, biosystem and environmental in general;
- Ethylmercaptan has unstable smell properties especially in the presence of oxide and base. This is particularly expressed in equipment and installations with compressed natural gas (LPG) for the cars;
- In Europe are generaly not used ethylmercaptan for odorization natural gas.
- The harmonization between national and international (EU) laws of regulations in the field of natural gas odorization with the EU.

According to real estimation, of the replacement procedure ethylmercaptan by tetrahydrothiophen can be completed in the next 3 to 4 years. [3, 4]

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ROMANIA - HUNGARY - SERBIA

# QUANTITY AND RECYCLABILITY OF Fe - METALS AT THE END-OF-LIFE VEHICLES IN REPUBLIC OF SERBIA

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**Abstract:**
The growth of the world's population has determined the need for faster, simpler and easier communication. Due to such communication, along with modern social - economic and industrial development, the number of vehicles has largely increased. At the end of life, vehicles represent a potential threat to the environment. This paper gives a statistical view of the number of registered vehicles by brands in Serbia. The amount of Fe – metals by vehicle dismantling, and the possibility of their recycling is shown. It was pointed out the necessity of harmonization of our laws which regulates this area with the laws of the EU, as well as the need for implementation of appropriate ISO standard in the Republic of Serbia.

**Key Words:**
Statistic data, ISO standard, Fe-metals, recyclability

## 1. INTRODUCTION

In order to minimize the impact of vehicles disposal on the environment, the End-of-Life Vehicles Directive (2000/53/EC) aims to promote the collection, reuse and recycling of their components. Generally speaking, there are few problems if the vehicles are disposed and not recycled, like occupying the landfill space, potential leakages of fuel and motor oil into water recipient and soil, emissions of volatile compounds, and possible fires. Some of the components are classified as harmful or either hazardous to the environment. Those problems are still present in recycling operation, if the dismantling operations are not handled by regulations, and this means that all fluids (oil, fuel, windshield washer fluid, anti-freeze, brake liquids, etc), batteries, and other nonmetal parts should be extracted.

In Serbia, the recycling business is present but the most of them are recycling just one sort of material or car parts. For now, the new products are being exported and some of these parts, like batteries, are reused. Fuels are being sent to oil refinery, tires are used in cement industry in combustion processes, but shredder dust, textiles, car seats, glass and some other parts are being landfilled. [2]

## 2. THE STATISTICS OF REGISTERED CARS IN SERBIA

According to data from project "Razvoj integrisanog i održivog sistema reciklaže motornih vozila na kraju životnog ciklusa u Srbiji", in Serbia are 1.534.658 registered passanger vehicles in 2008. [3]

In Serbia, almost one third of total population owns „Zastava" (31%), followed by „Opel" (18%), „Volkswagen" (16%), „Lada", „Fiat" and „Reno" (7%). [3]

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## 3. AMOUNTS OF FE-METALS AND RECYCLING POTENTIONAL BY VEHICLE DISMANTLING

The car is a product of high complexity for whose benefit in the production is used more than hundred different technologies and that are built around 15 000 parts. Car parts are produced from different materials. The total weight of the current passenger car is represented by iron and steel.

The European Union Directive said that the acquisition of vehicles at the end of the life cycle of vehicles and parts should be organized by the state. It is necessary to provide storage and the space to be made by the treatment of spent vehicles and their components.

International Standard ISO 22628 in 2002 very clearly define the issue of recycling of passenger vehicles, which is not the case in Serbia where there is no standard for this. ISO 22628 also defines and recyclability rate (percentage by mass of the new vehicle potentially able to be recycled, reused or both), and recoverability rate (percentage by mass of the new vehicle potentially able to be recovered, reused or both), as shown in the figure 2. [2, 4]

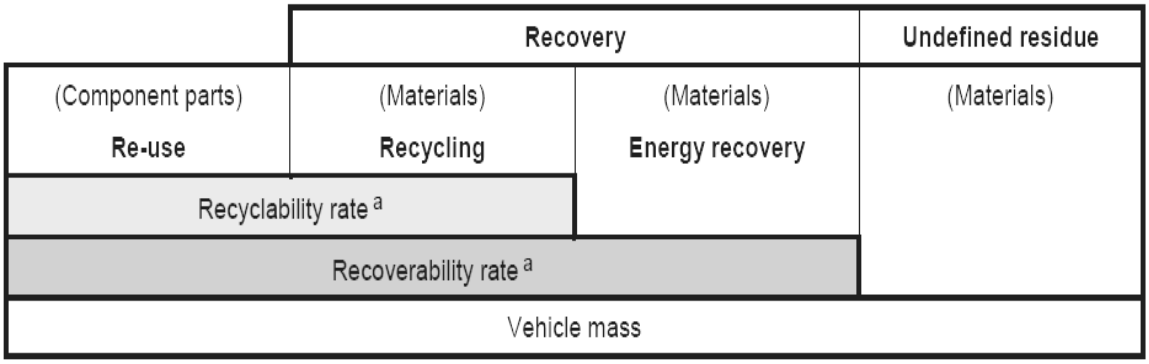



Figure 2. Material distribution of the total mass of vehicles for the further treatment [4]

Almost a third of passenger cars in Serbia are the brand "Zastava" (which is about 511.553 vehicles), which presents models "Koral", "Skala" and "Florida" by one-third (approximately 170.517 vehicles). [1, 3]

Potential for recycling Fe-metals from vehicles "Zastava" is calculated by the following formula:

Number of vehicles from particular model "Zastava" × vehicle weight
× percentage of Fe-metals in vehicle × rate of recyclability

Table 1. Recyclability potential of Fe-metals in "Zastava" vehicles [1]

| Model of Zastava car (Fiat Auto) | Number of vehicles | Vehicle weight [kg] | Percentage of Fe-metals [%] | Rate of recyclability [%] | Fe-Metals recyclability potential [kg] |
|---|---|---|---|---|---|
| Koral | 170.517 | 807 | 73.6 | 62.0 | 62.792.926 |
| Skala | 170.517 | 835 | 75.0 | 62.0 | 66.207.488 |
| Florida | 170.517 | 950 | 73.6 | 62.0 | 73.919.801 |
| | | | | Total | 202.920.215 |

**Zastava Koral**
Vehicle weight: 807 kg

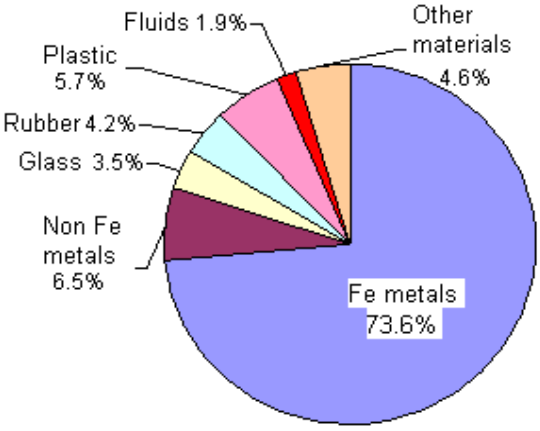



Figure 2. Participation of different types of material in the Zastava Koral [1]

**Zastava Skala**
Vehicle weight: 835 kg

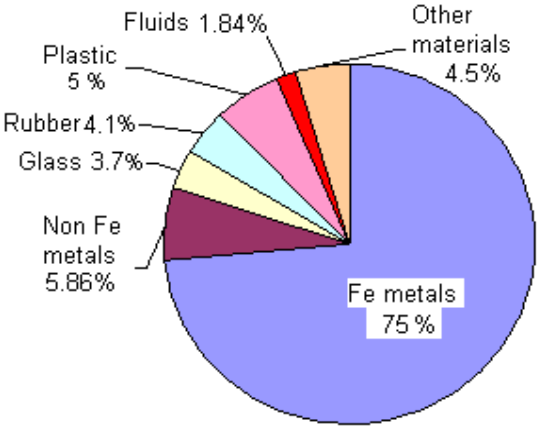



Figure 3. Participation of different types of material in the Zastava Skala [1]

**Zastava Florida**
Vehicle weight: 950 kg

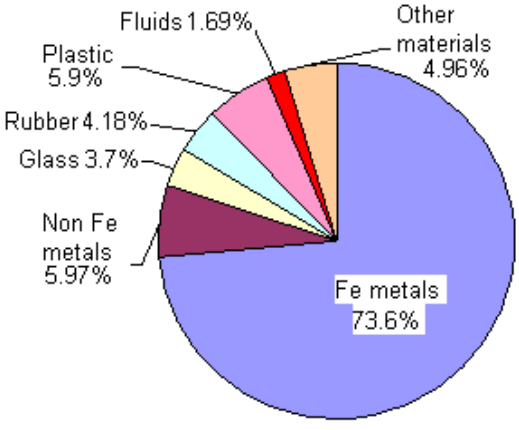



Figure 4. Participation of different types of material in the Zastava Florida [1]

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## 4. CONCLUSION

In this analysis is shown the potential for recycling Fe-metals only from vehicles brand "Zastava", which makes one third of the total number of registered passenger cars in Serbia (according to data for 2008. yr.). The remaining two thirds are foreign vehicle manufacturers with much greater potential for recycling, because they are more massive and have higher rate of recyclability. Serbia has significant capacity for processing Fe-metals, so vehicles for recycling are an important resource.

For accession Serbia to EU, it is necessary to enact a law that regulates this area, and harmonize it with EU legislation. [1, 3]

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# IMPLEMENTATION VERIFICATION REQUIRED EQUIPMENT TO COMBAT PESTS AND DISEASES IN ROMANIA IN ORDER TO ELIMINATE ENVIRONMENTAL CONTAMINATION WITH TOXIC SUBSTANCES

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**Abstract:**
At present, in Romania, the pest and diseases from the agricultural crops it is effected in proportion of 95 percent, by sprinkling and spraying of pesticides in the shape of liquid. These involve a very high risk of contamination of the operator and of the ambient environment with toxic substances. On that account, at present in our country, this risk has to be reduced through the introduction in our legislation of some European standards that suit with UE requirements (example: SR EN 907:2003, SR EN 13790-1:2004, SR EN 13790-2:2004 and so on). As part of this paper the authors presents the settlements that exist at present in Romania, as concerns the machinery test used for the pest and diseases control in agriculture, fruit growing and forestry and which of the European standards are applied.

***Keywords:***
Weed-killing equipments, the pump output, the fan output, output coefficient

## 1. THE CURRENT CONDITIONS IN OUR COUNTRY'S AGRICULTURE REGARDING THE AGRICULTURE SURFACE, SPRINKLED MACHINERY etc.

Romania was and is a prevalent agricultural country. The agricultural surface evolution between 1989 and 2004 is presented in the table from below.

Table 1. The agriculture surface evolution, thousands hectares

| Year | Agricultural Total | Arable | Grasslands | Hay fields | Vineyards and viticulture nursery | Orchards and fruit-growing |
|---|---|---|---|---|---|---|
| 1989 | 14759,0 | 9458,0 | 3257,0 | 1448,0 | 278,0 | 318,0 |
| 1990 | 14769,0 | 9450,0 | 3263,0 | 1465,0 | 277,0 | 131,0 |
| 1991 | 14798,0 | 9423,5 | 3309,8 | 1467,9 | 285,8 | 311,3 |
| 1992 | 14790,0 | 9356,9 | 3349,2 | 1480,6 | 298,6 | 304,8 |
| 1993 | 14793,1 | 9341,5 | 3362,6 | 1489,3 | 303,9 | 295,8 |
| 1994 | 14797,5 | 9338,0 | 3378,4 | 1493,7 | 298,4 | 289,0 |
| 1995 | 14797,2 | 9337,1 | 3392,4 | 1497,7 | 292,4 | 277,6 |
| 1996 | 14788,7 | 9338,9 | 3391,7 | 1498,5 | 289,0 | 270,6 |
| 1997 | 14794,0 | 9341,4 | 3409,8 | 1490,8 | 286,3 | 265,7 |
| 1998 | 14801,7 | 9350,8 | 3402,7 | 1503,4 | 281,8 | 263,0 |
| 1999 | 14730,7 | 9358,1 | 3322,8 | 1512,0 | 281,1 | 256,7 |
| 2000 | 14856,8 | 9381,1 | 3441,7 | 1507,1 | 272,3 | 254,6 |
| 2001 | 14852,3 | 9401,5 | 3421,4 | 1510,0 | 267,4 | 252,0 |
| 2002 | 14836,6 | 9398,5 | 3424,0 | 1513,6 | 259,6 | 240,9 |
| 2003 | 14717,4 | 9414,3 | 3355,0 | 1490,4 | 230,5 | 227,2 |
| 2004 | 14711,6 | 9421,9 | 3346,9 | 1498,4 | 223,3 | 221,1 |

The source: The statistical year-book of Romania, 1990-2005 issues

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The main indicators bound of human potential in Romanian agriculture are presented in table 2.

Table 2. The main indicators evolution of the human potential in Romanian agriculture (1990-2004).

| Year | The total population thousands persons | The rural population thousands persons | The total engaged population thousands persons | The population engaged in agriculture thousands persons | The rural population weight in total population % | The population weight engaged in agriculture in rural population % | The population weight engaged in agriculture in total engaged population % |
|---|---|---|---|---|---|---|---|
| 1990 | 23.207 | 10.598 | 10.840 | 3.055 | 45,7 | 28,8 | 28,2 |
| 1991 | 23.185 | 10.633 | 10.786 | 3.116 | 45,9 | 29,3 | 28,9 |
| 1992 | 22.789 | 10.422 | 10.458 | 3.362 | 45,7 | 32,2 | 32,1 |
| 1993 | 22.755 | 10.349 | 10.062 | 3.537 | 45,5 | 34,2 | 35,2 |
| 1994 | 22.731 | 10.303 | 10.011 | 3.561 | 45,3 | 34,6 | 35,6 |
| 1995 | 22.681 | 10.224 | 9.493 | 3.187 | 45,1 | 31,2 | 33,6 |
| 1996 | 22.608 | 10.196 | 9.379 | 3.249 | 45,1 | 31,9 | 34,6 |
| 1997 | 22.546 | 10.141 | 9.023 | 3.322 | 45,0 | 32,8 | 36,8 |
| 1998 | 22.503 | 10.155 | 8.813 | 3.296 | 45,1 | 32,5 | 37,4 |
| 1999 | 22.458 | 10.155 | 8.420 | 3.419 | 45,2 | 33,7 | 40,6 |
| 2000 | 22.435 | 10.190 | 8.629 | 3.523 | 45,4 | 34,6 | 40,8 |
| 2001 | 22.408 | 10.164 | 8.563 | 3.456 | 45,4 | 34,0 | 40,4 |
| 2002 | 21.795 | 10.186 | 9.234 | 3.357 | 46,7 | 32,9 | 36,3 |
| 2003 | 21.733 | 10.133 | 9.223 | 3.286 | 46,6 | 32,4 | 35,6 |
| 2004 | 21.673 | 9.777 | 9.158 | 2.893 | 45,1 | 29,6 | 31,6 |

The source: The statistic year-book of Romania, 1991 – 2005 issues

At present, the best and deseases control in Romanian agriculture is done, in proportion of 95 % (per cent), by spraying with pesticides in liquid aspect.

In 2005, in Romania, there were 14800 (14832) sprayers for cereal crops and 5640 (5641) sprayers for vineyards and orchards.

Sprayers mealing machinery with mechanical pull park evolution and structure related at the arable surface between 1990 and 2004 is presented in the table from below:

Table 3. The sprayers and mealing machinery with mechanical pull evolution and structure

| Specification | 1990 | 1994 | 1998 | 2002 | 2004 | 2004/ 1990 |
|---|---|---|---|---|---|---|
| Arable surface, thousands hectares | 9.450,0 | 9338,0 | 9350,8 | 9398,5 | 9421,9 | 1,00 |
| Arable surface that correspond on a physical tractor-hectares | 74,37 | 57,92 | 56,76 | 55,53 | 54,84 | 0,74 |
| Sprayers and mealing machinery with mechanical pull sprayers | 14994 | 12099 | 9424 | 7191 | 6573 | 0,44 |

The source: Calculated after the statistic year-book of Romania, 1991 – 2005

## 2. WHAT HAS BEEN ACHIEVED UNTIL NOW:

At present, in Romania, there is not a legislative framework (lawful stipulations regarding the obligatory character), equipment and skilled staff in this domain. 13790 European Norm (EN) concerning the "Sprayers control that are in exploitation" is known by the specialists from Romania, but it is not applied because there are not structures at national level to allow its application.

The operator staff training is actually null, the spraying being inadequately made, that is in discord with the current European norms from this domain. The control measures effected with unskilled staff lead to an accented pollution of the environment.

At present, the National institute is master regarding the new equipments acceptance. The specialists are occupied with: the plant protection machinery certification from the product concordance point of view, the samples effectuation from performance point of view and work safety.

The weed-killing equipments control and verification mainly follows the technical, constructive-functional characteristic properties establishing and of the manner in which, through their engineering and working, they jeopardize the users life safety or pollute the environment.

The institute performs the following determinations:

- the constructive parameters determination;
- the equipment enfeed at the tractor verification;

- the combiner stability determination;
- the working qualitative coefficients determination;
- the power coefficients determination;
- the working coefficients determinations.

The working qualitative coefficients are established at different operating speads of the machinery. For the optional run establishing, the tests manager has to pursue the obtaining of some qualitative coefficients with maximum values. At test the specialists establish:

- the pump output;
- the volumetrically productive capacity of the pump;
- the nozzle output;
- output coefficient;
- the transversal distribution measurement on the test stand;
- the pressure loss measurement;
- the pressure oscillation measurement at the spraying stopping on sections (apron segments);
- the substances norms;
- the fan output;
- the drops size;
- the operating pressure variation during the tanks evacuation;
- the agitation system efficiency.

The specialists from INMA, Cluj-Napoca branch have achieved two test stands of the distribution uniformity of the solution at sprayers, one of them for the sprayers in the field (uniformity on the working breadth) and the other one for the sprayers in space (for the output verification on nozzle).



a) b)

Figure 1. INMA Cluj – Napoca: a) – the stand achieved by INMA Cluj for spraying in field; b) – the team from Cluj together with specialist from Germany (Photo Bungescu Cluj 2008).

## 3. WHAT IS IT DONE AT PRESENT IN ORDER TO INCREASE THE PROFESSIONAL QUALIFICATION OF THE SPECIALISTS FROM THE AGRICULTURE?

A few achievements that contribute to the professional qualification bettering of the specialists from agriculture:

- the "Plant Protection" section establishment at the Agricultural Science and Veterinary Medicine University of Banat – Timisoara in 2002. As part of this specialization, the students also study pest and diseases control machinery in horticulture, vegetable growing, agriculture, fruit growing – viticulture and forestry. In the 3rd year of faculty they study the discipline "Machinery and Equipments for Plant Protection" (28 hours of course and 14 hours of laboratory). The discipline is directed by Dr. eng. Walter Stahli from Germany, co-worker being Dr. eng. Sorin – Tiberiu Bungescu. The discipline has a recent bibliographical material and a modern laboratory (machinery, devices component parts, measuring and control instrumentations) this being possible due to the collaboration with the companies: Lechler, Agrotop, Hardi, albuz and with Hohenheim University from Germany (Prof. dr. Siegfried Kleisinger)
- At the University from Craiova - Romania (Agriculture Faculty) there were already made the first steps for the establishment of this specialization, being, at present, under way of accreditation;
- For the operative staff with medium professional preparedness: agricultural mechanics, school leaver of agricultural high school, farmers from practice it is foreseen the establishment of a school of increasing of professional preparedness at Voiteg (Timis Country) with the support of Mechanization School from DEULA Germany, of Germany's Government, of USAMVB Timisoara and of German forum from Romania.




Figure 2. The students attend at practical demonstrations in field with Berthoud sprayer.



Figure 3. The student attend at practical demonstrations of utilitarian aviation.



Figure 4. Demonstration in Plant Protection Machinery and Equipments discipline laboratory

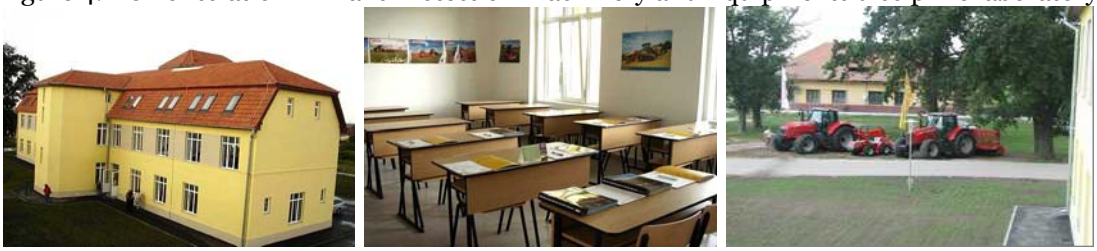


Figure 5. Photo of Agricultural High School at Voiteg (Timis Country)(Photo Bungescu Voiteg 2008)

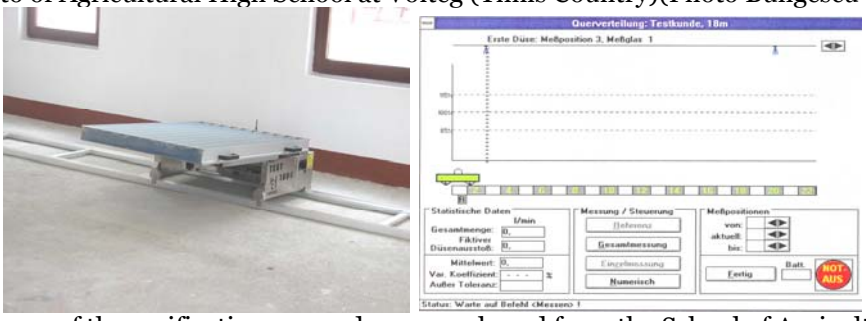



Figure 6. Pictures of the verification sprayed cars purchased from the School of Agriculture at Voiteg (Photo Bungescu Voiteg 2008)

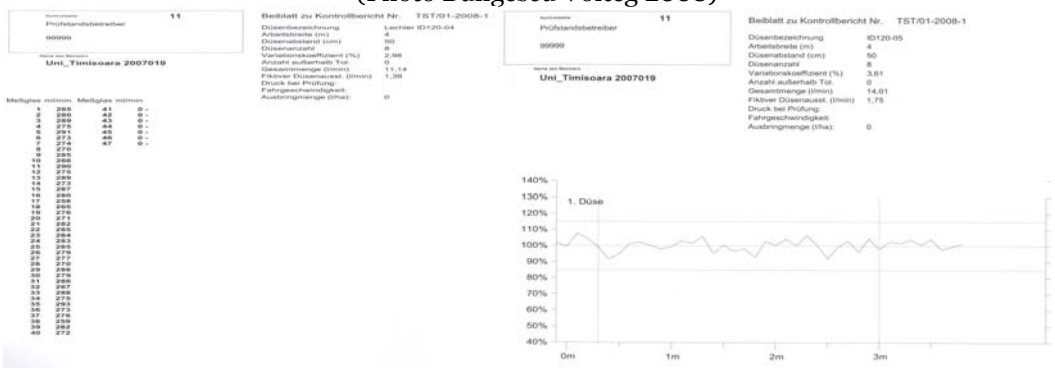



Figure 7. Results obtained from the stand to check a Voiteg of the pest and deseases control equipment (Bungescu 2008)




Figure 8. Plaquette for periodic verification of the pest and deseases control equipment in England.(Photo Bungescu England 2008)

- Romania attended the second workshop on verification equipment sprayed organized by the European Union together with the Federal Office of Plant Protection in Germany that took place in town Straelen in Germany in 2007. At this meeting attended by almost all countries in the European Union. Romania was first entering the books in the future.

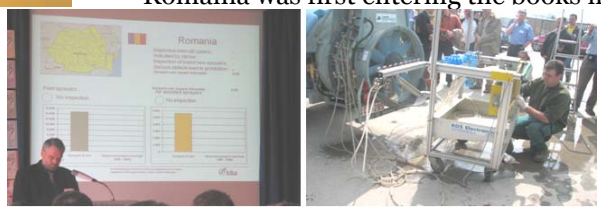



Figure 9. Photos from during the workshop in Germany (Photo Bungescu Germany 2007)

## 4. THE LEGISLATION THAT IA APPLIED AT PRESENT IN ROMANIA, BUT THAT IS NOT COMPULSOR

- **SR ISO 5681:1995** - Machinery and equipments for plant protection. Vocabulary;
- **STAS 9924-74** - Machinery for plant protection. The liquid tanks capacity;
- **STAS 9926-91** - Machinery for plant protection. Work protection and hygiene limitations;
- **SR ISO 6686:1999** - Machinery and equipments for plant protection. Nozzles with anti-eye dropper. Performances determinations;
- **SR ISO 6720:1999** – Agricultural machinery. Sowing machinery, fertilizer sower planting machinery and spraying equipments. Recommended working breadth.
- **STAS 12836-90** –Tractors and agricultural machinery. Methods for the conditions determination at experiments in field;
- **STAS 13042/1-91** –Agricultural machinery. Determination methods of constructive parameters;
- **STAS 13042/2-91** – Agricultural machinery. Determination methods of working coefficient;
- **SR EN ISO 12100-2:2004** – Machinery safety. Basis drafts. General principles of projection. Part 2: Technical principles.
- **SR ISO 730-1+C1:2000** - Agricultural tractors on wheels. Suspension machinery in three points mounted in the back. Part 1: The categories 1, 2, 3 and 4.
- **SR ISO 4254-6:2000** - Forest agricultural machinery and tractors. Technical devices that allow the security ensurance. Part 6: Machinery and equipments for plant protection;

The basis European Norms used for the technical verification of the plant protection equipment in use are:

- **SR EN 13790-1:2003** - Agricultural Machinery. – Sprayers – Inspection of sprayers in use – Part 1: Field crop sprayers, CEN, 2004, Brussels;
- **SR EN 13790-2:2003** - Agricultural Machinery – Sprayers - Inspection of sprayers in use – Part 2: Air-assisted sprayers for bush and tree corps;
- **SR EN 12761-1:2002** – Agricultural and forestry machinery – Sprayers and liquid fertilizer distributors, Environmental protection. – Part 1: General;
- **SR EN 12761-2:2002** - Agricultural and forestry machinery – Sprayers and liquid fertilizer distributors, Environmental protection. – Part 2: Field crop sprayers;
- **SR EN 907:2003** – Agricultural and forest machinery. Sprayers and liquid fertilizers administer machinery. Security.
- **ISO 5681** – Equipment for crop protection – Vocabulary;
- **ISO 10625** – Equipment for crop protection – Sprayer nozzles – Colour coding for identification;
- **ISO 19732** – Equipment for crop protection – Sprayers strainers – Colour coding for identification.

## 5. CONCLUSIONS: WHAT ARE THE EXPECTATIONS FOR THE FUTURE?

- The staff schooling that works in this domain with skilled specialists from UE countries;
- The creation of a control network of the sprayers in use from Romania (see figure 6);
- The new European legislation implementation in this domain at national level;
- The compulsory periodical control introduction of these machinery, control that should be effected by state. Working points: Bucharest, Cluj-Napoca and Timisoara (there were choosen these three cities because at present here there is interest for this domain).
- The organization possibility in the future of a Workshop at the University from Timisoara with Plant Protection Federal Office support from Germany – BBA on control themes of sprayers with a view to implementation in Romania of the European Norms in this domain.

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a) b)

Figure 10. Possible verification center in Romania: a) - A possible control network of sprayers in Romania; b) - The team who can implement in Romania in the future the European legislation in this domain (Bucuresti – Cluj-Napoca – Timisoara).

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# EXAMINATION OF BLACK LOCUST (Robinia pseudoacacia L.) AFFORESTATIONS IN BÁCS-KISKUN COUNTY

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**Abstract**

The traditional methods of soil examination are nowadays not sufficient any more to predetermine the productivity of the given tree species. The nutrient content analysis of the soil is also necessary. We should however know the nutrient demand of tree species, including black locust as well, more exact. Therefore examinations aiming the determination of the plants nutrient content would be necessary. In the course of these examinations the correlation between the nutrient reserves of the soil and the nutrient element content of the plant should be found. If in possession of these data we can complete the traditional soil examination to be performed before afforestations with the determination of the nutrient reserves of the soil, we will be able to prepare a much more exact forecast on the expectable growth of the planned target stand.

**Key words**:

Robinia pseudoacacia, black locust, afforestation, soil examination

## 1. INTRODUCTION

In Hungary there has been afforestations done in agricultural areas of significant extent during the recent decades. These were mainly concentrated to the sand regions of the Great Hungarian Plain. The main reason therefore is, that the traditional field plant production is on these sand-textured soils with little nutrient content the most uneconomical. Afforestation can be considered in these areas also as an activity bringing income, because due to the claimable subsidy system the subsidies cover nearly 100% of the implementation costs and the expenses arising from maintenance until the age of 5-6 years, and the subsequent maintenance costs again can be covered by the incoming revenues from selling timber. The maintenance expenses do not arise every year regularly, but from time to time about every 10 year in comparison with the yearly arising expenses in case of field plant production. Although the earning capacity of sylviculture only amounts to 5-6 % even in the best case, the relatively short cutting interval of 15-30 years ensures an acceptable income even for farmers being used to yearly income.

Due to the above considerations an increasing proportion of people making their living from agriculture afforest their fields. This economic approach requires from afforestation planners as well to review traditional planning principles and to work out some new, more precise methods to make the predetermination of stand growth more accurate.

Farmers afforest yearly 2500 – 3000 ha in Bács-Kiskun County. Among the applied tree species black locust is used most frequently. The reason is that it accomodates itself well to the site extremes, the proportion of its surviving in the afforestations is good, and its timber can be used from relatively young age, at least as firewood. In case of end use at the age of 30-35 years it can be used for several reasons, it is producing timber of a high value. It was not by chance, that the black locust became, 50 years ago already, the tree of the Great Hungarian Plain. The majority of the Hungarian farmers think it is a native tree species and do not know, that it was brought in to Hungary from North-America just 250 years ago.

Since – as mentioned – the afforestations can also be considered as a business activity, the quality of the stands being established in the course of the investment really matters. The findings during exploration of the natural sites before afforestation planning determine the investments for 30-40 years. That is why we have undertaken to examine the progress of

some black locust afforestations and to compare the findings in the natural sites exploration reports with the growth data of the 6-26-year-old stands. We have tried to explain why the growth of an actual stand is good or actually poor.

In our opinion it is more so since necessary to reconsider the aspects of selecting tree species, because the currently used aspects were written down in the 1960's by Dr. Imre Babos and his associates (BABOS et al. 1966). The environmental changes, which have meanwhile taken place and the growing business requirements lead us to reconsider the methods of natural sites exploration. We expect our work to improve the planning of afforestations and as a result to lead to the establishment of better tree stands in the future.

## 2. INSTRUMENTS

Soil drill; soil laboratory – various examining instruments; SUUNTO for measuring tree height and slope, tape measure for measuring diameter

## 3. METHOD

Site exploration in 25 forest tracts, collection and examination of 71 soil samples, in an area of total 113,4 ha.

Determination of site characteristics based on laboratory test and examinations on site. Measuring the height and diameter of at least 30 trees in each forest tracts, calculating average tree measures on this basis.

Determination of stand productivity on the basis of Károly RÉDEI edit. (1997): Handbook of black locust management. (in Hungarian) ERTI, Budapest.

Short, written evaluation of the site and the stand.

Chart 1 Forest improvement model of black locust stands, seed and coppice origin (Rédei edit. 1997)

| Description of improvement cutting | Remaining stand after improvement cutting | | | | | |
|---|---|---|---|---|---|---|
| | Age | Average height (Hm) | Basal area (G) | Average diameter (Dm) | Number of stems (N) | Average stem distance (am) |
| | year | m | $M^2$ | cm | pcs | M |
| | PRODUCTIVITY GROUP I. | | | | | |
| Cleaning | 5-6 | 7 | 7 | 6 | 2500 | 2,2 |
| Cleaning | 9-10 | 12 | 14 | 10 | 1800 | 2,5 |
| Selective thinning | 14-15 | 16 | 14 | 14 | 900 | 3,6 |
| Increment thinning | 23-24 | 22 | 17 | 22 | 450 | 5,1 |
| End use | 35 | 25 | 30 | 29 | 450 | 5,1 |
| | PRODUCTIVITY GROUP II. | | | | | |
| Cleaning | 7-8 | 7 | 8 | 6 | 2700 | 2,7 |
| Cleaning | 12-13 | 11 | 14 | 10 | 1800 | 2,5 |
| Selective thinning | 18-19 | 15 | 14 | 14 | 900 | 3,6 |
| End use | 30 | 18 | 28 | 20 | 900 | 3,6 |
| | PRODUCTIVITY GROUP III | | | | | |
| Cleaning | 9-10 | 7 | 8 | 6 | 3000 | 2,0 |
| Cleaning-like selective thinning | 15-16 | 10 | 8 | 8 | 1600 | 2,7 |
| End use | 25 | 13 | 21 | 13 | 1600 | 2,7 |

The evaluation of the soil characteristics happened due to the following aspects (Barna 1994):

Chart 2 Determination of fertile layer thickness of the forest soils depending on climate conditions

| Categories | Beech and hornbeam-oak climate | Turkay and Sessile oak - forest steppe climate |
|---|---|---|
| | cm | |
| Very shallow (ISE) | 0-20 | 0-40 |
| Shallow (SE) | 20-40 | 40-60 |
| Medium-deep (KMÉ) | 40-60 | 60-90 |
| Deep (MÉLY) | 60-100 | 90-140 |
| Very deer (IMÉ) | 100- | 140- |

Chart 3 Specific values of physical soil types

| Physical soil types | Hy (%) | Soil plasticity according to Arany | 5-hour capillary water rise (mm) |
|---|---|---|---|
| Rubble (TÖ) | - | - | - |
| Coarse sand (DHO) | -0,3 | - | 450- |
| Sand (HO) | 0,3-1,0 | -50 | 450-300 |
| Loam (V) | 1,0-5,0 | 30-50 | 300-75 |
| Clay (AG) | 5,0-6,0 | 50-60 | 75-40 |
| Heavy clay (NAG) | 6,0- | 60- | -40 |

Chart 4 pH-value of soils

| Categories | pH |
|---|---|
| Very strongly acidic | -3,0 |
| Strongly acidic | 3,0-4,0 |
| Sour | 4,0-5,0 |
| Slightly acidic | 5,0-6,8 |
| Neutral | 6,8-7,2 |
| Slightly alkaline | 7,2-8,0 |
| Alkaline | 8,0-9,0 |
| Strongly alkaline | 9,0-10,0 |
| Very strongly alkaline | 10,-11,0 |

Chart 5 Lime content of soils

| Categories | Lime content (%) |
|---|---|
| Calciferous in patches | 0-1 |
| Low-lime | 1-5 |
| Calciferous | 5- |

Chart 6 Humus content of soils

| Categories | Humus content (%) |
|---|---|
| Humus free | 0 |
| Low humus | 1-2 |
| Humus | 2-4 |
| High humus | 4-10 |
| Moorland | 10- |

## 4. CONCLUSIONS

In the course of the examination we have evaluated at the end 22 forest tracts. The total area amounts to 113,4 ha. The facts of the forest tracts are summarized in the chart 7/1-5.

**Unfavourable soil characteristics** (marked with red in the charts 7/1-5.)

1. The growth of the examined black locust stands is first and foremost influenced by the fertile layer thickness of the soil. Generally is a shallow fertile layer less than 40 cm already unfavourable.
2. This unfavourable effect is intensified, if the lime-content of the surface soil is about 5 % , and
3. straight below the sodium content reaches or exceeds 0,02%.
4. Furthermore the mechanical composition of the soil impacted also on the stand growth. The growth was further harmed, if the proportion of coarse sand in the surface soil exceeded 25%.

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Among the above mentioned soil characteristics the soil drought is increased by the shallow, calciferous fertile layer of soil composed of coarse sand. The examined sites belong to the water resources management levels very dry – dry. And the sodium content of about 0,02% has already a toxic effect on the roots. The situation is aggravated thereby, that straight below the shallow – very shallow fertile layer significant sodium content can be detected!

Chart 7/1. Soil examinations

| | Village, member, item | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Császártöltés 247A | | Császártöltés 247B | | Császártöltés 16H | | | Császártöltés 81B | | |
| Area (ha) | 14,4 | | 4,2 | | 1,8 | | | 10,0 | | |
| Sstand | Robinia pseudoacacia | | Robinia pseudoacacia | | Robinia pseudoacacia | | | Robinia pseudoacacia | | |
| Age in 2005 (years) | 6 | | 6 | | 16 | | | 26 | | |
| Examined soil layers (cm): | 0-70 | 70-200 | 0-80 | 80-200 | 0-60 | 60-100 | 100-200 | 0-20 | 20-140 | 140-200 |
| Climate | ESZTY | | ESZTY | | ESZTY | | | ESZTY | | |
| Hydrology | VFLEN | | VFLEN | | VFLEN | | | VFLEN | | |
| Gen. soil type | HH | | HH | | HH | | | HH | | |
| Thickness of fertile layer of the soil (cm): | KMÉ | | KMÉ | | KMÉ | | | ISE | | |
| Physical soil types | HO | | HO | | HO | | | HO | | |
| pH $H_2O$ | 8,1 | 8,5 | 7,9 | 8,5 | 7,9 | 8,0 | 8,4 | 8,0 | 8,3 | 8,5 |
| pH KCl | 7,7 | 8,1 | 7,6 | 8,0 | 7,3 | 7,4 | 7,7 | 7,4 | 8,0 | 8,1 |
| $CaCO_3$ (%) | 10,4 | 12,7 | 10,1 | 11,1 | 3,8 | 23,1 | 31,5 | 10,0 | 9,2 | 11,3 |
| Sodium (%) | | 0,035 | | 0,037 | | | 0,042 | | 0,023 | 0,026 |
| Total salt (%) | | | | | | | | | | |
| hy (%) | 0,35 | 0,31 | 0,39 | 0,27 | 1,29 | 1,15 | 0,72 | 0,38 | 0,34 | 0,27 |
| $K_A$ | | | | | 33 | 34 | | | | |
| 5-hour capillary water rise (mm) | 310 | 415 | 280 | 430 | 380 | 340 | 325 | 225 | 380 | 360 |
| Humus (%) | 0,39 | 0,16 | 0,49 | 0,14 | 1,40 | 1,21 | | 0,60 | 0,35 | 0,16 |
| Mechanical composition: clay | 0,68 | 1,03 | 0,80 | 0,88 | 6,00 | 8,35 | 2,80 | 1,30 | 1,40 | 1,20 |
| silt | 2,64 | 2,85 | 3,00 | 2,71 | 14,20 | 18,40 | 20,70 | 2,70 | 2,60 | 1,80 |
| fine sand | 81,18 | 84,12 | 79,50 | 80,00 | 77,00 | 71,35 | 73,20 | 82,00 | 79,10 | 72,80 |
| coarse sand | 15,50 | 12,00 | 16,70 | 16,40 | 2,30 | 1,90 | 3,30 | 14,00 | 16,90 | 24,20 |
| Average height (m) | 5,0 | | 5,0 | | 14,0 | | | 15,0 | | |
| Average diameter (cm) | 5,0 | | 4,0 | | 14,0 | | | 12,0 | | |
| Classification | Productivity group I. | | Productivity group I. | | Productivity group II. | | | Productivity group III. | | |
| Notes | The medium-deep fertile layer of the soil can compensate the unfavourable effects of the high lime- and sodium content for the time being! Supplementary examinations are necessary! | | The medium-deep, slightly loaming fertile layer of the soil can compensate the unfavourable effects of the high lime- and sodium content for the time being! Supplementary examinations are necessary! | | The depth of the low humus content in the fertile layer of the soil can compensate the unfavourable effects of the high lime- and sodium content only on a limited scale! | | | The very shallow fertile layer of the soil and the high lime- and sodium-content measurable in the whole section collectively cause the poor growth! | | |

Chart 7/2. Soil examinations

| | Village, member, item | | | |
|---|---|---|---|---|
| | Császártöltés $91B_3$ | Bugac 315C | Bugac 272C | Kisszállás 73F |

| Area (ha) | 4,4 | | | 12,1 | | 2,2 | | | 8,8 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Target stand | Robinia pseudoacacia | | | Robinia pseudoacacia | | Robinia pseudoacacia | | | Robinia pseudoacacia | | |
| Age in 2005 (years) | 27 | | | 8 | | 6 | | | 7 | | |
| Examined soil layers (cm): | 0-10 | 10-50 | 50-200 | 0-60 | 60-200 | 0-55 | 55-80 | 80- | 0-30 | 30-60 | 60- |
| Climate | ESZTY | | | ESZTY | | ESZTY | | | ESZTY | | |
| Hydrology | VFLEN | | | VFLEN | | VFLEN | | | VFLEN | | |
| Gen. soil type | HH | | | HH | | HH | | | HH | | |
| Thickness of fertile layer of the soil (cm): | ISE | | | KMÉ | | SE | | | ISE | | |
| Physical soil types | HO | | | HO | | HO | | | HO | | |
| pH $H_2O$ | 7,6 | 8,5 | 8,7 | 8,1 | 8,6 | 8,1 | 8,5 | 8,6 | 7,7 | 8,3 | 8,3 |
| pH KCl | 7,5 | 7,9 | 8,2 | 7,6 | 8,3 | 7,6 | 7,7 | 7,9 | 7,3 | 7,9 | 7,5 |
| $CaCO_3$ (%) | 9,9 | 10,2 | 8,4 | 4,0 | 11,5 | 3,3 | 12,5 | 15,7 | 1,1 | 7,1 | 17,7 |
| Sodium (%) | | 0,032 | 0,032 | | 0,031 | | 0,028 | 0,047 | | 0,026 | 0,044 |
| Total salt (%) | | | | | | | | | | | 0,010 |
| hy (%) | 0,50 | 0,27 | 0,22 | 0,46 | 0,20 | 1,00 | 0,59 | 0,37 | 0,61 | 0,30 | 1,08 |
| $K_A$ | | | | | | | | | | | |
| 5-hour capillary water rise (mm) | 170 | 390 | 410 | 300 | 510 | 390 | 415 | 465 | 110 | 435 | 395 |
| Humus (%) | 0,86 | 0,23 | | 0,81 | | 1,30 | 0,57 | 0,19 | 1,12 | 0,13 | 0,67 |
| Mechanical composition: clay | 2,52 | 1,50 | 0,62 | 1,35 | 0,95 | 1,80 | 2,90 | 0,95 | 1,70 | 1,50 | 0,10 |
| silt | 2,58 | 2,15 | 3,38 | 3,50 | 0,88 | 12,50 | 6,03 | 3,98 | 3,80 | 2,40 | 22,40 |
| fine sand | 79,50 | 82,65 | 85,60 | 70,85 | 78,37 | 72,25 | 80,77 | 78,67 | 74,20 | 77,90 | 72,10 |
| coarse sand | 15,70 | 13,70 | 10,40 | 24,30 | 19,80 | 13,50 | 10,30 | 16,40 | 20,30 | 18,20 | 5,40 |
| Average height (m) | 10,0 | | | 9,0 | | 10,0 | | | 9,0 | | |
| Average diameter (cm) | 4,0 | | | 10,0 | | 7,0 | | | 10,0 | | |
| Classification | Productivity group III. | | | Productivity group I. | | Productivity group I. | | | Productivity group I. | | |
| Notes | The very shallow fertile layer of the soil and the high lime- and sodium-content measurable in the whole section collectively cause the poor growth! | | | The low humus, medium-deep fertile layer of soil can compensate the high lime- and sodium-content of the lower layers for time being! | | The low humus content of the fertile layer of the soil can be classified as nearly medium-deep! This is sufficient for the primarily well growth of the black locust! | | | The root system of the stand has presumably not filled out fertile layer of soil yet. Supplementary data are necessary for verifying the showed well growth in contempt of the relatively poor site! | | |

**Favourable soil characteristics** (marked with green in the charts 7/1-5.)

1. At least medium-deep (deeper than 50 cm) fertile layer of soil.
2. Low lime content of fertile layer of soil (below 5%).
3. Low sodium content of the subsoil (below 0,02 %).
4. Humus content more than 1,00 %.
5. Loaming soil (silt content about 10%), and low proportion of coarse sand.

These soil characteristics should be accordingly taken into consideration to a greater extent in the course of afforestation planning. The data also show that we could classify only young, at most 10 years old stands into the productivity group I. The older stands of 26-27 years all belong due to their growth to the poorest productivity group III. *It can be accordingly expected, that the growth of the at first well growing black locust stands will later fall back thus far, as the root system fills out the lime- and sodium-free fertile layer of soil.* Since it is in the examined forest tracts generally shallow, it can be stated with certainty that this quality decrease is due to happen soon!

**Abbreviations used in the Charts 7/1-5:**

| | |
|---|---|
| Climate: | ESZTY – forest steppe |
| Hydrology: | VFLEN – independent of the phreatic water |
| Genetically soil type: | HH – sandy soil with poor humus content |
| Thickness of nfertile layer of the soil: | ISE – very shallow |
| | SE – shallow |
| | KMÉ – medium deep |
| Physical soil type: | HO – sand |

Chart 7/3. Soil examinations

| | Village, member, item | | | |
|---|---|---|---|---|
| | Kisszállás 73D | Kelebia 138C | Kelebia 169N | Kelebia 164C |
| Area (ha) | 8,9 | 3,2 | 4,9 | 4,0 |

| Target stand | Robinia pseudoacacia | | | Robinia pseudoacacia | | | Robinia pseudoacacia | | Robinia pseudoacacia | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age in 2005 (years) | 7 | | | 6 | | | 8 | | 8 | | |
| Examined soil layers (cm): | 0-30 | 30-60 | 60- | 0-45 | 45-60 | 60- | 0-50 | 50- | 0-30 | 30-60 | 60- |
| Climate | ESZTY | | | ESZTY | | | ESZTY | | ESZTY | | |
| Hydrology | VFLEN | | | VFLEN | | | VFLEN | | VFLEN | | |
| Gen. soil type | HH | | | HH | | | HH | | HH | | |
| Thickness of fertile layer of the soil (cm) | ISE | | | SE | | | SE | | SE | | |
| Physical soil types | HO | | | HO | | | HO | | HO | | |
| pH $H_2O$ | 8,3 | 8,4 | 8,3 | 7,4 | 7,8 | 8,4 | 7,9 | 8,2 | 7,9 | 8,3 | 8,5 |
| pH KCl | 7,8 | 7,9 | 7,4 | 7,1 | 7,4 | 7,9 | 7,6 | 7,8 | 7,6 | 7,9 | 8,1 |
| $CaCO_3$ (%) | 3,3 | 3,2 | 6,0 | 1,6 | 2,6 | 4,2 | 3,8 | 3,2 | 3,0 | 4,4 | 7,2 |
| Sodium (%) | | 0,025 | 0,014 | | | 0,033 | | 0,012 | | 0,021 | 0,022 |
| Total salt (%) | | | 0,010 | | | | | | | | |
| hy (%) | 0,33 | 0,30 | 0,86 | 0,34 | 0,27 | 0,29 | 0,25 | 0,25 | 0,36 | 0,28 | 0,21 |
| $K_A$ | | | | | | | | | | | |
| 5-hour capillary water rise (mm) | 350 | 395 | 465 | 150 | 420 | 440 | 350 | 430 | 175 | 410 | 475 |
| Humus (%) | 0,22 | 0,17 | 0,43 | 0,46 | 0,22 | 0,18 | 0,19 | 0,19 | 0,58 | 0,22 | |
| Mechanical composition: clay | 1,70 | 1,80 | 1,30 | 1,80 | 1,50 | 0,90 | 0,80 | 0,50 | 1,30 | 1,30 | 0,70 |
| Silt | 1,70 | 1,10 | 8,40 | 0,90 | 0,80 | 2,80 | 1,10 | 1,30 | 1,80 | 1,20 | 1,60 |
| fine sand | 81,90 | 80,70 | 84,60 | 79,30 | 81,60 | 77,10 | 75,30 | 82,20 | 80,70 | 80,50 | 75,80 |
| coarse sand | 14,70 | 16,40 | 5,70 | 18,00 | 16,10 | 19,20 | 22,60 | 16,00 | 16,20 | 17,00 | 21,90 |
| Average height (m) | 7,0 | | | 6,0 | | | 9,0 | | 9,0 | | |
| Average diameter (cm) | 7,0 | | | 6,0 | | | 8,0 | | 8,0 | | |
| Classification | Productivity group II. | | | Productivity group I. | | | Productivity group I. | | Productivity group I. | | |
| Notes | Despite very shallow fertile layer of the soil and shallow presented sodium-content the black locust shows medium growth. We have expected poorer results due to the facts! Therefore supplementary examinations are necessary for reliable evaluation! | | | Despite very shallow fertile layer of the soil and relatively shallow presented high sodium-content the black locust is well-grown for the time being. The examined soil characteristics do not explain it! Therefore supplementary examinations are also necessary for reliable evaluation of the site! The decreasing of the stand growth is to be expected soon! | | | The fertile layer of the soil nearly classifiable as medium-deep and the relatively low lime- and sodium-content enable the black locust to grow well for the present. Supplementary examinations would be still necessary! | | Despite shallow fertile layer of the soil and relatively shallow presented high sodium-content the black locust is well-grown for now. The examined soil characteristics do not explain that! Therefore supplementary examinations are also necessary for reliable evaluation of the site! | | |

Chart 7/4. Soil examinations

| | Village, member, item | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tompa 89D | | Kisszállás 58E | | Kerekegyháza $47K_1$ | | Kerekegyháza $47K_2$ | | Kerekegyháza $45F_1$ | | |
| Area (ha) | 5,2 | | 3,0 | | 2,5 | | 2,5 | | 2,3 | | |
| Target stand | A | | A | | A | | A | | A | | |
| Age in 2005 (years) | 8 | | 8 | | 9 | | 9 | | 10 | | |
| Examined soil layers (cm): | 0-40 | 40-180 | 0-10 | 10-180 | 0-85 | 85-180 | 0-60 | 60-180 | 0-50 | 50-80 | 80- |
| Climate | ESZTY | | ESZTY | | ESZTY | | ESZTY | | ESZTY | | |
| Hydrology | VFLEN | | VFLEN | | VFLEN | | VFLEN | | VFLEN | | |
| Gen. soil type | HH | | HH | | HH | | HH | | HH | | |
| Thickness of fertile layer of the soil (cm): | SE | | ISE | | KMÉ | | KMÉ | | KMÉ | | |
| Physical soil types | HO | | HO | | HO | | HO | | HO | | |
| pH $H_2O$ | 7,5 | 8,3 | 7,5 | 8,2 | 8,3 | 8,5 | 8,4 | 8,7 | 8,2 | 8,8 | 8,5 |
| pH KCl | 7,0 | 7,9 | 7,0 | 7,9 | 7,7 | 7,9 | 7,9 | 8,2 | 7,9 | 8,3 | 8,6 |

Chart 7/4. Soil examinations (continuing)

| | Village, member, item | | | | |
|---|---|---|---|---|---|
| | Tompa 89D | Kisszállás 58E | Kerekegyháza $47K_1$ | Kerekegyháza $47K_2$ | Kerekegyháza $45F_1$ |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CaCO_3$ (%) | | 12,0 | | 10,9 | 6,8 | 13,3 | 7,2 | 11,5 | 9,3 | 11,5 | 7,3 |
| Sodium (%) | | 0,037 | | 0,032 | | 0,028 | | 0,027 | | 0,024 | 0,030 |
| Total salt (%) | | | | | | | | | | | |
| hy (%) | 0,89 | 0,35 | 0,92 | 0,38 | 0,41 | 0,43 | 0,36 | 0,25 | 0,37 | 0,22 | 0,46 |
| $K_A$ | | | | | | | | | | | |
| 5-hour capillary water rise (mm) | 335 | 390 | 350 | 500 | 285 | 480 | 390 | 415 | 215 | 425 | 200 |
| Humus (%) | 1,32 | 0,29 | 1,30 | 0,21 | 0,45 | 0,18 | 0,38 | | 0,37 | | 0,29 |
| Mechanical composition: clay | 1,60 | 5,80 | 1,60 | 2,30 | 1,80 | 1,60 | 1,70 | 1,30 | 1,80 | 1,40 | 3,80 |
| silt | 10,20 | 4,20 | 10,80 | 4,00 | 2,70 | 4,90 | 2,20 | 1,50 | 2,10 | 0,80 | 1,90 |
| fine sand | 69,00 | 59,90 | 73,10 | 72,10 | 31,00 | 80,10 | 64,70 | 70,40 | 62,60 | 55,00 | 79,60 |
| coarse sand | 19,20 | 30,10 | 14,50 | 21,60 | 26,50 | 13,40 | 31,40 | 26,80 | 33,50 | 42,80 | 14,70 |
| Average height (m) | 9,0 | | 8,0 | | 9,5 | | 3,2 | | 6,8 | | |
| Average diameter (cm) | 9,0 | | 9,0 | | 10,0 | | 3,0 | | 8,0 | | |
| Classification | **Productivity group I.** | | **Productivity group I.** | | **Productivity group II.** | | **Productivity group III.** | | **Productivity group III.** | | |
| Notes | The unfavourable effects of shallow fertile layer of the soil and shallow presented sodium are compensated by loaming structure and low humus content! | | The unfavourable effects of shallow fertile layer of the soil and shallow presented sodium are compensated by loaming structure and low humus content! | | The relatively high lime-content damages the unfavourable effects of medium-deep fertile layer of the soil! Supplementary examinations are necessary! | | The above facts do not explain such poor growth of the young black locust stand! Supplementary examinations are necessary! | | Despite medium-deep fertile layer of the soil because of high lime- and sodium-content in the whole section and low humus content the black locust shows poor growth. Nevertheless supplementary examinations would be necessary for reliable evaluation of the site! | | |

Chart 7/5. Soil examinations

| | Village, member, item | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Kerekegyháza 45$F_2$ | | Lajosmizse 110H | | Lajosmizse 110J | | Lajosmizse 111E | |
| Area (ha) | 2,3 | | 2,3 | | 2,6 | | 7,5 | |
| Target stand | A | | A | | A | | A | |
| Age in 2005 (years) | 10 | | 10 | | 10 | | 7 | |
| Examined soil layers (cm): | **0-35** | 35-180 | **0-60** | 60-180 | **0-70** | 70-130 | **0-55** | 55-140 |
| Climate | ESZTY | | ESZTY | | ESZTY | | ESZTY | |
| Hydrology | VFLEN | | VFLEN | | VFLEN | | VFLEN | |
| Gen. soil type | HH | | HH | | HH | | HH | |
| Thickness of fertile layer of the soil (cm): | **ISE** | | **KMÉ** | | **KMÉ** | | **SE** | |
| Physical soil types | HO | | HO | | HO | | HO | |
| pH $H_2O$ | 8,2 | 8,9 | 8,2 | 8,5 | 8,2 | 8,4 | 8,2 | 8,5 |
| pH KCl | 7,8 | 8,3 | 7,6 | 7,8 | 7,7 | 7,6 | 7,8 | 7,9 |
| $CaCO_3$ (%) | **7,6** | **17,2** | **3,0** | **24,2** | **6,0** | **3,0** | **2,1** | **1,0** |
| Sodium (%) | | **0,031** | | **0,052** | | **0,026** | | **0,030** |
| Total salt (%) | | | | | | | | |
| hy (%) | 0,40 | 0,20 | 0,52 | 0,73 | 0,47 | 0,67 | 0,46 | 0,38 |
| $K_A$ | | | | | | | | |
| 5-hour capillary water rise (mm) | 320 | 450 | 355 | 460 | 430 | 445 | 390 | 380 |
| Humus (%) | 0,51 | | **0,66** | | **0,40** | **0,57** | **0,31** | **0,32** |
| Mechanical composition: clay | 1,50 | 0,10 | 0,20 | 0,08 | 2,60 | 5,80 | 3,20 | 1,40 |
| silt | 2,90 | 1,70 | 5,20 | 9,90 | 2,90 | 3,00 | 2,40 | 2,20 |
| fine sand | 62,00 | 81,60 | 78,80 | 87,50 | 75,80 | 71,20 | 74,20 | 67,80 |
| coarse sand | 33,60 | 16,60 | 15,80 | 2,50 | 18,70 | 20,00 | 20,20 | 28,60 |
| Average height (m) | 3,7 | | 8,0 | | 6,0 | | 3,0 | |
| Average diameter (cm) | 3,5 | | 10,0 | | 8,0 | | 2,0 | |

Chart 7/5. Soil examinations (continuing)

| | Village, member, item | | | |
|---|---|---|---|---|
| | Kerekegyháza 45$F_2$ | Lajosmizse 110H | Lajosmizse 110J | Lajosmizse 111E |

| Classification | Productivity group III. | Productivity group II. | Productivity group III. | Productivity group III. |
|---|---|---|---|---|
| Notes | The very shallow fertile layer of the soil, the high lime- and sodium-content and the soil poor in organic materials and rich in coarse sand explain properly the extremely poor growth of the black locust. Extremely dry site! | Despite high lime- and sodium-content the black locust stand shows surprisingly well growth. The well growth is due to the medium-deep fertile layer of the soil! Supplementary examinations would be necessary! Extremely dry site! | The above facts do not explain such poor growth of the black locust. Supplementary examinations would be necessary! Extremely dry site! | The above facts do not explain such poor growth of the black locust. Supplementary examinations would be necessary! Extremely dry site! |

After all it has become obvious, that the afforestation planning nowadays can not be based only on these, traditional examination aspects any more. We have come namely to contradictory or unexplainable results in more cases. Glaring examples for that show the forest tracts Kelebia 169N and Kerekegyháza 47K. In these and similar cases detailed nutrient testing would be also necessary for evaluating site quality. The examinations should be extended at least to the following elements: N, P, K, Ca, Mg, Zn, Fe, Mn.

*And the case Kisszállás 58E shows that the depth situation of lime and sodium should be determined more exact!*

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# DEPOSITIONAL ENVIRONMENT OF THE DANUBE-TISZA-DANUBE HYDROSYSTEM OF SOUTHERN BANAT OBTAINED FROM SOME PARAMETERS OF METAL ADSORPTION IN WATER

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**ABSTRACT**

An increasingly demand for meliorative action of Southern Banat region was evaluated by the parameters of adsorption of alkaline and heavy metals from suspended particles of the DTD canal water. Annual dynamics is categorized by statistical analyses, recognized trends of sodium absorption ratio and a concentration of iron in total suspended solids. All these provide preliminary informational basis for irrigation, flood areas and transportation determination. Environmental protection of these waters is required because iron and sodium are present in alluvial deposits, and the sodium is gradually increasing. EDS informative data pointed out metals (aluminum, titanium, zinc, iron) in alluvium of the Danube.

**Key words:**
SAR, Fe/TSS, adsorption, Box-plot, South Banat, DTD hydrosystem

## 1. INTRODUCTION

Large river transportation of loess material includes the loessification process which converts deposits. The building of dames and gates, and channelization of rivers slowly influnced on transportation of metals during sedimentation at the reduced river flow [2, 6, 7, 11, 12]. Meliorative canals could cause displacement of bio-activity of the soil of agricultural Vojvodina Province [5,9]. Therefore, in this paper, the movement of metals was observed from the assessment of metal adsorption in water from the index of sodium alkalization ratio- SAR and ratio of iron in total suspended solids- Fe/TSS.

## 2. MATERIAL AND METHODS

Our model to study progress of alkalization of waters in Southern Banat region from continual monitoring of the Danube-Tisa-Danube hydrosystem is represented. The SAR index- sodium adsorption ratio in miliequivalents- $SAR = Na / \sqrt{(Ca + Mg)/2}$, was calculated according to guidelines for interpretations of irrigation water quality [1, 3] and the amount of iron in suspended material Fe/TSS from concentration in mg/l [2], and bioindicators [5, 9]. Integrating data are taken from Hydrological yearbooks [4].

Deposit analysis of the groundwater drainage wells was made by the use of Scanning Electron Microscope (SEM) JEOL JSM-6460 L. The EDS pattern of elemental composition (total wt %) were recorded on an OXFORD INCA Microanalyses suite and presented in diagram. A spatial framework for collecting, storing, and classifying information on the character of river network was proposed using the software Stat.soft Statistica 8 [13].

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## 3. THE RESULTS AND DISCUSSION

Following categorization of indices and conductivity in suspended material in BLOCKS (Figs. 1-5), the ratio of iron in total suspended solids increased during the lowest concentration of solids estimated in rivers Tamis, Brzava and Moravica in the Tamis river basin. Hence, the tributaries of Great canal Banatska Palanka-Novi Becej were investigated and categorized with elevated suspended solids- an increased sedimentatation obtained from the comparison of values with the The Danube in Southern Banat (St Pančevo- at the confluence of the Tamis river, downstream St Smederevo, St Banatska Palanka- at the confluence of canal network in Banat). Near the Botos- the gate of The Tamis and DTD hydrosystem, the movement of iron in total suspended solids was narrow. Previously, the fraction of iron in total suspended solids was obtained from The Sava River in Croatia pointed out by author- median 3 % [2], while in The Danube River it stretches through 1-3 % of median values. The integrating data of the small eutrophic Moravica river pointed out 3 % median of Fe/TSS ratio and there was the smallest fraction of the iron in suspended solids obtained from a decade of the research but comparable to acceleration of alkaline metal adsorption in 2005 of depositional environment. The sedimentation of iron is clarified in the samples of The Karas River when the concentration od suspended solids was in the range 0-10 mg/l (Figs. 1-2). From this point of wiew, the importance of research of sediments of residential areas is important [8].

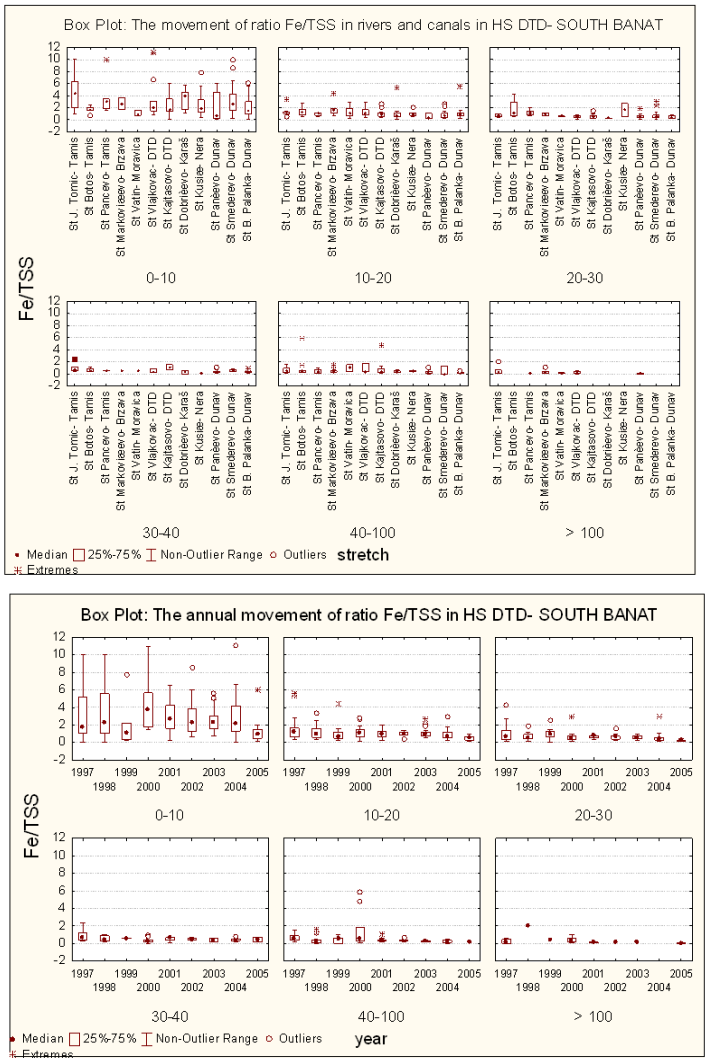



Figure 1-2. Box-plot graphs of ratio of iron in total suspended solids categorized in annual dynamics of data and stretches obtained from HS DTD of Southern Banat Region

The equality of means of metal adsorption parameters downstream the main gates of the Tamis River hydrographic unit (Tamis, Brzava and Moravica) and southern tributaries of The Danube- Karas and Nera were tested by ANOVA (Fig. 7). Obtained from standardized values of the SAR index and ratio of iron in total suspended solids, the similiar values are evaluated in the rivers Tamis, Nera and The Danube River nearly The St Smederevo (correlation of the phosphates with the SAR index pointed

out the level of erosion). The confluence of phosphates, obtained from standardized values, was higher at the localities St Jasa Tomic- Tamis River, St Markovicevo- Brzava, St Kusić- Nera and St Smederevo- The Danube during the period 1997-2005. The comparison of parameters Fe/TSS and SAR index is showing the similiar variability at the same localities 1997-2005 while the negative standardized values were observable at the boundary Station Jasa Tomic- Tamis River, Brzava, Nera and St Smederevo- The Danube (Figs. 1- 7).

The consequence of seasonality between November-February from weather warming generated high water because of snow melting after cold period in February of 1999 when the huge quantity of precipitation in Bega river basin contributed in high water level [10]. During the same period of high water in hydrographical basin of the Tisza and The Danube River, the weather in Ukraine triggered increasing of cezium in The Danube [7]. Taking responsible activities of Romania-Serbia engineers: hydroelectrical interventions, retention and distribution of water in Banat region are concerned for the next decade.

Integrating data of iron and alkaline metals of Danube-Tisza-Danube hydrosystem pointed out depositional environment (Figs. 1 - 8). The alteration of indices was observed in drought 2000 year. Obtained through the dynamics of metals in alluvion of Carpathian rivers entering Serbia, there was measured the highest concentration of metals and conductivity during sedimentation in DTD hydrosystem in Banat region in 2000. The concentration of copper significantly increased during the drought 2000 year, but the metal reduction gradually decreased in rainy year 2001 [4]. After the high erosion of water, the movement of metals in DTD hydrosystem could be categorized as C 3 - S 1 – good irrigation water quality of meliorative hydrosystem. The study of biodiversity of algae in southern Banat indicated good ecolological potential compared with the brackish water diatoms such as *Entomoneis paludosa* and *Bacillaria paradoxa*. The prominent algae of Banat from genus *Cymbella* thrive in canals during the low iron content (Fig. 8).

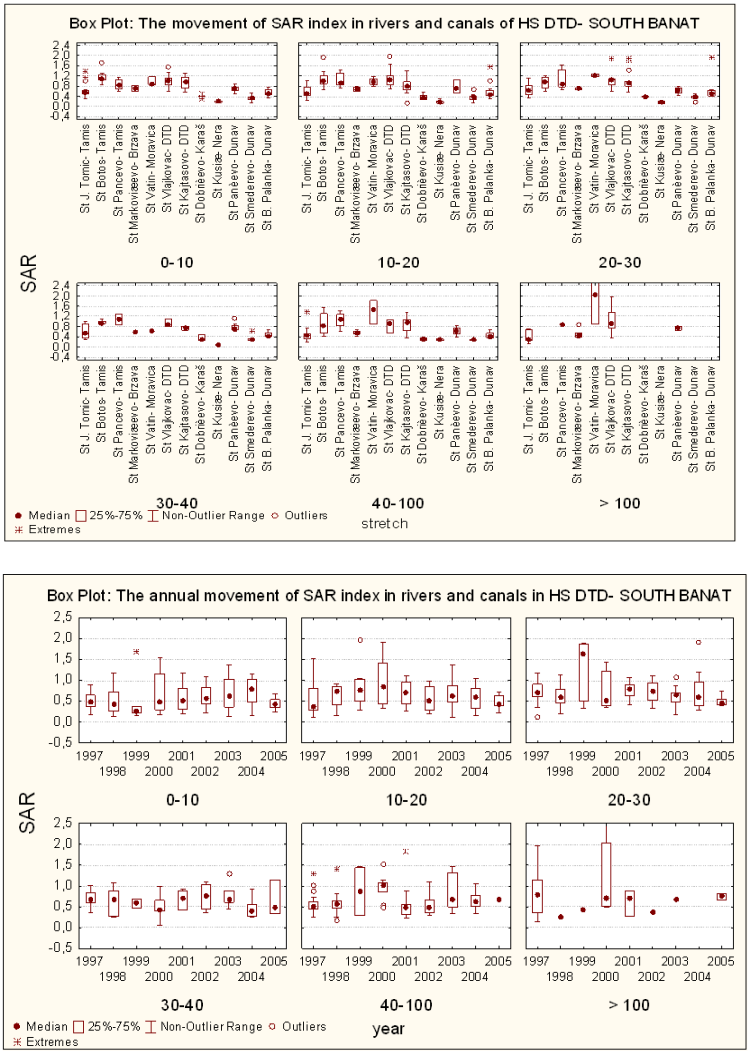



Figure 3-4. Box-plot graphs of SAR index in total suspended solids categorized in annual dynamics of data and stretches obtained from HS DTD of Southern Banat Region.

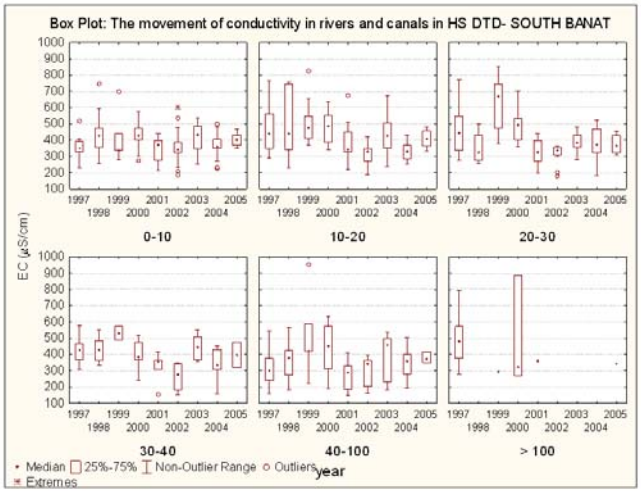



Figure 5. Box-plot graphs of conductivity in total suspended solids categorized in annual dynamics of data obtained from HS DTD of Southern Banat Region.

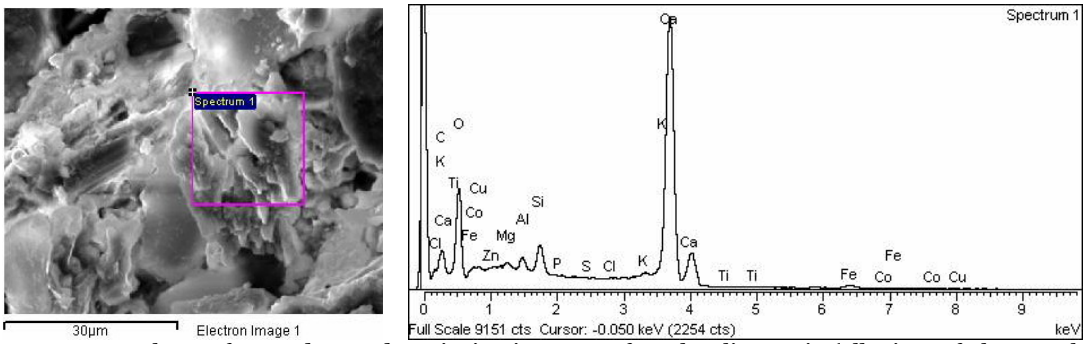



Figure 6. EDS analyses of groundwater deposits in piezometer from locality Kovin (alluvium of The Danube in Southern Banat nearby St Smederevo) (December, 2007). Elemental composition in wt %: O: 61.09, Al: 1.20, Si: 2.46, P: 0.00, K: 0.47, Ca: 33.11, Ti: 0.00, Fe: 1.05, Zn: 0.00, Cl: 0.00, Mg: 0.62, S: 0.00, Co: 0.00.

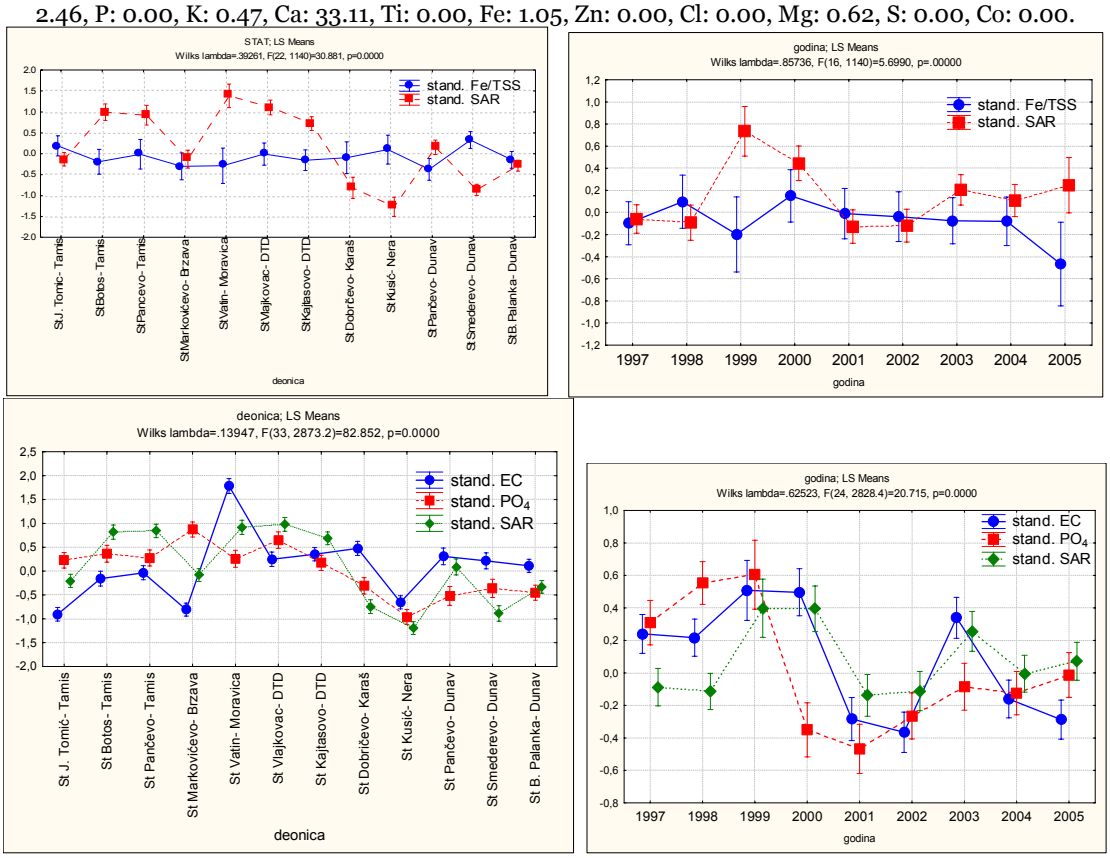



Figure 7. Equality of means was tested by ANOVA for standardized parameters: SAR index, ratio Fe/TSS, phosphate concentration and conductivity

## 4. CONCLUSION

In general, picture of the relations of some metals obtained through indices of alkalization and corrosion- the ratio of iron during sedimentation is represented in box-plot categorized graphs- „BLOCKS" of rivers of Southern Banat. Because of the movement of metal adsorption in hydrosystem, considering gradual alkalization of surface and groundwater water, during the lowest concentration of suspended material, an attention is given to changes of Danube-Tisza-Danube hydrosystem water quality.

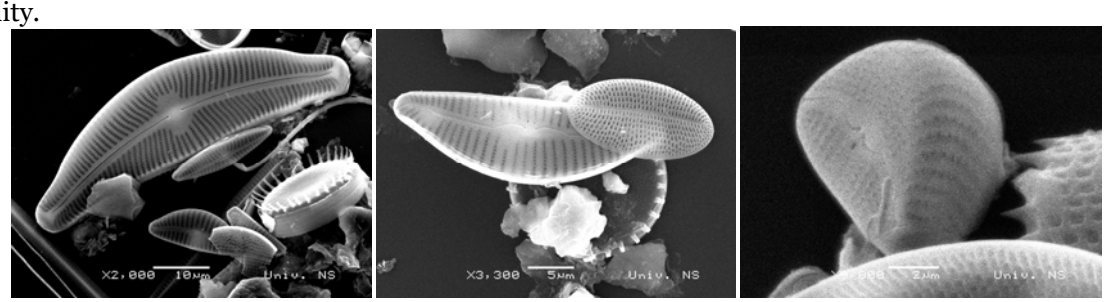



**Figure 8.** Scanning electron microscopy magnification of prominent diatoms of HS DTD in southern Banat region in 2004 (genus *Cymbella* with centric diatoms).
Genus *Cymbella* thrive in canals with low iron content.

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# BIOMASS A REGENERATING SOURCE OF THERMAL ENERGY FOR DRYING INSTALLATIONS

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**ABSTRACT:**

I order to reduce $CO_2$ emissions in accordance also with the principles of durable development, we analyzed the feasibility of using available sources of biomass for supplying thermal energy to installations of agricultural products convective drying. For economical efficiency increasing and optimum development of agricultural products resources which can be kept by drying, the dryers must be placed or displaced as close as possible to the source of products which are to be dried. This aspect limits the fossil, fuels used in Diesel oil and GPL. In this paper we determined the economical and ecological efficiency of supplying thermal energy to a convective dryer. This dryer was realized in CEEX program projected to be capable of using a large fuel variety in conditions of using wood biomass from industrial and forest waste, from maize energetically culture: maize grains and stalks, compared to a Diesel oil using, both for warm water and for drying agent direct warming. At present, from an economical point of view no significant differences are realized, but from an ecological and social point of view the biomass using is to be preferred.

**KEYWORDS**:

biomass, agricultural products, economical and ecological efficiency

## 1. INTRODUCTION

The dehydration is at present one of the principal methods of fruit and vegetables conservation, with a specific reduction of energy expenditure. At industrial level, the dehydration of the food products, characterized by relatively low cost of goods, is used on a large scale because the final products have reduced weight and volume. Thus, by a rigorous control of technological process, is assured the putting into present regulations of hygiene and food security of all food products.

The principal concerns at global level in fruit and vegetables the dehydration in the last 10 years had as objective the drying process and the modalities of its control.

The most significant effects of the automatically controls drying process are: - reduction of specific costs of goods;

- reduction of the number of the operators and associated costs;
- reduction of specific energy expenditure;
- opportunity of the optimal control of the drying process.

Other method used in the last 20 years, in the fruit and vegetables dehydration is the utilization of unconventional sources of energy. On these lines, were realized the drying installations using sun energy, the heat of geothermal waters, the installations of a biogas production, the combustion installations of scraps, thermo-chemical gasification of biomass etc. The convective drying process demands much thermal energy that can be produced from burning agricultural biomass in installations with high efficiency and safety in operation. During the development of agriculture it was indispensable to extent the efficient utilization of available resources and the reduction $CO_2$ emission.

The convective drying of vegetables and fruit is at present and in perspective, one of the most important modalities of conservation and efficiency of vegetables and fruit.

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## 2. DRYING INSTALLATIONS FEEDING WITH THERMAL ENERGY PRODUCED FROM BIOMASS

It is for $CO_2$ emission reduction and in accordance with the principles of durable development to recommend the using on a large scale of energy regeneration resources that have performances possible comparatively presented in the table 1.

Table 1

| System | Possible power (kW) | Cost installed power EUR/kW | The energy cost EUR/kWh | Starting up period (years) |
|---|---|---|---|---|
| CFV (s) | 0,5 - 100 | 10000 – 15000 | 0,25 – 0,4 | 0,5 |
| Thermal solar | 10 – 30 MW | 2 – 3 mil | 0,15 – 0,25 | 3 – 4 |
| Aeolian (s) | 200 – 2000 | 1000 – 5000 | 0,07 – 0,1 | 0,5 |
| Micro-hydroelectric plant (s) | 20 – 100 | 1000 – 1500 | 0,05 – 0,08 | 1 |
| Biomass | 2 – 500 | 1000 – 1500 | 0,05 – 0,08 | 0,5 |

The specific prices for primary thermal energy and that available obtained from different sources of energy are presented in the table 2.

Table 2

| Combustible type | Calorific power | Specific primary price Lei/kWh | Utilization efficiency (%) | Useful specific price Lei/kWh |
|---|---|---|---|---|
| Diesel oil | 38,7 MJ/l | 0.280 | 85 | 0.329 |
| GPL | 26,9 MJ/l | 0.295 | 90 | 0.328 |
| Electricity | 3,6 MJ/kWh | 0.321 | 100 | 0.321 |
| Wood: chips, pellets, chopped | 18,5 MJ/kg | 0.039 | 75 | 0.052 |
| Corn grains | 16,2 MJ/kg | 0.100 | 80 | 0.125 |
| Corn stalks | 17,5 MJ/kg | 0.066 | 70 | 0.094 |
| Switch-grass: pellets | 15,2 MJ /kg | 0.043 | 80 | 0.054 |

At present in the biomass market obtained by cultivation in the agricultural lands, corn and switch-grass compressed in pellet have imposed. From comparative energetic analysis of the corn and switch-grass using for the production of alcohol or thermal energy results the data presented in the table 3.

Table 3

| Parameter | UM | Corn for alcohol | Corn for thermal energy | Switch-grass for alcohol | Switch-grass for thermal energy |
|---|---|---|---|---|---|
| Annual production | t/ha | 6.5 | 6.5 | 10.0 | 10.0 |
| Reaped primary energy | GJ/ha | **136.5** | **136.5** | **185** | **185.0** |
| Energy after processing | GJ/ha | 64.2 | 136.5 | 73.0 | 175.8 |
| Consumed Energy in processing and conversion | GJ/ha | 42.8 | 20..25 | 15.6 | 12.7 |
| Net thermal energy | GJ/ha | **21.4** | **115.0** | **47.2** | **163.1** |

For thermal energy production from biomass, the following methods can be used: burning in layer, in boilers of hot water; gasification and burning in the same enclosure, in boilers of hot water; gasification in a gas generator and burning in a separate furnace, part of a heat exchanger.

Each method has both advantages and disadvantages and is used in function type of application. For heating air in the convective dryers, whereupon using biomass like combustible, are used heat exchangers of the following type: hot water/air; burned gas/air; vapor/air (seldom).

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### 2.1 Examples of the convective dryers with thermal energy from biomass

Forwards are presented typical examples of convective dryers fed with thermal energy produced from biomass.

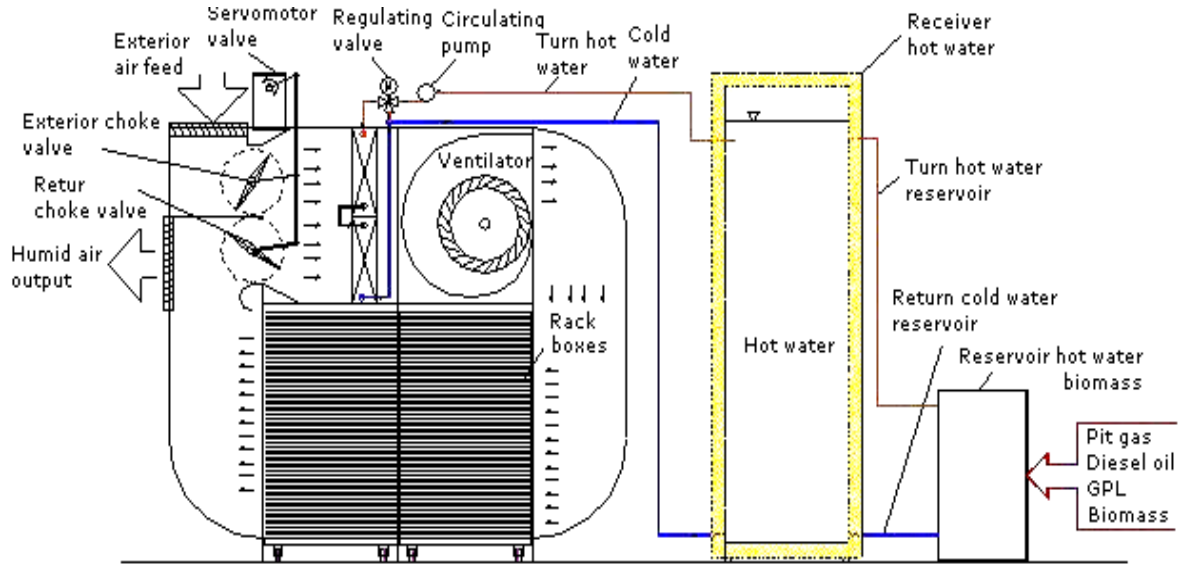



Fig. 1 The functional diagram of a convective dryer of type USCMER 30/60



Fig. 2 Convective dryer of type USCMER 30/60

In figure 1 is presented the functional diagram of a convective dryer that has a small capacity of USCMER 30/60 type realized inside CEEX PROGRAM. This uses for moisture eliminator heating hot water produced in a reservoir fed with diesel oil or wood biomass.

In figure 2 is presented the convective dryer USCMER 30/60 installed in the drying section.

In the figure 3 is presented the functional diagram of a convective dryer in which the air is fired with a heat exchanger burned gas/air in that to burned the gas of generator produced by a generator gas manually fed in batches, with biomass.

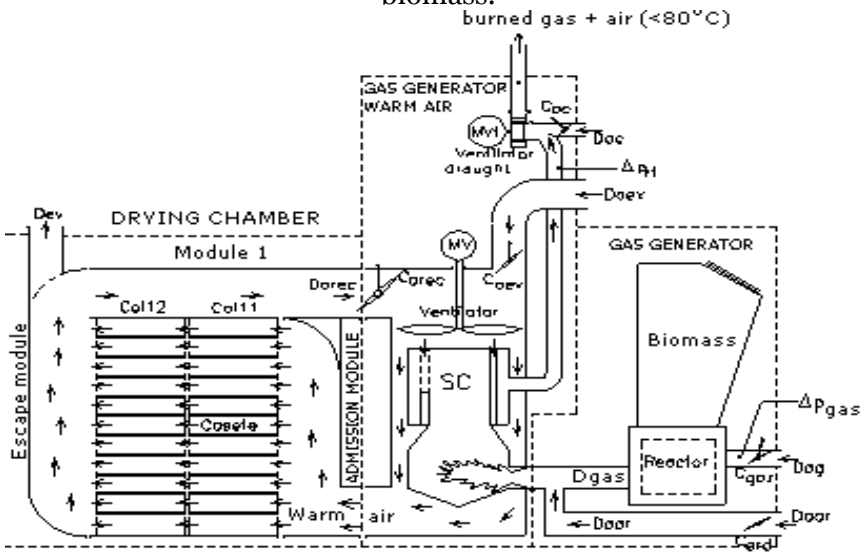



Fig. 3 The functional diagram of a dryer fed from a gas producer

In figure 4 is presented the dryer FD-50 produced in Thailand, with a drying surface of 15 m², feeding with thermal energy from generator gas of the type cross-draft.



Fig. 4 Dryer FD-50 fed with thermal energy from a cross-draft gas generator

## 3. THE COMPARATIVE ANALYSIS OF FEEDING WITH THERMAL ENERGY FROM BIOMASS

In order to draw a conclusion concerning the opportunity of biomass using for producing thermal energy utilizable in convective dryers, has been realized a model and a program of simulation for technical-economic analysis of a dryer with the base parameters: drying surface: 30 m²; efficient thermal power: 60 kWt.

We have analyzed three variant of feed a moisture eliminator:

1 - heat exchanger hot water/air + boiler of hot water with burning of diesel oil; 2 - heat exchanger hot water/air + boiler of hot water with burning of wood biomass with two stages, gasification + final burning;

3 – heat exchanger burned gas/air + gas burner of generator + gas generator of wood biomass.

In table 4 are presented the principal characteristics of a convective dryer used as a base for the comparative economic analysis.

Table 4

| Size | UM | Value |
|---|---|---|
| Drying surface | mp | 30.00 |
| Maximum thermal power | kWt | 60.00 |
| Medium efficiency drying fruit | - | 0.40 |
| Medium efficiency drying vegetables | - | 0.25 |
| Medium specific loading fruit | kg/mp | 10.00 |
| Medium specific loading vegetables | kg/mp | 8.00 |
| Medium during batch fruit | h | 6.00 |
| Medium during batch vegetables | h | 10.00 |
| Drying period fruit | months | 4.00 |
| Drying period vegetables | months | 4.00 |
| Drying period fruit | h | 2880.00 |
| Drying period vegetables | h | 2880.00 |
| Maxim total function annual hours | h/year | 5760.00 |
| Medium loading dryer | - | 0.75 |
| Total hours used annual | h/year | 4320.00 |
| Diesel oil price | RON/l | 3.00 |
| Electric energy price | RON/kWh | 0.32 |
| Using biomass price | RON/t | 100 |
| Calorific power diesel oil | MJ/kg | 42.00 |
| Calorific power wood combination | MJ/kg | 15.00 |
| Fresh fruit medium price + transport | RON/kgfp | 1.20 |
| Dried fruit selling medium price 15 EUR | RON/kg | 51.00 |
| Fresh vegetable medium price + transport | RON/kgfp | 0.80 |
| Dried fruit medium price 12 EUR | RON/kg | 40.80 |

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The analysis results of economical profitableness of using different variants of producing thermal energy for the analyzed dryer are synthesized in table 5.

The table 5

| Indicator | UM | Hot warm-Diesel oil | | Hot water -Biomass | | Gas generator - Biomass | |
|---|---|---|---|---|---|---|---|
| | | *fruit* | *vegetables* | *fruit* | *vegetables* | *fruit* | *vegetables* |
| Production Cost | RON/kg | 12,77 | 17.99 | 11.06 | 13.80 | 11.44 | 14.00 |
| Fresh material | % | 41,75 | 26.68 | 48.25 | 34.80 | 47.86 | 34.40 |
| Hand-made | % | 31.15 | 33.50 | 36.00 | 43.70 | 37.50 | 43.05 |
| Energy | % | 17.55 | 28.84 | 3.81 | 6.00 | 4.50 | 7.24 |
| Redeeming and maintenance | % | 9.55 | 10.99 | 11.95 | 15.52 | 11.95 | 15.41 |
| **Rate** | RON | **94400** | | **102200** | | **103000** | |
| Net annual profit | RON/an | 184000 | 186700 | 194600 | 208000 | 194000 | 206900 |
| **Profit installment** | First year | **1.95** | **1.98** | **1.91** | **2.04** | **1.89** | **2.01** |
| | First year | **3.93** | | **3.95** | | **3.90** | |
| **Annual $CO_2$ emission** | t/year | **9,732** | | **0** | | **0** | |

It is provide that the profit rate does not differ very much in the three analyzed solutions which still confirm the low interest in extending of using the biomass as source of energy for convective dryers. The difference is given by the emission of $CO_2$ quantity in atmosphere, about 10 t/an.

When the green certificates are paid, the variants of biomass using will became more efficient. There are no evident economical differences between the two variants of biomass using; the gas generator solution which can use a less exigent combustible and with higher humidity and with higher moisture content could be considered as the optimal one for the near future.

The variants of biomass using are better especially in isolated regions. From this point of view, the energy feeding variants of convective dryers from cogeneration installations fed only with biomass are interesting and feasible technically and economically.

## 4. CONCLUSIONS

The vegetables and fruit convective drying tends to became a method used on a large scale in order to keep fruit and vegetables for a long time, which permits the continuous consuming of vegetal products all over the year.

The fruit and vegetables drying do not need a special training which makes it accessible to a large mass of rural and urban population.

It is proved that better economical results are obtained by using biomass as combustible compared to diesel oil using having as an ecological secondary effect the reduction of $CO_2$ emission.

The constructive variant of dryer with heat exchanger burned gas/air + furnace of gas generation + wood biomass gas generation, has the same economical performances as the hot water + biomass one, but needs a smaller investment, has a smaller weight and is more easily to move to the place of drying material production.

For assuring an energetically independence feasible from a technical and economical point of view the variants of feeding the convective dryers with energy from cogeneration installations fed only with biomass are to be preferred.

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# ANTIMICROBIAL AND ANTIOXIDANT POTENTIAL OF WASTE PRODUCTS REMAINING AFTER JUICE PRESSING

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**ABSTRACT**

Pomace (skin, seeds and flesh) remaining after juice pressing is rich in anthocyanins and other phenolic phytochemicals and could have potential antimicrobial and antioxidant effects. In our study, aqueous and methanol extracts made from the pomace of six fruits, used widely in juice making (*Fragaria x ananassa, Prunus cerasus, Ribes nigrum, R. rubrum, Rubus idaeus, R. fruticosus)*, were tested for antimicrobial activity on Gram-positive and Gram-negative bacteria (*Bacillus cereus, B. subtilis, Campylobacter jejuni, E. coli, Salmonella* Typhimurium *and Serratia marcescens)* and on pathogenic *Candida* species (*C. albicans, C. krusei, C. glabrata, C. parapsilosis, C. pulcherrima,)* by broth dilution assay. Total soluble phenol content was measured by the Folin-Ciocalteu method and antioxidant capacity was determined using DPPH.

*C. jejuni and E. coli* were the most sensitive bacteria especially to the methanol extracts. The growth of *C. albicans, C. krusei* and *C. pulcherrima* was not inhibited by any of the extracts. In general, *Ribes* and *Rubus* species were efficient inhibitors. Phenol content and antioxidant capacity was high in the dark colored pomace (up to 50.4 µg gallic acid equivalent/mg dry matter content and 83%, respectively).

**Keywords:**
pomace, antimicrobial, antioxidant, phenol

## 1. INTRODUCTION

Phenolic compounds naturally present in fruits have antioxidant activity and can protect the plant from environmental stress and fungal or bacterial infections. The main classes of polyphenols are phenolic acids, flavonoids including anthocyanins, stilbenes, lignans and complex polymers. Waste products remaining after juice processing (peel, seeds, stems, flesh) are good sources of these ingredients. There is an increasing interest to use pomace for the extraction of natural antioxidants and other value added products [1, 2, 3, 4]. The extracted phenolic compounds of pomace could also have antibacterial and antifungal properties [5, 6]. There is a consumer demand for foodstuffs with minimal or no added synthetic preservatives. Natural antioxidants with antimicrobial activities can be used for enhancing food quality and shelf life. Beside food industry, agriculture and medicine can also have benefits from pomace-derived bioactive compounds as natural antifungal and antibacterial agents.

In the present study, the *in vitro* biological activities of water and methanol extracts of pomace (peels, seeds, flesh) remaining after pressing the juice of six fruits were investigated on food-spoiling and human pathogenic bacteria (*Bacillus cereus, B. subtilis, Campylobacter jejuni, E. coli, Salmonella* Typhimurium *and Serratia marcescens)* and on pathogenic Candida species (*C. albicans, C. krusei, C. glabrata, C. pulcherrima, C. parapsilosis)* by broth dilution method.

## 2. MATERIALS AND METHODS

### 2.1. Strains and culture conditions

*Bacillus subtilis ssp. subtilis BD170, B. cereus var. mycoides ATCC 9634, Escherichia coli SZMC 0582, Serratia marcescens SZMC 0582,* and a clinical isolate of *Salmonella* ser. Typhimurium were grown on T1 medium (10 g glucose, 4 g beef extract, 4 g peptone, 1 g yeast extract, 1 L water). *Campylobacter jejuni* were cultured on Campylobacter blood-free selective agar medium (CCDA; Charcoal cefoperazone deoxycholate agar, Merck). The yeasts *Candida albicans* ATCC10231, *C. glabrata* CBS 138, *C. krusei* CBS573, , *C. parapsilosis* CBS604, and *C. pulcherrima* CBS 5833 were grown on RPMI1640 medium (Sigma).

### 2.2. Fruits and extraction methods

Fruits investigated in this study were *Fragaria ananassa* (strawberry), *Prunus cerasus* (sour cherry), *Ribes nigrum* (black currant), *Ribes rubrum* (red currant), *Rubus fruticosus* (blackberry) and *Rubus idaeus* (raspberry). Fresh fruits were purchased on a local market (Szeged). Fruit juices were freshly pressed, and the remaining pomace was dried overnight at 60°C and then grounded to powder. One gram pomace was extracted with 3 x 10 ml of distilled water or methanol. The extracts were evaporated to dryness at 100°C in an oven (water extracts) or at 40 °C in a water bath (methanol extracts). The dry material was dissolved in 4 ml distilled water (water extracts) or 10 % methanol-water solution (methanol extracts), and frozen in 1 ml aliquots at -20°C. One sample from each extract was dried again and weighed for dry matter content calculation. The extracts were diluted in the appropriate media for the tests.

### 2.3. Determination of antibacterial and antifungal effect by broth dilution method

Absorbance of the bacterial or yeast cultures was measured at 620 nm in the presence of the fivefold diluted extract. In each well, 100 µl of diluted and sterile-filtered (0.45 µm, Millipore) extract was mixed with 100 µl cell suspension ($10^5$ cells/ml) containing the appropriate medium (final dilution of the tested extract was tenfold). Each test plate contained a positive growth control. The samples were tested in triplicate and the results were recorded after 48 h.

### 2.4. Determination of total soluble phenol content

Phenol content was measured by the Folin-Ciocalteu method at 725 nm. Calibration was made with gallic acid and results are given as µg gallic acid equivalent/mg dry matter content of the extract.

### 2.5. Determination of antioxidant capacity

Antioxidant capacity was measured at 517 nm using DPPH (1,1 diphenyl-2 picrylhydrazyl) and determined using the formula: % capacity=$[(A_{control} - A_{extract})/A_{control}]$ x 100.

## 3. RESULTS AND DISCUSSION

### 3.1. Antibacterial and antifungal effect

Best results were obtained with the dark coloured pomace of *Ribes nigrum* and *Rubus fruticosus*. Both aqueous and methanol extracts of these fruits reduced the growth of almost all bacteria in this study, and *S.* Typhimurium growth was completely inhibited by *R. nigrum* pomace extracts. In general, methanol extracts had stronger inhibitory effect than water extracts. The most insensitive bacterium was the Gram-negative *S. marcescens*, and the most sensitive one, the also Gram-negative *C. jejuni* which was inhibited by all of the investigated extracts (Table 1).

The components present in aqueous and alcoholic extracts are partly dissimilar. Water extract contains the majority of anthocyanins, tannins, starches, saponins, polypeptides and lectins of the pomace, while methanol extracts, in addition, polyphenols, lactones, flavones, and phenons [7]. Phenolic and organic acids acidify the cytoplasm of microorganisms, while certain small hydrophobic molecules, called permeabilisers, can disintegrate the outer membrane of Gram-negative bacteria causing bactericidal effects. Puupponen-Pimia and co-workers [8] found that raspberry extracts caused permeabilisation of *Salmonella* membrane.

We hypothesized that the presence of such permeabilisers found in methanol extracts can cause the better growth inhibition effect of these extracts.

Table 1 Growth inhibition effect of pomace extracts on bacteria

| | Gram positive bacteria | | | | Gram negative bacteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *B. subtilis* | | *B. cereus* | | *E. coli* | | *S. marcescens* | | *S.* Typhi-murium | | *C. jejuni* | |
| | W | M | W | M | W | M | W | M | W | M | W | M |
| *Fragaria ananassa* | 4 | 1 | 4 | 1 | 4 | 3 | 4 | 4 | n.d | n.d | n.d | n.d |
| *Prunus cerasus* | 4 | 4 | 2 | 4 | 3 | 1 | 4 | 1 | 2 | 0 | 1 | 1 |
| *Ribes nigrum* | 1 | 1 | 4 | 0 | 1 | 1 | 1 | 4 | 0 | 0 | 0 | 2 |
| *Ribes rubrum* | 4 | 4 | 4 | 4 | 4 | 1 | 4 | 1 | 1 | 1 | 1 | 1 |
| *Rubus fruticosus* | 1 | 1 | 1 | 0 | 4 | 1 | 4 | 2 | 3 | 2 | 1 | 0 |
| *Rubus idaeus* | 4 | 4 | 3 | 4 | 4 | 2 | 4 | 1 | 4 | 2 | 1 | 0 |

0 - no growth; 1 - growth<25 %; 2 - growth<50 %; 3 - growth<75%; 4 - growth>75%. Control growth is taken as 100%. W: water extracts; M: methanol extracts. n.d. - no data.

*Candida* species showed lower sensitivity to the pomace extracts. The growth of *C. albicans, C. krusei* and *C. pulcherrima* was not inhibited by any of the extracts. *R. nigrum* and *R. fruticosus* water extracts reduced the growth of *C. glabrata*, and inhibited totally the growth of *C. parapsilosis*. *F. ananassa* and *R. idaeus* had inhibitory effect on both sensitive Candida species while *P. cerasus* and *R. rubrum* had no effect on any of the yeasts (Table 2).

Similar data on the non-sensitivity of *C. albicans* to plant extracts can be found in the literature [9, 10]. Our results with *C. parapsilosis* were, however, in contrast to those where this and seven other yeast species showed resistance to berry water extracts and juices [11].

Table 2 Growth inhibition effect of pomace extracts on Candida species.

| | *C. albicans* | | *C. krusei* | | *C. glabrata* | | *C. pulcherrima* | | *C. parapsilosis* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | W | M | W | M | W | M | W | M | W | M |
| *Fragaria ananassa* | 4 | 4 | 4 | 4 | 2 | 4 | 4 | 4 | 1 | 4 |
| *Prunus cerasus* | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| *Ribes nigrum* | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 0 | 1 |
| *Ribes rubrum* | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| *Rubus fruticosus* | 4 | 4 | 4 | 4 | 2 | 4 | 4 | 4 | 0 | 4 |
| *Rubus idaeus* | 4 | 4 | 4 | 4 | 1 | 4 | 4 | 4 | 2 | 4 |

0 - no growth; 1 growth<25 %; 2 - growth<50 %; 3 - growth<75%; 4 - growth>75%. Control growth is taken as 100%. W: water extracts; M: methanol extracts

### 3.2. Phenol content and antioxidant capacity

Phenol content of the water and methanol extracts can be seen in Table 3. *R. nigrum* had the highest and *F. ananassa* the lowest value. Antioxidant capacity ranged from 66 % (*R. rubrum*) to 83 % (*R. nigrum*) (Fig.1). It seems that there is no firm correlation between the soluble phenol content and antioxidant capacity. In spite of this, higher phenol content resulted in better inhibitory effect against sensitive bacteria and yeasts. Linear regression between phenol content and antibacterial effect showed $R^2$ value of 0.6197 for water extracts and 0.5438 for methanol extracts.

Table 3 Soluble phenol content of pomace given as μg gallic acid equivalent/mg dry matter content of extracts

| | Water extract | Methanol extract |
|---|---|---|
| *Fragaria ananassa* | 13.61 ± 0.17 | 17.0 ± 0.33 |
| *Prunus cerasus* | 31.43 ± 0.35 | 27.22 ± 1.16 |
| *Ribes nigrum* | 49.70 ± 0.10 | 50,44 ± 0.06 |
| *Ribes rubrum* | 28.16 ± 0.13 | 20.54 ± 0.66 |
| *Rubus fruticosus* | 23.88 ± 0.61 | 46.50 ± 2.50 |
| *Rubus idaeus* | 29.71 ± 0.71 | 36.72 ± 3.70 |

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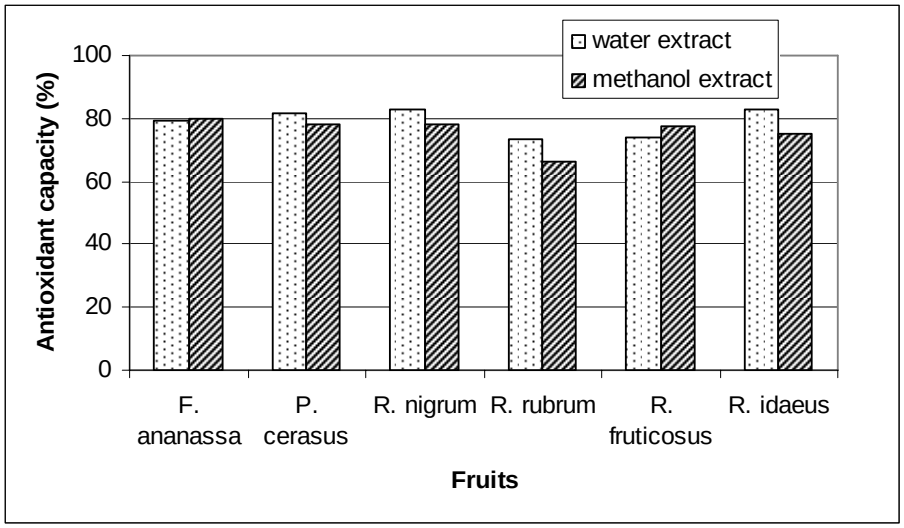



Fig. 1 Antioxidant capacity of fruits pomace extracts

Pomace remaining after juice processing is not a waste product. It is rich in extractable bioactive compounds, and can be used in various ways in the food industry as source of natural antioxidants and/or preservatives. There is also a perspective to use the antimicrobial capacity of pomace in agriculture and medicine. Our results suggest that especially dark coloured pomace, extracted with solvents for hydrophobic molecules, are good candidates as antimicrobial agents.

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# MAPPING OF RISKS ON THE MAIN ROAD NETWORK OF SERBIA

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**Abstract**:
Evaluation of traffic safety is very complex work. During this process it is necessary to define parameters which will represent on the best way risk in traffic.
In the paper are presented methodology of work and most important results from study "ROAD ASSESSMENT PROGRAM ON THE MAIN ROAD IN SERBIA". Investigation is taken for period of five year (2002.-2006.) with special consideration on analyze of traffic safety on the main road. We pay attention on the great significance of road assessment on traffic safety management in Serbia how we advance level of traffic safety and find out micro location with increase risk in traffic on the main road in Serbia.

**Key Words:**
Traffic Accident, Road, Road Assessment, Risk

## 1. INTRODUCTION

The road network takes a very high position in the hierarchy of significance of impact on traffic safety. Therefore, it is the obligation of the state (as the road manager) to monitor and manage traffic safety of road network through its own mechanisms (organisation, human and technical resources, methodology of work, finances etc.) within its responsibilities. "Risk mapping" is a suitable technique for identification, control, and management of risks on roads.

Risk mapping has been carried out based on the collected, systematised, and analysed quality data on traffic accidents and their consequences along road directions would make a quality basis for all further managing activities aimed at improvement of traffic safety.

It should be pointed out that such risk mapping is carried out for the first time in Serbia and that the best risk mapping practice in the world has been observed (in particular risk mapping in Europe – EuroMAP, risk mapping in Australia - AusMAP, risk mapping in America – usRAP)[2].

### 1.1. The research subject and objective

The subject of the research is the spatial analysis of traffic accidents on the main roads in the territory of municipalities in the Republic of Serbia based on the number of traffic accidents, casualties, and traffic load (AADT – average annual daily traffic).

The main objective of the paper is to calculate the collective and individual risk that was the basis for graphic presentation per sections on the 1st rank public roads based on the data on roads, traffic, accidents and their consequences, all aimed at simulating local communities, municipal administrations to do everything that is in their power, as decision makers in the territories they manage, and contribute to reduction of casualties in traffic accidents.

### 1.2. Research period and territory

The research encompasses the period of five years, i.e. the period from the year 2002 to 2006. The territory includes the first rank public roads in the territory of the Republic of Serbia. The research included 34 main roads in the total length of 4,912.5 km. Those road directions were divided into 558 micro-sections that are homogenous in the sense of road characteristics and traffic.

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### 1.3. Limitations in the paper

The limitations refer to comprehensiveness because the research did not include the territory of Kosovo and Metohija. In addition to that, the Analysis is based on available data from the UIS (unified information system) of the Ministry of Internal Affairs (MIA) of the Republic of Serbia, namely, on other public databases so that the quality and access to data determine largely the quality of the research results.

## 2. METHOD OF WORK

The following methods were used in the research of mapping of risks in traffic on the first rank public roads in Serbia:

- Method of analysis (research based on explanation of the problem through dividing of complex thoughts onto simpler integral parts)
- Synthesis (reversed procedure in comparison to analysis);
- Classification method (finding of sets with similar properties);
- Method of comparison (comparison of the same or similar facts, phenomena or processes, namely finding of their similarities in behaviour and differences);
- Statistical method (finding of structures and rules of occurrence within certain intervals based on indicators).

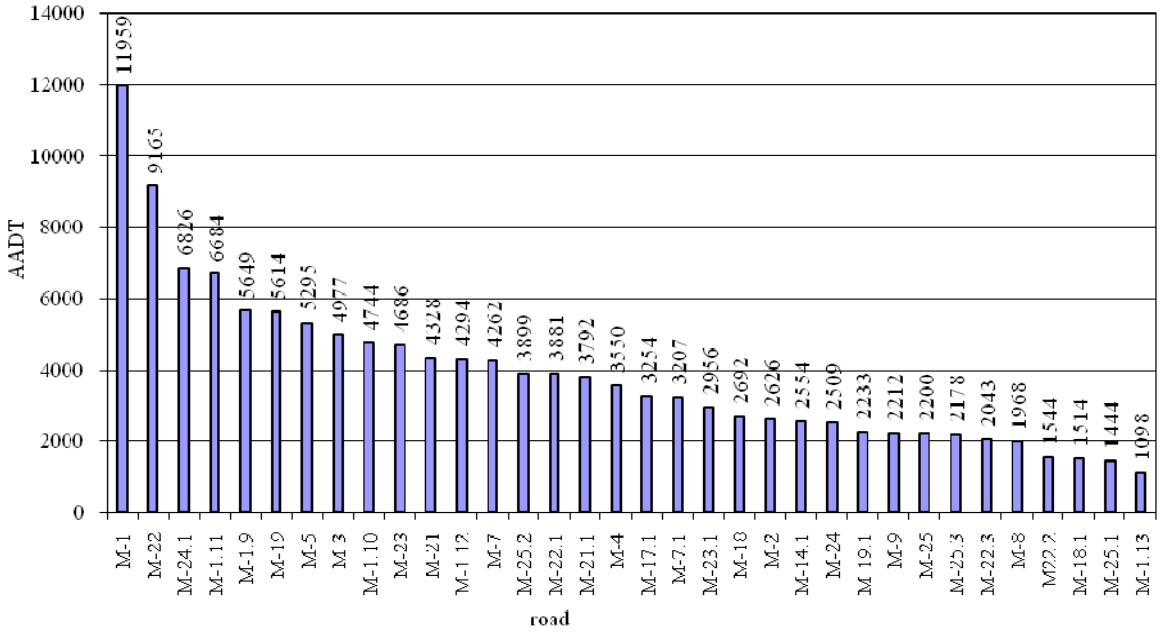
## 3. THE OUTLINE OF THE MOST SIGNIFICANT RESEARCH RESULTS

### 3.1. Structure of the first rank public roads in the territory of Serbia

Republic of Serbia is one of the European countries with a medium population density and well developed network of the first rank public roads (hereinafter we will use the term "main roads"). Geographical position of Serbia is favourable. A larger number of international roads pass through Serbia, which increases additionally the traffic scope and affects the traffic safety characteristics.

The research encompassed 34 main road directions in the total length of 4,912.5 km. Those road directions were divided into 558 micro-sections – traffic sections that are not homogenous in the sense of road and traffic properties.

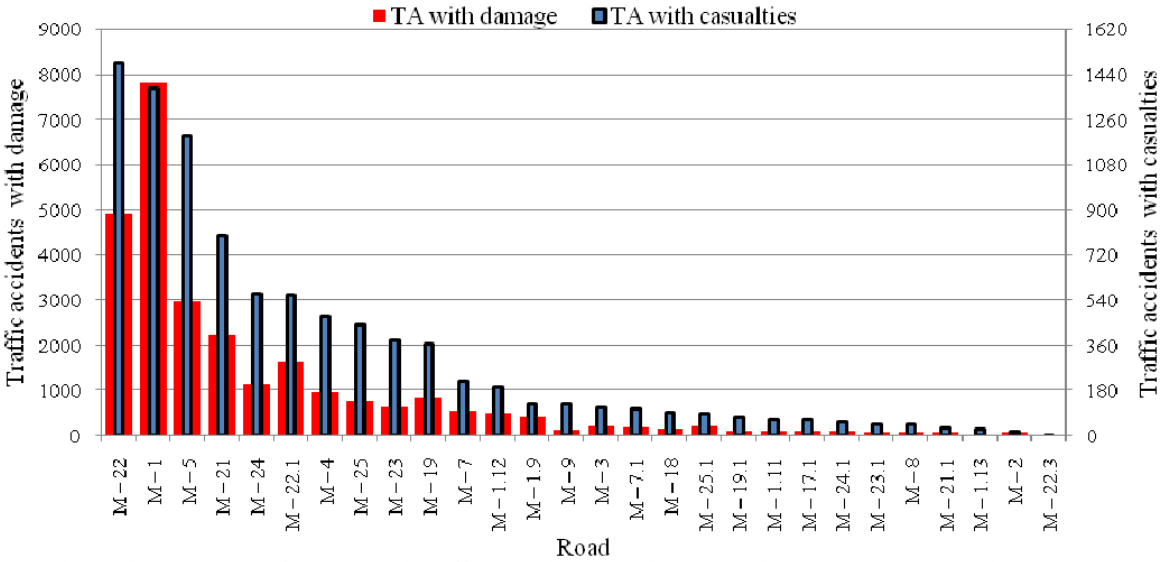
The length of roads differs significantly. The longest road is the M-1 road (a branch of the Corridor X through Serbia) with the total length of 494.5 km (10.1%). It is followed by M-22 road that is 487.9 km (9.9%) long and M-24 that is 475.7 km (9.7%) long. The shortest road is the M-14.1 road (2.2 km) (Graph 1).




Graph 1. Main roads distributed according to their length (Serbia, 2008)

### 3.2. Analysis of traffic accidents per main roads in Serbia

According to the number of traffic accidents on the main roads in Serbia, we can single out three road directions: M-1 where 9,205 (25.4%) of accidents happened during the analysed period, M-22 with 6,411 (17.7%) and M-5 with 4,176 (11.5%). Almost **55%** of all traffic accidents that happened on the main roads in Serbia happened on the above-mentioned three roads (Graph 2). There were 3,034 (8.4%) traffic accidents on M-21 road.

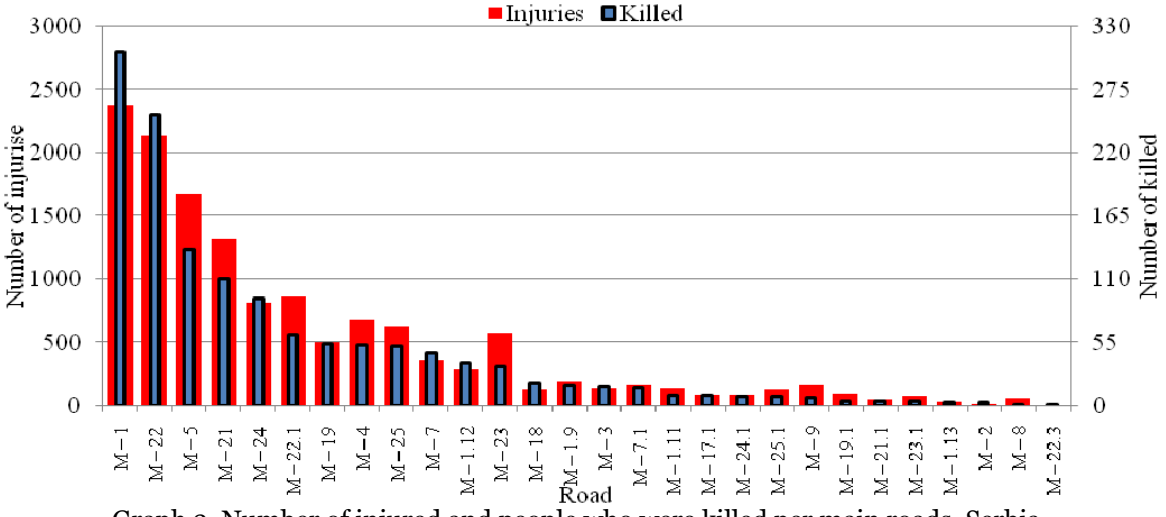



Graph 2. The number of registered traffic accidents with material damage and casualties, per main roads, Serbia, the period from 2002 to 2006

### 3.3. Consequences of traffic accidents

The above-mentioned three main roads in Serbia can also be singled out according to the number of casualties: M-1 with 2,690 (17.7%) casualties within the analysed period, M-22 with 2,383 (15.7%) and M-5 with 1,806 (11.9%) of casualties, along with the road M-21 with 1,432 (9.4%) of casualties (Graph 3). On those four roads, there was 54.8% of the total number of casualties on the main roads in Serbia.

The distribution of the number of casualties of all categories (killed, seriously and less seriously injured) is similar to the distribution of number of accidents with casualties per roads. The number of people who were killed in accidents and number of those who were injured is particularly high on the M-1 road (308 killed, namely 22.5% and 2,382 injured, or 17.3%), M-22 (253 killed, namely 18.5% and 2,130 injured, or 15.4%) and M-5 (136 killed, namely 9.9% and 1,670 injured, or 12.1%) in comparison to all other roads (Graph 3).




Graph 3. Number of injured and people who were killed per main roads, Serbia, the period from 2002 to 2006

### 3.4. Spatial distribution of risks per roads and traffic safety evaluation

Traffic safety evaluation is an exceptionally complex procedure. During that process, it is necessary to define parameters, which will represent the level of threats in traffic in the proper way and define their quantitative values that are meritory for comparison of results of the set parameters.

The following, generally accepted indices in experts circles were used in the process of identification of dangerous sections:

- **Individual Risk of the Killed and Seriously Injured**

Setting of the relationship between the number of the killed and seriously injured people in traffic accidents and the number of vehicle kilometres establishes the value of the Individual Risk of the Killed and Seriously Injured.

- **Collective Risk of killed and seriously injuried**

Collective risk represents relation number of killed and serious injuries in traffic accident and section length. This parameter is representative for ranking micro location according risk in traffic.

After defining of evaluation parameters, it was necessary to commence with their calculation. Based on the data on traffic accidents and their consequences (UIS MIA), each traffic accident and its consequences were "lowered" onto the appropriate road, onto the road section and onto one-kilometre section (kilometre of a road). Individual risks of occurrence of traffic accidents and risks of casualties were calculated for all road and one-kilometre sections of the main roads network.

In such a way, the lowest and highest risk values and risk scope were defined, based on which the following risk classes were adopted:

- Risk scope for Individual Risk is 8 (Table 1), number of the killed and seriously injured on 100 mil. vehic.-km,
- Risk scope for Collective risk of killed and serious injuries is 15 (Table 2)

The risk maps per roads for each micro-section were prepared for all the parameters.

Table 1. Number of the killed and seriously injured on 100 mil. vehic.-km,

| Ordinal No (mark of traffic safety) | Level of risk (description) | Individual Risk Killed and Seriously Injured for section | |
|---|---|---|---|
| | | class (interval) | rang (color) |
| 1 | low risk | up to 8 | |
| 2 | low-medium risk | [8 – 16) | |
| 3 | medium risk | [16 – 24) | |
| 4 | high-medium risk | [24 – 32) | |
| 5 | high risk | over 32 | |

Table 2. Collective Risk of killed and serious injuries

| Ordinal No (mark of traffic safety) | Level of risk (description) | Collective Risk Killed and Seriously Injured for section | |
|---|---|---|---|
| | | class (interval) | rang (color) |
| 1 | low risk | up to 15 | |
| 2 | low-medium risk | [15 – 30) | |
| 3 | medium risk | [30 – 45) | |
| 4 | high-medium risk | [45 – 60) | |
| 5 | high risk | over 60 | |

The risk map shows 30 of the most threatened sections on the main roads network of the Republic of Serbia according to the values of those two evaluation parameters.

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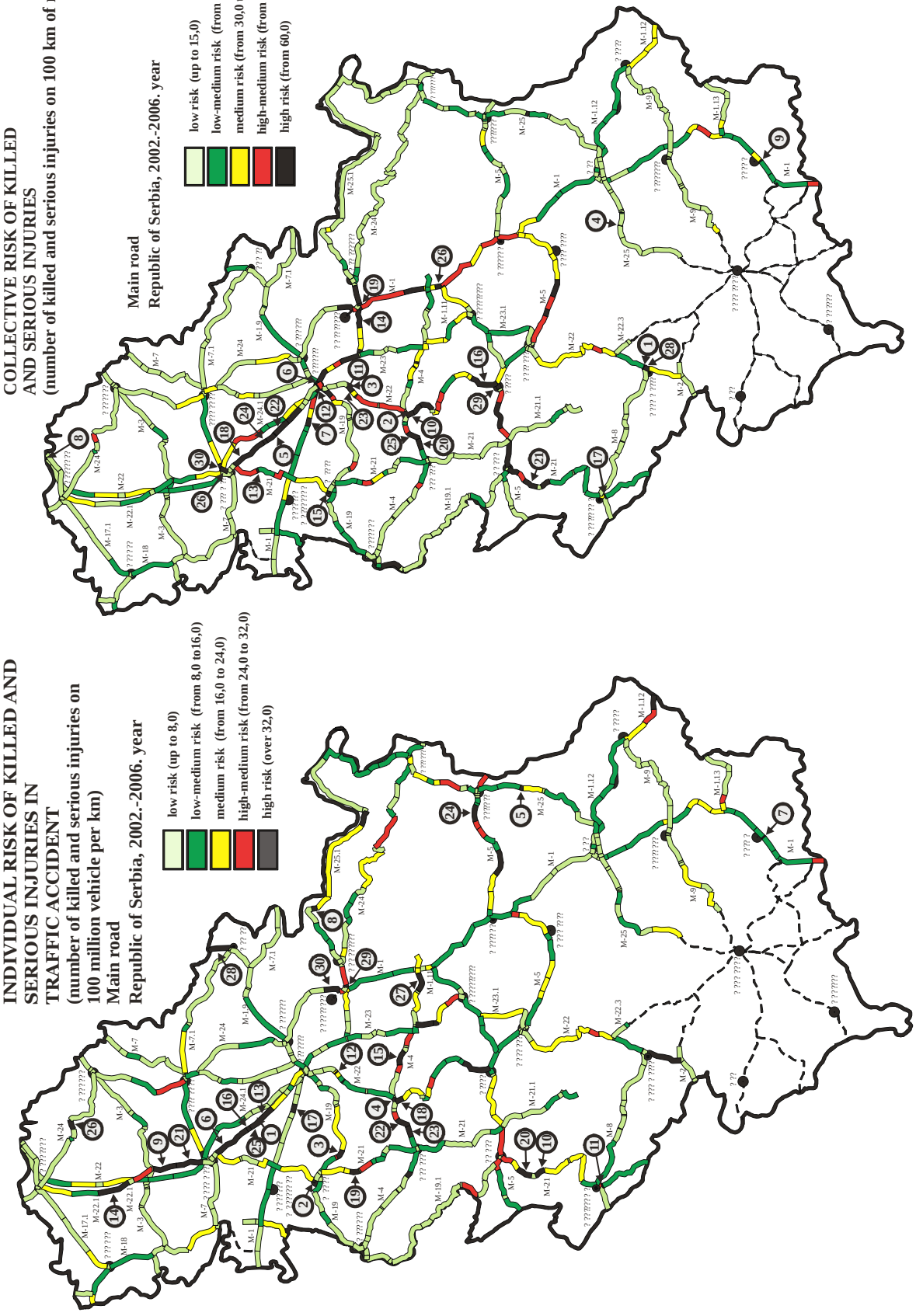



Figure 1. Individual and collective risk, main roads, Serbia, 2002-2006

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## 4. FINAL CONSIDERATIONS WITH GENERAL PROPOSAL OF MEASURES

The basis of each activity of traffic safety increasing, namely preventing of traffic accidents and their consequences has to rely on precisely diagnosticised status and clearly defined conditions within which those phenomena occur. The detailed analysis and permanent monitoring of distribution (spatial, temporal) of traffic accidents, namely casualties, enables more efficient planning and implementation of measures and activities aimed at their prevention because the results of such analyses point us when and where we should undertake certain measures.

Risk mapping is one of the most significant techniques in realisation of the above-mentioned process. The efficiency of such approach has been recognised in many countries, which achieve the best results in prevention of traffic accidents and their consequences. Risk maps enable simple identification of the safest and most dangerous road sections within a region or a country while the comparison of maps from several countries enables the comparison of safety of the same ranked roads between them.

In the conditions that are currently valid in our country, it is necessary to prepare the data records on traffic accidents in a better quality way so that the accuracy and reliability of data would be at a high level.

At an annual level, it is necessary to carry out the analyses of spatial distribution of risks on the national road network and risk maps should be the output result of such analyses. Such an approach enables defining of priorities in work in the forthcoming period but it also creates the conditions for evaluation of efficiency of everything that has been done within the previous period in the field of improvement of traffic safety on certain roads.

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# UTILIZATION OF WASTE MATERIALS FROM BIOMASS AS ENERGY-GENERATED PRODUCT IN TECHNOLOGICAL PROCESS

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**ABSTRACT:**
Climate changes, energy dependency and reduction of fossil fuels lead to great public interest and utilization for renewable energy sources (RES). Demand for renewable energy is consequence of global energy crisis and fact that utilization of solar energy, geothermal energy, eol energy and energy of biomass reduces pollution to environment.
EU and USA are intersted in overall energetic balance, energetic efficience of thermal plants powered by biomass, rationalization of standard fuel dissipation in agriculture and higher level of environmental protection
These paper analyzes possibility for utilization of waste materials from fabricated fruit as energy-generated product for producing heat in technological process.

**Key words:**
renewable energy sources, biomass, energy efficiency.

## 1. INTRODUCTION

Consequences of climate changes, energy dependency and reduction of fossil fuels lead to great public interest and utilization of renewable energy sources (RES). Serious interest for renewable energy is the consequence of global energy crisis, but also fact that with usage of Solar energy, wind energy, geothermal water and biomass energy, nature and environment are far more less contaminated. Energy crisis that was engendered at the begining of 2009. when the conflict between Russia and Ukrain started, lead to energy crisis in the most parts of Europe.

## 2. RENEWABLE ENERGY SOURCES (*RES*)

Renewable Energy Sources (RES), are offering great potencial for future energy consuption, but costs for energy production at these moment are to high.

Therefore it must elapse some period of time before it reaches new dimension of RES appliance. Unfortunately at these moment, human kind must rely on nonrenewable energy sources – oil, coal, nuclear energy and natural gas. RES without hydroenergy, provides about 1% of total energy at these moment. In the environmental approach, future rate must be significantly enlarged, because nonrenewable energy sources are decreasing every day. Development and appliance of RES (especially wind energy, Solar energy and biomass energy) are very important in many different ways. RES have very important role for decreasing $CO_2$ emissions in atmosphere. With increasing usage of RES, energetic system sustainability is geting more progressive and dependency from importing energy resources and electric power reduces [4].

Towards data that are shareware to public and national statistical database, oil consuption in the world amounts about four billions of tons per year, while on the another hand total oil reserves amounts about 120 – 160 billion tonnes. Oil refinement will achieve peak by 2010. year, and there is the fact that fossil and nuclaer fuels offer only short time and nonrenewable development. Fossil fuel reserves are desappearing very fast, in this way many peple predicts two decades before everyone must use RES.

Members of EU have been decided to increase share of RES from 8.5 % in 2005. to 20% by 2020.

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EU actions in field of RES lead to higher number of employed people, more than 350.000, and annual transactions are estimated to 30 billions €. World energy consumption by data for year 2000. (TPES – Total Primary Energy Supply) by RES is about 13.5. %.

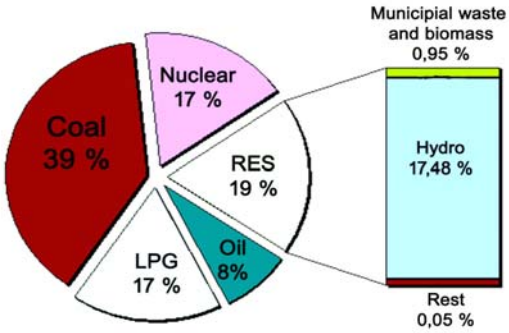



Figure 1. RES share in world electric power production

The largest share of RES (11%) have biomass and municipal waste, water bodies have 2.3%, while all other RES have 0.5%. For world electricity production in year 2000.,share of RES is about 19% (Figure 1.). Most important share of RES has hydroelectric power plant with 17.48%, biomass and municipial waste have share of 0.95% and all others have 0.57%.

Implementation strategy and RES utilization program with us, such as in all other regions of the world depends from each source characteristics. All other countries have the same target, increasing RES share within energy obtaining in future decades. RES are very important for $CO_2$ emission reduction. Using of RES significantly bring safe obtaining, first of all electric power, because it reduces dependency growth from importing energy.

RES are separated to:

*Classic RES*:

- Combustible renewable waste (solid biomass, woodcoal, agricultural and animal waste, municipal and industrial waste, biogas) and
- Hydroelectric power plants.

*New RES:*

- Small hydroelectric power plants,
- Geothermal energy,
- Solar energy,
- Wind,
- Energy of see (sea, tide and low tide, thermal gradient).

But in wider sense RES means:

- Water power energy,
- Solar energy,
- Wind energy,
- Geothermal enegy,
- Oceans and see energy,
- BIOMASS energy.

## 3. BIOMASS AND WASTE BIOMASS (WBM)

Biomass is organic matter from animal or herbal origin, which converts in many different ways to useful energy.

Energy from herbs represents acumulated solar energy wherewith light is transforming to chemical energy.

Biomass constitute from agriculture waste 98%, forest production 1,5% and wood refining production 0,5%.On the another side biomass can divide to energetic plants, agricultural scrap and waste. Biomass waste from agricultural production is one of the most perspective energy sources in Serbia and beside that biomass do not generate hazardous substances. Seizing of biomass from waste as a fuel can save considerable funds which strive in purchasing of all other energy-generating products.

Biomass and waste materials are utilizing as energy sources for their combustion and heat generation which propel electric generators or for fluid heating. Energy acumulated in biomass is chemical nature so in energy exploatation, there is no work [1].

Biomass energetic potencial is enormous and it amounts about 80% of total RES potencial. That is the energy which is equivalent to 2,6 millions of tons of combusted oil. Technological advance lead to development in technologies which are based on biomass waste, energy and resources that agroindustrial complex unload, but also and all other areas of agricultural development. In the same time, introducing with new technologies shows pozitive impacts on the environment, apropos to environmental protection and improvement. Available biomass in Serbia could be energetic source for unrenewable liquid and gas fuels replacement, so as for electric energy in agroindustrial complex[7].

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## 4. „VINO ŽUPA" EXAMPLE

Energy-generating products that are using at the moment in the fabric complex „"VINO ŽUPA' - DD" are heavy fuel oil – mazut and electric energy. Because of constant fossil fuel price changes and obtaining instability, usage of biomass as energy-generating product is reasonable in economic and ecological aspect.

Biomass from waste (WBM), which emergent in agricultural products treatment in fabric „Vino Župa"-Aleksandrovac, management plans to use as motor fuel for biomass boiler which is in instalation phase.

WBM in the case of "Vino Župa" (seeds, stems, apple and grape rapes and wood waste), belong to RES and CO2 neutral energy sources.

As a fuel in biomass boiler, waste materials from fruits and vegetables production are estimated:

Table 1. Estimated fruit and vegetable production

| Name | H- humidity [%] | Quantity | Period |
|---|---|---|---|
| Wood waste and sawdust | 40 | 20 m³/day | from 01.06.-31.10. |
| Cherry seeds with foreskin | 49 | 1000 t | from 01.06.-30.06. |
| Cherry, plum, peach, apricot seeds with foreskin | 49 | 1000 t | from 01.07.-31.07. |
| Cherry, plum, peach, apricot seeds with foreskin | 49 | 500 t | from 01.08.-31.08. |
| Apple slurry | 84,61 | 10000 t | from 01.08.-31.10. |
| Grape rape | 50,20 | 2500 t | from 10.09.-20.10. |
| Grape stem | 60 | 2500 t | from 10.09.-20.10. |

Table 2.Boiler technical characteristics

| Type | SURI P -12/SURI-RGF 15 |
|---|---|
| Production max. | 12000 *kg/h* |
| Boiler capacity | 7812 *kW* |
| Max. Preasure | 13 *bar* |
| Tested preasure | 16.9 *bar* |
| Max. steam temperature | 195 ℃ |
| Feeder water temp. | 105 ℃ |
| Fuel | Biomasa |
| Lower fuel heat potencial (W=40%, A=0.5%) | 9908.22 kJ/kg |
| Boiler efficiency rate | 82.57% |
| Exit flue gases temperature | 161 ℃ |
| Boiler mass – net | 47831 *kg* |
| Boiler mass – fatigue | 73756 *kg* |
| Heating area | 900 $m^2$ |
| Preasure fall on the gas phase | 1600 *Pa* |
| Preasure fall on the water phase | 0,1 bar |
| Fuel consumption | kg/h 3437 |
| Air flow | 15880 m³/h |
| Flue gases flow on $t_{exit}$ | 36150 m³/h |

Towards data from study of Innovation Centre of Technical Faculty in Belgrade, accessible quantities of biomass are totally appeasing requirements for technological dry saturated steam production with 12 t/h and 12 bar.

Table 3. .Average biomass heat potencial

| Biomass | kJ/kg | 9908 |
|---|---|---|

## 5. CONCLUSIONS

So far „Vino Župa" was utilized mazut as a fuel which leaded to creation of gases that polluted air and environment and contributed to Greenhouse effects.

Since fuel price varied in last couple of years, boiler with biomass satisfied both ecological and environment aspects. Economical calculations pont that boiler will be redeemed for couple of years with curent prices of oil and production trend.

That confirms conclusion that biomass is economically payable, but only in cases when biomass was generated in big volumes next to direct exploitation presence.

With examination of analysis we can conclude that there is a strong connection between Strenghts and Opportunities for maximum RES utilzation as energy-generating product. But also it is essential to benefit from Strenghts and Opportunities so we could eliminate Weaknesses and Threats.

Corresponding to global trend and requirement for energy, RES has future in resolving ecological and economic world crisis[3].

Table 4. SWAT analysis

| Strenghts | Weaknesses |
|---|---|
| Low-cost resouces – low redemption price<br>Non load waste to environment<br>Good expet sense<br>Good liquidity and profitability<br>Developed technology<br>Production Innovation<br>Biomass is $CO_2$ neutral fuel<br>Accessibly<br>"Clean" ash<br>High total energy potencial<br>Employing | Low fuel power<br>Transport<br>High humidity rate<br>Low energy value by mass unit<br>Different admixtures (Chlor)<br>unhomogeneity |
| **Opportunities** | **Threats** |
| EU access<br>EU strategy for RES – until 2020.year 20%<br>World trends<br>Energy crisis<br>20 boiler producers in Serbia<br>Lower dependency from import<br>Equall and renewable country development, regions development in Serbia and dedication of local communities<br>Agricultural development<br>Cogeneration and threegeneration<br>Renewable developmnet | Law regulations<br>Undeveloped public sense<br>Unfriendly political an economic situation |

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# THREATS IN TRAFFIC FOR THE YOUNG PEOPLE IN THE TERRITORY OF SERBIA

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**Abstract:**
Every year 1.2 million people from all over the world are killed in traffic accidents. Hundreds of thousands of people get injured on the roads, and a very large number of them remain permanently handicapped and disabled for further independent life. The participation of young drivers in traffic accidents with the killed and traffic accidents with injured persons is very high. Injuries in traffic accidents take the second place as causes of death among young people aged 5 to 25.
The paper analyses the characteristics of casualties in traffic belonging to the age group from 15 to 24 in the territory of the Republic of Serbia in the period from the year 2002 to 2006. A special emphasis in the paper is placed on spatial distribution of casualty risk among young participants in traffic. For that purpose, we prepared the public risk map for death in the age groups from 15 to 19 and 20 to 24 per municipalities in the Republic of Serbia.
The objective is to establish spatial distribution of casualty risk for members of those age groups per municipalities in Serbia and to identify in such a way the areas with the highest public risk in traffic.

**Key words:**
Traffic, Safety, Risk, Young People

## 1. INTRODUCTION

Every year, according to the statistics, 1.2 million people are known to die in road accidents worldwide. Millions of others sustain injuries, with some suffering permanent disabilities [4].

The analyses of traffic accidents and their consequences all over the world show a large share of the young people in the number of casualties in traffic. A high level of participation of the young people in traffic accidents is a critical element of social and economic cost for the social community.

Different age groups are characterised by different knowledge, attitudes, capacities, behaviour, and different traffic exposure. Injuries in traffic accidents take the second place as causes of death among young people aged 5 to 25 while among young participants in traffic aged up to 25 young men make 75% of casualties.

Most often, young people show the appropriate physical preconditions but they still lack life and traffic experience, maturity in traffic, which could give the most favourable shape to those preconditions that is necessary for accomplishment of the final aim. They have good perceptive and reaction capacities but that is not sufficient for safe vehicle driving. Among young people, there is often a disharmony between self-confidence, actual psycho-physical capacities of their bodies and technical potentials of their vehicles. In all age groups, overestimating of one's own subjective potentials is a frequent case caused by still undefined self-awareness, insufficiently developed self-consciousness, and self-criticism, unawareness of one's own limitations.

The subject of this paper are the casualties in traffic belonging to the age group from 15 to 24 in the territory of the Republic of Serbia in the period from the year 2002 to 2006. The main objective of this paper is to establish spatial distribution of casualty risk for members of those age groups per municipalities in Serbia and to identify in such a way the areas with the highest public risk in traffic.

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There are certain limitations in the paper due to the current social-political situation at Kosovo and Metohija so that this Province has not been included in the research. We used the databases from the UIS (unified information system) of the Ministry of Internal Affairs (MIA) of the Republic of Serbia, so that the quality of results obtained through the analyses depends on accuracy of the input data.

## 2. METHOD OF WORK

In the research of threats to young participants in traffic, we applied the following methods in order to obtain the best quality results:

- Statistical method
- Analytical method
- Classification method (finding of sets with similar properties);
- Method of comparison (comparison of the same or similar facts, phenomena or processes, namely finding of their similarities in behaviour and differences);
- Method of presentation of results in graphs.

Fro the needs of the research we established the database on casualties among young participants in traffic accidents in "MICROSOFT ACCES"programme software. For data processing we used "MICROSOFT EXCEL" programme software, an data were presented on maps for he purpose of easier spotting of municipalities in which it is necessary to implement the traffic safety strategy aimed at reduction of number of casualties among young participants in traffic.

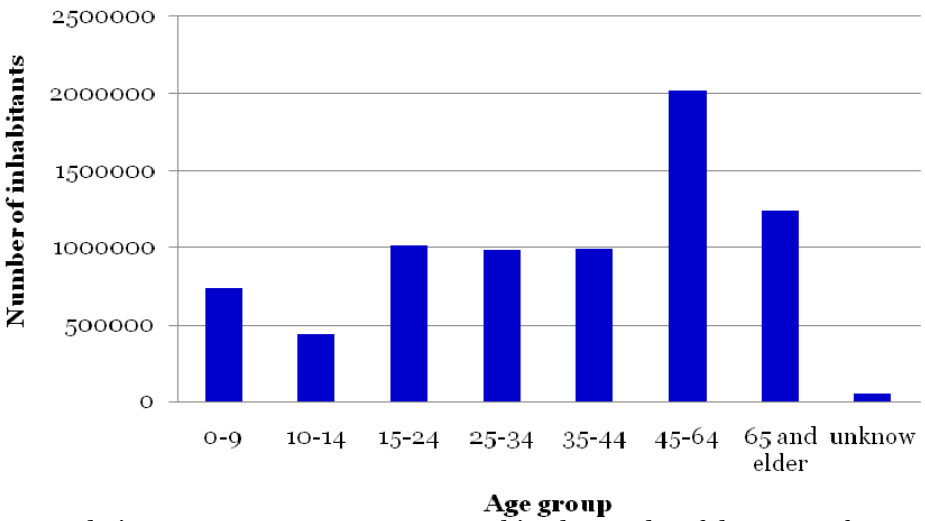
## 3. THE OUTLINE OF THE MOST SIGNIFICANT RESEARCH RESULTS

### 3.1. Population structure in Serbia

According to the results of the research of the World Health Organisation (WHO) 3,242 persons die on the average a day on the roads in the world. From 20 to 50 million people a year get injured or permanently disabled in traffic accidents. In Serbia, 4,423 persons were killed in traffic accidents in the period from 2002 to 2006 and 83,563 of them were injured. The number of the killed persons aged from 15 to 24 is 625 (15% of the total number of those who were killed) while 21,560 of them were injured (25% of the total number of those who were injured).

In order to be able to analyse and evaluate traffic safety in a country it is necessary, first of all, to analyse the structure (the age structure in particular) of the population of the relevant country.

The last census was conducted in Serbia in 2002 by the Republic Institute for Statistics of Serbia. Persons aged from 15 to 24 make 13.49% of the population (Graph 1).



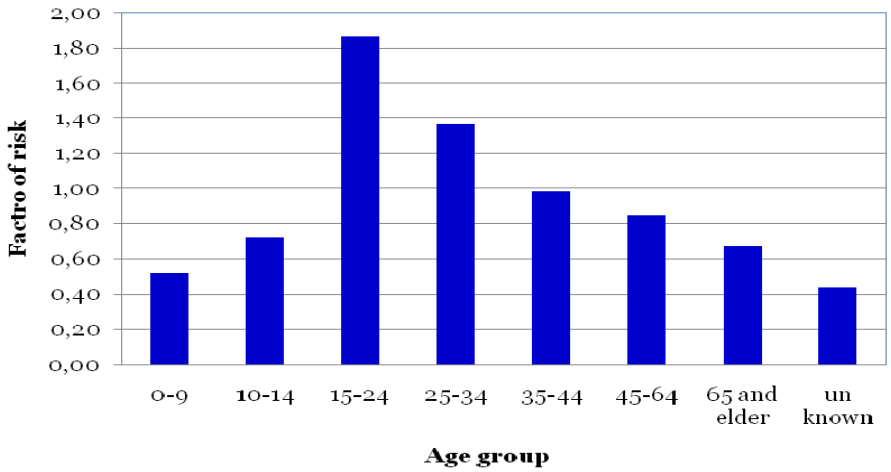

Graph 1. Population structure per age groups, Serbia, the results of the census from 2002 [2]

### 3.2. Structure of casualties among participants in traffic according to consequences

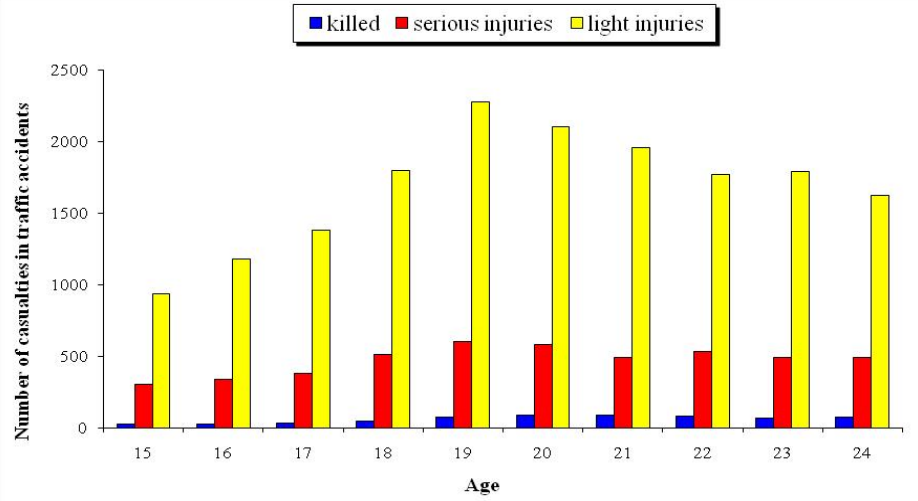
The highest share in the structure of casualties among participants in traffic belongs to persons in the age group from 15 to 24 (Table 1). Out of 87,986 of casualties in total in the analysed period 22,185 (25.21%) of casualties belong to the age group from 15 to 24. The number of casualties among members of the age group from 45 to 64 is also very high - 20,212 (22.97%) of casualties among participants in traffic. They are followed by the age group from 25 to 34 and from 35 to 44. If we take into account the fact that the age group from 45 to 64 is far more numerous than the age group from 15 to 24, it is clear that the number of casualties in a younger age group is even more emphasised.

Table 1. Structure of casualties among participants in traffic according to consequences per age groups, Serbia, 2002-2006

| Age group | Killed | serious injuries | light injuries | Number of casualties |
|---|---|---|---|---|
| 0-9 | 123 | 978 | 3400 | 4501 |
| 10-14 | 69 | 947 | 2719 | 3735 |
| 15-24 | 625 | 4740 | 16820 | 22185 |
| 25-34 | 642 | 3736 | 11429 | 15807 |
| 35-44 | 529 | 2949 | 7989 | 11467 |
| 45-64 | 1320 | 6010 | 12882 | 20212 |
| 65 and elder | 1100 | 3492 | 5241 | 9833 |
| unknow | 15 | 51 | 180 | 246 |
| Sum | 4423 | 22903 | 60660 | 87986 |




**Graph 2.** Factor of risk per age group, Serbia, 2002-2006




Graph 3. Casualties in traffic accident for young people (15-24 years), Serbia, 2002-2006

### 3.3. Spatial distribution of casualties among young participants in traffic

Establishing of the level of threats to certain groups of participants in traffic is most often based on the scope of public risk (casualties and number of those who were killed).

Public risk of deaths in traffic represents the number of the killed young participants in traffic per 100.000 of young people, and number of casualties among young participants in traffic per 100.000 of young people represents the public risk of casualties in traffic.

For the needs of those analyses, we used the following two databases in this paper:

- Number of inhabitants per municipalities in the territory of Serbia
- Number and characteristics of traffic accidents and their consequences per municipalities in the territory of Serbia.

Ranking of casualties among young participants in traffic according to the public risk scope is determined through setting of public risk ranks and classes (Table 2). First, we determined the lowest, and the highest value and scope of the risk and later on we defined the risk classes in-between those two values.

Table 2. Public risk ranks and classes for threats to young people

| Ordinal No (mark of traffic safety) | Level of risk (description) | Public risk | |
|---|---|---|---|
| | | class (interval) | rang (color) |
| 1 | low risk | up to 5,0 | |
| 2 | low-medium risk | [5,0 – 10,0) | |
| 3 | medium risk | [10,0 – 15,0) | |
| 4 | high-medium risk | [15,0 – 20,0) | |
| 5 | high risk | over 20,0 | |

Based on the ranking of casualties among young people in traffic that has been carried out in such a way, we can identify and single out the municipalities with the highest public risk, namely the municipalities where undertaking of measures aimed at reduction of traffic threats to young participants in traffic is urgently needed.

### 3.4. Public risk of casualties among young participants in traffic in the territory of Serbia

According to the above-mentioned criterion, the highest risk of deaths among young people (those aged from 15 to 19) in traffic is present in the territory of municipality of Backi Petrovac and it makes 57.9 of the killed young people per 100,000 young people. A very high risk of deaths among young people is also present in 23 municipalities in Serbia, such as the municipality of Malo Crnice (50.6), Ivanjica (43.1), Prijepolje (42.3), Cajetina (41.9), and Knjazevac (41.4) etc. The municipalities with a very low risk include the municipality of Cacak (4.9), Stara Pazova (4.1), Leskovac (3.9), Novi Sad (2.0), Kragujevac (1.6) etc.

When it comes to threats of casualties among young people aged from 20 to 24 the situation is somewhat different. If we compare Figure 1 with Figure 2 we can see that the number of municipalities with a very high risk of deaths among young people aged from 20 to 24 is much larger (50) than in the age group from 15 to 19 (23). Namely, the highest public risk of deaths has been identified in the territory of municipality of Cajetina – it makes even 114.5. The public risk of deaths is also very high in the territories of municipalities of Velika Plana (83.2), Kanjiza (78.9), Zabalj (63.2), Sremski Karlovci (62.9), Backi Petrovac (61.5) etc. In the territories of those municipalities, the number of casualties among young people per 100,000 of young participants in traffic is far higher than in the territories of other municipalities in the Republic of Serbia.

The graph presentation of distribution of public risk of deaths (Figure 1 and Figure 2) shows the best the threat ratio among young people aged from 15 to 19 and young people aged from 20 to 24. Such presentation also simplifies spotting of municipalities that should be the first to become the "subject" of measures of reduction of threats to young people in traffic.

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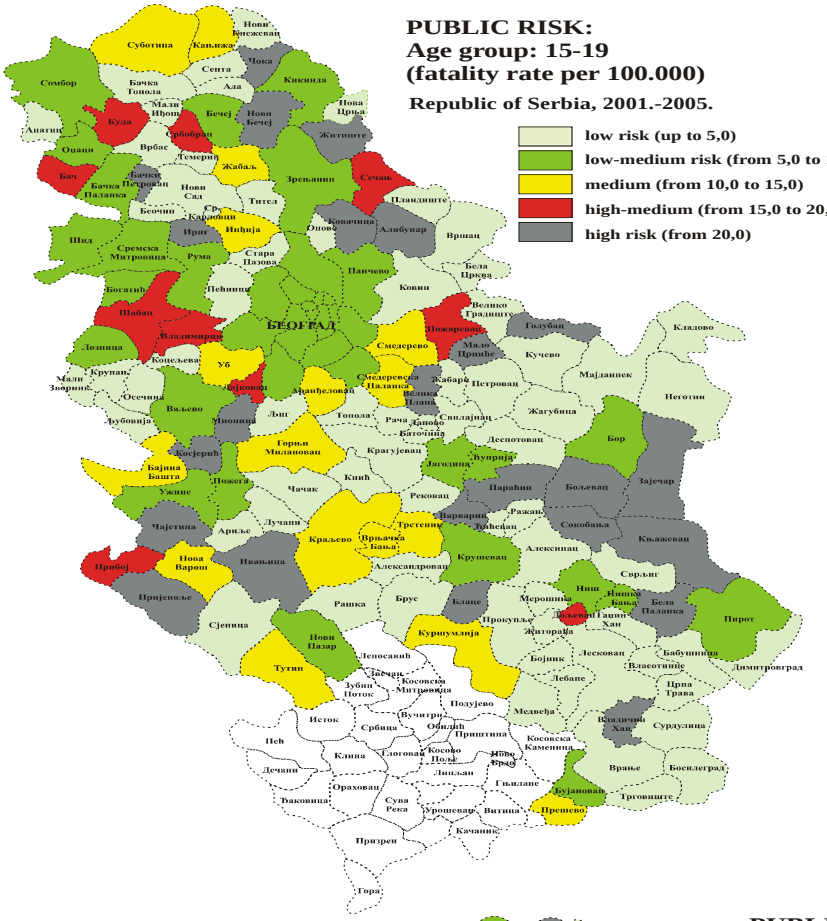



Figure 1. Public risk of deaths among young people (15-19) per municipalities in the territory of the Republic of Serbia in the period from 2002 to 2006

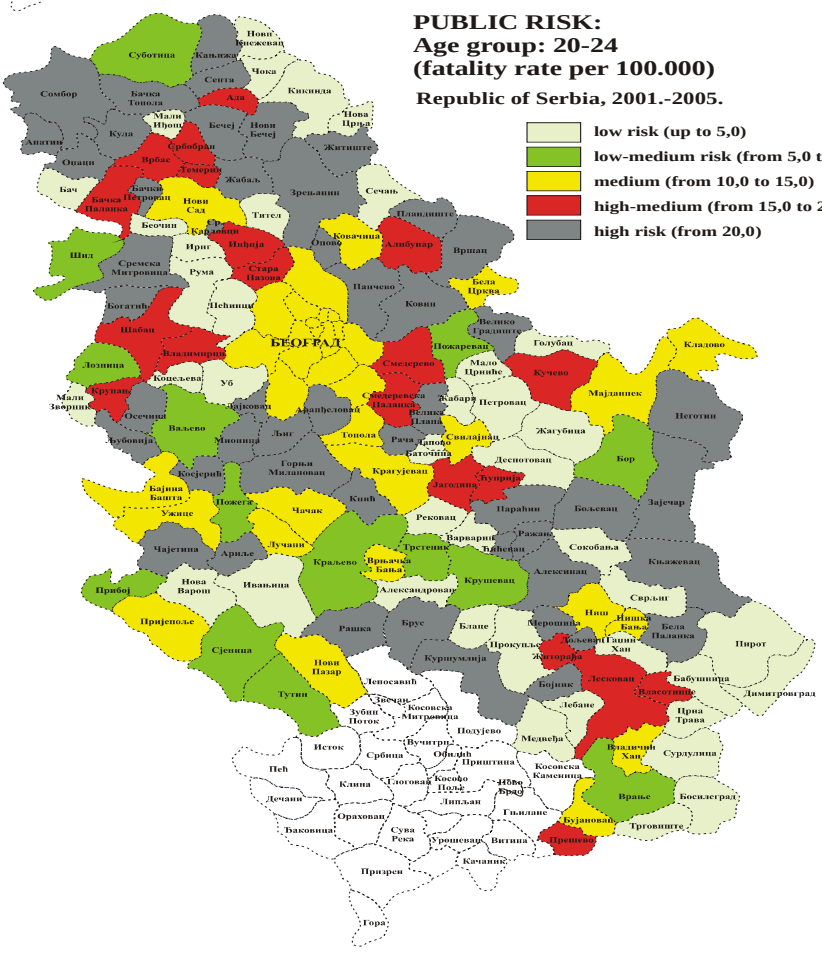



Figure 2. Public risk of deaths among young people (20-24) per municipalities in the territory of the Republic of Serbia in the period from 2002 to 2006

## 4. FINAL CONSIDERATIONS WITH GENERAL PROPOSAL OF MEASURES

In the period from 2002 to 2006, 87.986 of persons were casualties in traffic accidents on the roads in Serbia and 22.185 of them belong to the age group from 15 to 24.

An emphasised number of casualties among young people is not the problem in Serbia alone but in many developed countries of the world as well so that this phenomenon has to be analysed as the problem, which has to be treated as a high priority one within public reactions of the society on the whole. Due to that, the attention has to be paid to special measures that can contribute to reduction of the number of traffic accidents with young participating young drivers.

Local government is always playing a significant role in traffic safety and its responsibilities cover a wide spectrum of social services, from technical to health care and social services. In order to develop an efficient traffic safety programme it is necessary to prepare and conduct a comprehensive analysis of traffic safety, which should be updated periodically (per time intervals during the year, per year etc.).

Some of the measures that should be implemented aiming at improving traffic safety among young people in traffic include:

- Young people are capable of clear spotting, understanding, evaluating, and reacting fast and their memory is sharp and vivid. Therefore, the most efficient measure within social reaction towards the young people is timely and quality preparation for traffic in order to take the advantage and channel properly the advantage that young people posses.
- The introduction of graded driving licence – upon legal maturity young people are liable to obtained riving licence for all categories of vehicles, except for buses and trolleybuses. As it has been noted that the system of preparation for traffic does not produce "safe" drivers, it is necessary to prescribed issuing of temporary driving licences with the validity period of two years fro the beginners, which will not allow them to carry out more complex driving tasks.
- The establishment of the Traffic Safety Agency within the Government, which will have the authority and responsibility for decision making, control over resources and co-ordinate the work of all Government sectors dealing with traffic safety (health care, transport, education and police).
- Preparation of the national traffic safety strategy and action plan – traffic safety strategy should take into account the needs of all the participants in traffic, in particular of vulnerable categories and it should be linked with strategies in other sectors. Practically speaking, each municipality in Serbia should pass its own traffic safety strategy in accordance with characteristics obtained through the analysis because its efficiency during implementation may be threatened if it is not the result of concrete analysis.
- To promote educational campaigns designated to young people in traffic.
- To improve and maintain the database on accidents and casualties.
- To carry out and stimulate researches, monitor and implement practices from successful countries.

Such an approach in consideration and further resolving of problems in traffic safety promotes the implementation of further researches in the field of traffic safety at a micro-level, which represents the additional quality in further work related to enhancement of its protection mechanism.

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# DETERMINING THE FLOW OF GOODS WITH THE GOAL OF INCREASE OF EFFECTIVENESS IN CARGO TRANSPORTATION IN THE RIVER-SEA DIRECTION

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**Abstract:**
Important place in the process of increase of effectiveness in cargo transportation by waterways are reserved for direct river-sea transports. This refers to transports between places on inland waterways and sea ports. This is the reason why, in order to improve this means of transport, it is necessary to determine technical and economic factors, which determine suitability of this means of transport. Determining the flow of goods is one of the most important factors.
Serbia is a country with very favourable transport-geographical position considering that the shortest road and rail corridors between countries of Western and Central Europe and Southern Europe and Middle and Far East go through its territory. International waterway Danube flows 558 km through Serbia, connecting the North Sea and the Black Sea through canal Danube-Main. Due to this well-located transport-geographical position international freight transport on pan-European corridors VII and X has been constantly increasing.
The goal of this paper is to determine the total flow of goods for Serbia, as precisely as possible. From this information potential flow of goods on river Danube - sea direction can be set aside.

**Key words:**
Flow of goods, river ports, sea ports, river-sea vessel.

## 1. INTRODUCTION

The goal of this research is to display data on transport of goods on our inland waterways. This research provides the data on economic, technical and geographical characteristics of transport and traffic of goods. Additionally, the following indicators are also obtainable: types and carrying capacities of vessels, vessel flags, places of loading and unloading of goods, countries of loading and unloading of goods, types of transport and amounts of transported goods. Moreover, this research offers the data on domestic and international goods flows by ports of loading, unloading, as well as data on vessel flags.

The data from this are used for presenting overall volume and structure of goods traffic on inland waterways, as well as for comparing the goods traffic on inland waterways with the traffic done by other modes of transport. Statistic of inland waterways transport enabled comparison with corresponding statistics of other Danube countries, received from the Danube Commission, with headquarters in Budapest.

The data collected through this research are also used for calculating global statistical indicators, such as physical volume index of transport services. The obtained results are sent to international organizations dealing with transport, such as The Danube Commission, UN ECE-inland transport committee, Organization for Economic Cooperation and Development (DUNCOM, UN ECE-IT and OECD), etc.

## 2. TOTAL INTERNATIONAL FREIGHT TRANSPORT

Total international freight traffic in the period 1996-2006, annually increased by 10.8% on average. Export of goods realized by all transport modes, grew with the average rate of 10.9%, import with the rate of 6.7%, and in this period the highest increase rate of 12.8% was noted in

transit. Considerably higher growth rate were noted in the period 2001-2006, in comparison with the period 1996-2000. It is understandable taking into account that in 1999 Serbia was being destructed by NATO aviation. As a consequence, rail and inland waterway networks were particularly damaged. In the period 2000-2006 total international freight traffic increased at the annual rate of 20.3%. Export of goods grew at the rate of 15.9%, import at the rate 13.6% and transit at the rate of 34.4%. Although transit of goods performed by all modes of transport showed extremely dynamic growth rates in this period, it was noticed that the highest growth rate, with the reconstruction of our waterways, was recorded in inland waterways transit of goods.

In 2006, majority of total goods conveyed by all modes of international transport were transported by road freight vehicles, around 42.9%, 21.8% were transported by inland waterways, and 23.0% by rail transport and 12.3% is the share of oil and gas transported by pipelines. Looking back to 1996, it can be noticed that the largest amount of goods was carried by inland waterway transport (49.2%), followed by road transport (28.5%). In the same year the share of rail transport in total international freight transport was 14.1% and 8.2% was the share of pipeline transport.

**2.1. Export of goods by modes of transport**

Total export of goods realized by all modes of transport in the period 1996-2006 grew at the average annual rate of 10.9%. The highest growth rate in this period was registered in rail transport (15.4%); a little bit slower increase was noted in road transport (12.8%) and the slowest raise of 3.6% was in inland waterways transport. Significantly slower growth rate of 3.8% in export was noted in the period 1996-2000, in contrast to the period after 2000, when the export increase rate was 22.9%.

Comparing different modes of transport, it is apparent that from 2000 to 2006, the fastest export increase was in rail transport, as it increased almost four times during this period, road transport increased about 2.5 times and inland waterways transport more than 2 times. Share of road and rail transport in total export increased during the period 1996-2006, unlike inland waterway transport whose share dropped from 35% to 17.9% in 2006.

Export of goods to European countries in 2006, compared to 1996, a year before the NATO aviation aggression, was over three times higher. Transport by rail was almost four times higher, transport by road three times and inland waterways transport over two times higher.

Compared to 2000, total export of goods to European countries, done by all odes of transport, was almost three times higher, where a fast growth over five times was noted in rail freight transport.

Total export of goods to the EU countries in the period 1996-2006 increased by 3.8 times, but with different progress rates in various modes of transport. Thus the rail freight transport in the observed period was almost 14 times higher, road transport 3.8 times higher and inland waterway transport by 22.3% higher.

Total export to EU member states in 2006, compared to 2000 was over 3.7 times higher, where the fastest rise of over 11 times was recorded in rail transport. In the same period export of goods to EU member states by road increased 2.6 times and export by inland waterway transport 2.5 times.

Total export of agricultural product realized by all modes of transport in 2006 was 1782 thousand tons, whereof cereals made over 68%. Export by road made more then half of total amount of exported food products, export by inland waterways almost two fifths, while the rest was exported by rail. Export of metal products was 1463 thousand tons, of which the largest share of 657 thousand tons comprised plates, wires and other construction materials for railway tracks. Over two fifths of the products from this group were transported by rail.

The export of machinery, transport equipment, manufactured goods and miscellaneous articles was 1379 thousand tons, where four fifths of the goods were transported by road. The export of crude and manufactured minerals and building materials was 895 thousand tons and majority of it, almost two fifths was transported by inland waterways.

**2.2. Import of goods by modes of transport**

Total import of goods realized by all modes of transport in the period 1996-2006 noted a slight slower rate in comparison to export growth rate. In the referent period, average growth rate of import was 6.7% while the highest increase rate of 13.7% was noted in pipeline transport. Road transport recorded annual growth rate of 7.0% and rail transport of 5.9%. Compared to other transport modes, the lowest growth rate of only 1.5% was noted in inland waterway transport.

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In the period 2000-2006, overall import of goods was 2.1 times greater. The fastest growth rate of almost eight times was recorded in pipeline transport, mainly because of the reuse of oil pipelines from Omisalj (Croatia) to our refineries in Novi Sad and Pancevo. In the same period, rail transport increased by more than two times, road transport by 67.6% and the lowest increase of 30.4% was noticed in inland waterway transport.

Total import of goods from European countries in the period 1996-2006 increased almost two times with equal growth rates in all modes of transport. Therefore, rail transport to European countries in the observed period was two times greater, inland waterway transport more than two times and road transport almost two times.

In the same period import of goods from the EU member states increased three times and transport of goods by road increased over three times. Import of goods from the EU by inland waterways was the only mode of transport with negative trend, meaning that it decreased two times. In 2000, 79.6% of total goods from the EU countries were imported by road transport and the rest by rail and inland waterway transport. Six years later, in the trade with the EU, road transport was still a dominant mode of transport, as almost three fifths of total goods, for our economy needs, were transported by road. A third of the goods were transported by rail, only 4.8% by inland waterways and 3% by pipelines (natural gas from Hungary).

Almost two fifths of the total import of 15723 thousand tons referred to crude oil and its products. Import of crude oil was 2222 thousand tons; import of gas was 3333 thousand tons, while amount of imported refined oil products was 420 thousand tons. The largest amount of this type of goods was imported by pipeline transport (over four fifths), followed by rail and inland waterway transport. Import of ores and metal waste was 1929 thousand tons and import of solid mineral fuels was 1594 thousand tons.

The largest amount of imported ores and metal waste was carried by inland waterways, 88,5% and share of this mode in solid mineral fuels import was considerably small, taking into account the composition of goods (a fourth of total import was transported by inland waterways). This group of goods was mostly conveyed by rail, over three fifths of the total quantity. Imported metal products were mostly carried by road, 45.1% and by inland waterway transport 19.7%. Referring to the import of machinery, transport equipment, manufactured goods and miscellaneous articles, 40.8% of total goods were transported by road and a third by rail transport.

### 2.3. Transit of goods by modes of transport

Total transit of goods over the territory of Serbia, related to all transport modes, increased by 3.5 times in the period 1996-2000. The fastest increase was recorded in goods transported by road vehicles, while slowest increase was noted in inland waterway transport, i.e. transport on the Danube.

Out of 17555 thousand tons carried in transit by rail, road and inland waterway transport in 2006, 4037 thousand tons were transferred from and to Turkey via our transportation network, out of which 75% was transported by road vehicles. In goods transit to and from Bulgaria, 3876 thousand tons were carried, out of which 57.8% by road, 32.0% by rail and 10.2% by inland waterways. In goods transit to and from Greece, over Serbian transportation network, 2137 thousand tones were transported, whereof 46.1% by road and 53.9% by rail. Total transit between Germany and Serbia was 3324 thousand tons of goods and between Serbia and Romania 2974 thousand tons.

## 3. INLAND WATERWAYS TRANSPORT

Besides the Danube, the international rivers Sava and Tisa with their tributaries and navigable canals provide 1360 km of navigable waterways for the ships with carrying capacity of up to 400 tons. The majority of ports in Serbian part of the Danube, after the construction of the big dam have been equipped to provide docking for smaller river-sea boats. This significant improvement in navigation enables direct transport between Serbian ports on the Danube and the sea ports on the Black and Mediterranean Seas, without reloading in ports situated in the delta of the Danube.

After years of stagnation due to the destruction of the bridges on Sava and the Danube (1999), building of new and reconstruction of old bridges, as well as after clearing of waterways, regular navigation through Serbian part of the waterways to the Black Sea was enabled. Building of the waterway Danube-Main-Rhine facilitated successful connection of river ports on the Danube with the ports in The Rhine river basin and the Northern Sea ports. Building of the

navigable canal Cherna Voda-Constanta shortened the waterway to the Black Sea for over 200 km. Total international goods transport by inland waterways in 2006, compared to 1996 increased by 11.7%, with slightly more dynamic increase of export (43.2%) and import (16.8%). Nevertheless, in the period 2000-2006, after clearing the waterway network, total international inland waterways transport increased by more then 3.5 time, where extreme rise of more then 16 times was noted in transit transport of goods.

### 3.1. Export of goods by inland waterways

Somewhat more then fifth of the total amount of goods exported by inland waterways in 2006 was carried to the EU member countries. 15.8% of the total export to the EU was carried to Germany on waterway Danube-Maine-Rhine. Three fifths of the total goods in export were exported to the river-sea ports on the Black Sea, out of which, more then a half was transported through reloading into sea boats, to the countries of the Black Sea region. By reloading to sea boats, majority of goods were exported to Italy, Spain and non-European countries.

Less then one fourth of the total 1472 thousand tons was transported by Serbian boats. The largest amount of the exported goods was carried by Ukrainian and Romanian boats.

### 3.2. Import of goods by inland waterways

Only 18.4% out of the total of 3406 thousand tons imported to Serbian ports were carried by Serbian boats. Not even a single ton was carried by Serbian boats in external trade with Austria and Slovakia. It is interesting that vessels of all other countries of the Danube region except Serbia were included in goods import trade with Austria. Only 157 thousand tons of goods were imported from the EU countries. The largest quantities of goods were imported from the river-sea ports in the lower basin of the Danube. Hence, 1693 thousand tons were imported from Romania and 1516 thousand tons from Ukraine. However, only 282 thousand tons of goods imported from Romania were of Romanian origin.

Referring to 2006 export, agricultural products presented the major part amounting to 51.2% of the total export. Cereals had the largest share in export form this group, 98.1%. Export of crude and processed minerals was 330 thousand tons, whereof cement and lime made 16.3%. In the same year, 248 thousand tons of metal products were exported. Almost half of it referred to steel plates.

During 2006, over 500.0% of the imported goods related to ores and mineral waste, whereof 94.8% was iron ore. 409 thousand tons of solid fuels were imported, 376 thousand tons of metal products and 362 thousand tons of fertilizers.

### 3.3. Transit of goods by inland waterways

In 2006, 4146 thousand tons were carried in transit over the Danube. The largest amount of goods was loaded in Ukraine, 40.0%, then in Romania, 12.4% and in Bulgaria 7.8%. 10.8% of the goods in transit were loaded in the countries outside the Danube river region, carried over Serbian waterways for unloading to the countries of the Black Sea region.

In the same year, the largest quantity of goods carried by the Danube in transit through territory of Serbia was unloaded in the EU countries, about 63.8%. 65.5% of the total goods unloaded in the EU were unloaded in Austria and about 25.3% in Germany.

The largest volume of goods flow in transit was between Ukraine and Austria, 27.9% of total transit. Also significant goods flow in total goods transit by inland waterways of the Republic of Serbia were done between Ukraine and Croatia, as well as between Romania and Austria, with shares of 13.4% and 12.3% respectively.

**ACKNOWLEDGMENTS**

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# VACUUM IMPREGNATION PRETREATMENT OF FRESH CUT VEGETABLE

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**ABSTRACT**

Vegetal products are generally characterized through a high level of sensitivity due to environmental factors and to the operations they are submitted to during their preparation. This leads to meaningful changes regarding vegetal products nutritional and sensorial characteristics. The prevention of such drawbacks can be made by introducing active compounds in their structure in order to protect them from unwanted alterations. The introduction of compounds can be achieved through classical infusion, through the immersion of the products in hypertonic solutions of the respective compound, or through a new technology, vacuum impregnation. In this paper, we present the data obtained during the experiments regarding impregnation whit some nutraceutical under a 500 mbarr vacuum of some vegetables, evaluated through physical and chemical proprieties.

## 1. INTRODUCTION

The increasing interest of people for the consumption of foods that have a beneficial effect on health has oriented both the research and the production in food industry towards the goal of obtaining such products[1]. Due to this fact, one of the main directions in the alimentary industry is focused upon the preservation of the existing natural compounds either through the minimum processing of the raw materials or through the strengthening of the foods with multiple physiologic active compounds such as prebiotics, probiotics, vitamins, fiber, mineral salts etc[2].

Another possibility to introduce the compounds in the structure of vegetable products, especially in the internal structure of fruit and vegetables, consists in the usage of a new technology, vacuum impregnation.

Vacuum impregnation consists in the immersion of vegetable products, characterized through high porosity (apple, quince, strawberries, apricots, peaches, peppers, mushrooms, etc), in solutions which contain dissolved substances meant to impregnate the product, followed by their storage in a place under a certain void pressure[3]. This technology can be applied in order to better the texture of the product to reduce its level of oxidation and its exudates at defrosting, to maintain its color, and to strengthen the different vegetable products with all kinds of nutrients: vitamin E[4], minerals salts like Ca and Zn[5], probiotics[6].

The aim of this paper is to use vacuum impregnation in order to introduce ascorbic acid into the structure of apples, so that the products become strengthened with vitamins and follow the vitamin's stability during the storage of apples in terms of refrigeration and defrosting[7]. We also took into account the need to prevent the sliced apples to turn brown during this process, knowing their sensitivity towards oxidative factors on the one hand and the antioxidant properties of ascorbic acid[8] on the other hand.

## 2. THE STUDY

### Materials and methods

Golden Delicious apple were purchased from a local store.

The following instrumentation has been used: installation for impregnation under void which consists in a RL-2 void pump and a vacuum-meter - manufactured by REFCO Manufacturing Ltd. from Switzerland- linked to a void exicator.

For impregnation we used a 0.5 per cent ascorbic acid (Fluka CH 9470 Buchs) solution.

The dosage of vitamin C was realized by iodomethric method[9], using solutions of potassium iodide 1 per cent and potassium iodate n/1000.

**Experimental**

The healthiest products have been chosen for the experiments, they were washed, their seeds and the seed home were removed with an stainless tubular knife and afterwards they were pealed off and cut in round shapes with the help of an stainless knife. The round circles had between 7 and 10 mm and a mass between 11 and 13.5 g. The samples were immersed in a solution in order to avoid their contact with the the air, apples sensitivity towards oxidation being a well known feature.

For impregnation we used a 0.5 per cent ascorbic acid solution.

For impregnation at atmospheric pressure, the apple slices were immersed within the solution. When the time expired, the apples have been removed from the ascorbic acid solution, they were put on a filter paper in order to obviate excessive water. One of the samples was used in order to dosage the vitamin C, while three other samples have been placed in glass containers and stored in the absence of light under refrigeration at 4 0C. Vitamin C has been dosed after three, six and nine days.

Two samples were kept under refrigeration at -180C. In this case, the dosage of vitamin C was done after 9 and 14 days.

For vacuum impregnation, the apple slices were immersed in the solution, introduced in the void exicator and maintained at a 500 mbarr vacuum pressure for 10 minutes. When the time expired, the apples have been removed from the solution; they were put on a filter paper in order to obviate excessive water. We calculated the quantity of impregnated solution and expressed it in percentage. A sample was used immediately for determination of vitamin C and three samples were placed in glass containers and stored in the absence of light under refrigeration at 4 0C. Vitamin C was dosed after three, six and nine days.

Two samples were stored in a freezer at -18$^{o}$C. In this case, the dosage of vitamin C was done after 9, and 14 days. The dosage of vitamin C was done using an iodomethric method. The method was chosen because it is simple and quick, it can be used for uncolored products, if we want to do some tests in order to obtain comparative results for products of the same species. The method is based on ascorbic acid oxidation with iodine produced through a reaction between potassium iodide and potassium iodate in an acid environment.

From an average sample made of examined material 10-20g is taken. The weighing are done using a analytical balance. The weighted material is grinded in a mortar with a bit of hydrochloric acid 2 per cent and 5 d of quartz sand, until a homogeneous paste is obtained. 40-50 ml dilution of hydrochloric acid 2 per cent is added and after a short mixing it is left to settle aut for e few minutes, then is filtered in a measuring bottle of 100 cm$^3$. The material remained in the mortar is washed 3-4 times with hydrochloric acid 2 per cent levigating and filtering the dilution and washing the measuring botlle. Thenceforth it is brought to the sign with hydrochloric acid 2 per cent and strongky stirred.

In an Erlenmayer of 100 cm$^3$, 10 cm$^3$ of the obtained extract is instilled, 30 cm$^3$ of distilled water, 5 cm$^3$ of potassium iodide 1 per cent and 5 cm$^3$ of starch glue 0,2 per cent as an indicator are added. It is titrated using potassium iodate n/1000 up to dark blue persistent 30 seconds.

The calculation results: $\text{VitaminaC} = \frac{V \times V_1 \times 0{,}088}{G \times V_2} \times 100$

where:

V - potassium iodate volume n/1000 for titrating [cm$^3$];
$V_1$ - extract volume [cm$^3$];
$V_2$ - semples volume [cm$^3$];
G - Weight of the analyzed sample [g];

Each measurement was taken in duplicate.

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## 3. ANALISES, DISCUSION, APROACHES, INTERPRETATIONS

The results which were obtained after the dosage of ascorbic acid for the analyzed samples are listed in Table 1 and Table 2.

Table1. The content of vitamin C in the apples impregnated with a solution of ascorbic acid 0.5 per cent at atmospheric pressure and under vacuum after the preservation under refrigeration.

| Nr. crt. | Sample | Vitamin C content [mg/100g product] | | | |
|---|---|---|---|---|---|
| | | $T_0$ | $T_1$ | $T_2$ | $T_3$ |
| 1. | Control | 6,47 | 3,92 | - | - |
| 2. | Sample impregnated at atmospheric pressure and refrigeration | 36,03 | 12,09 | 8,55 | 5,92 |
| 3. | Sample impregnated under vacuum and refrigeration | 81,46 | 73,05 | 62,41 | 37,26 |

$T_0$ = immediately after impregnation, $T_1$ = 3 days, $T_2$= 6 days =, $T_3$ = 9 days

Table 2 The content of vitamin C in the apples impregnated with a solution of ascorbic acid 0.5% at atmospheric pressure and under vacuum after the preservation under freezing.

| Nr. crt. | Sample | Vitamin C content [mg/100g product] | | |
|---|---|---|---|---|
| | | $T_0$ | $T_4$ | $T_5$ |
| 1. | Sample impregnated at atmospheric pressure and freezing | 37,29 | 31,42 | 30,45 |
| 2. | Sample impregnated under vacuum and freezing | 79,84 | 72,96 | 72,47 |

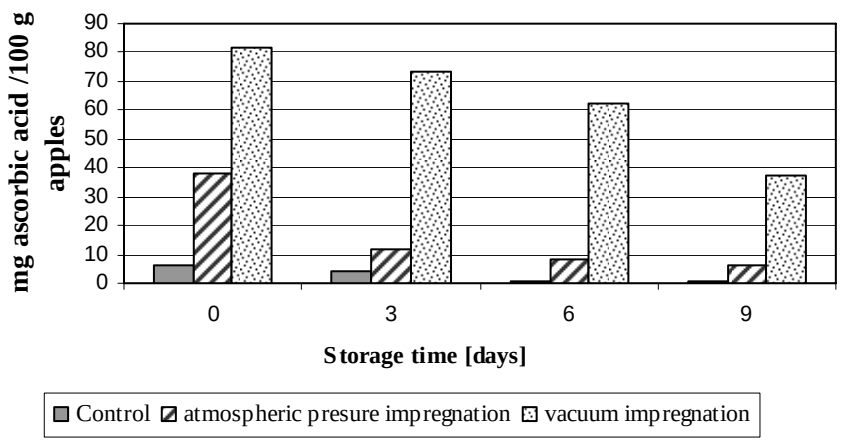
$T_0$ = immediately after impregnation, $T_4$ = 9 days, $T_5$ = 14 days

This study shows that by the vacuum impregnation of apples, Figure 1 (in certain work conditions) the content of ascorbic acid can be increased by 55% compared to the atmospheric pressure impregnation.

A reduction of ascorbic acid degradation has also been observed regarding the samples which had been impregnated under vacuum, compared to samples impregnated at atmospheric pressure, in the cases of preservation under refrigeration as well as the preservation in freezing conditions. Thus:

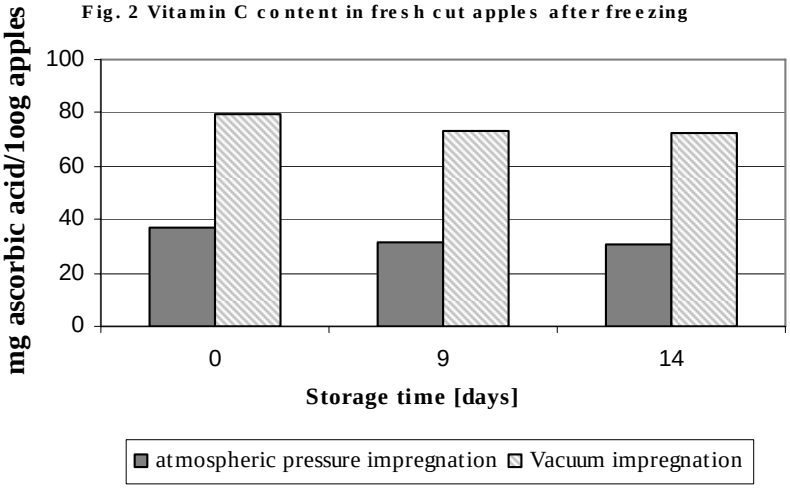
- after 3 days the sample impregnated under vacuum reduced its content of vitamin C by only 10.32% while the sample impregnated at atmospheric pressure reduced its Vitamin C content with 33.5%;
- after 6 days the sample impregnated under vacuum reduced its content of vitamin C by only 23.38% while the sample impregnated at atmospheric pressure reduced its Vitamin C content with 76.27%;
- after 9 days the sample impregnated under vacuum reduced its content of vitamin C by 54.26% while the sample impregnated at atmospheric pressure reduced its Vitamin C content with 83.56%;

Fig.1 Vitamin C content in fresh cut apples after refrigeration



The growth of ascorbic acid content and its higher stability can be explained by the fact that under vacuum impregnation the ascorbic acid penetrates into the plant tissue replacing the air (oxygen) from the apples porous structure.

Fig. 2 Vitamin C content in fresh cut apples after freezing




By keeping products in frozen state, as was expected, the stability of vitamin C is higher (Figure2) than by preserving the products refrigerated. Nevertheless in this case the vacuum impregnation content of vitamin C was reduced by only 8.61% after 9 days and 9.22 after 14 days, in comparison to impregnation at atmospheric pressure where the reduction was of 15.7% after 9 days, respectively with 18.34 after 14 days.

## 4. CONCLUSIONS

Vacuum impregnation allows the ascorbic acid to incorporate itself in the structure of the apples in a much higher quantity than under atmospheric pressure. At the same time, vitamin C, impregnated under vacuum, has a greater stability in time due to the absence of oxygen.

Impregnation under vacuum thus presents a great potential of strengthening porous plants with other nutrients intended to improve their nutritional characteristics and also with compounds that can have a positive effect upon their physical or sensorial characteristics.

The sensorial evaluation of products impregnated under vacuum is particularly important in order to observe their degree of acceptance by consumers, task with which we shall continue these studies.

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# ENVIRONMENT ECOLOGICAL PROCESS IN HUNEDOARA AREA THROUGH REINSERTION IN ECONOMIC CIRCUIT OF SCRAP AND PULVEROUS WASTE

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**ABSTRACT:**

The Hunedoara area, from industrialization viewpoint is placed before 1989 on 3 places after Bucuresti and Brasov. Representative was the iron and steel, energetic and mining industries. Through specific technological process, besides the main products have output a series of residues, that in 95% from cases were deposited on dumps and ponds.

In paper is presented a synthesis of results obtained of authors regarding to reinsertion in the economic circuit of scrap and pulverous waste existing in Hunedoara area.

Through these capitalization of wastes in the iron and steel industry I done substantial economies in cost-price of final product, on aside, and but the other side are in progress an ecological process of environment Hunedoara area through give back of occupied surfaces with these waste to the natural frame.

**KEY WORDS:**

waste, recycling, siderurgy, pollution, industry

## 1. INTRODUCTION

A long and hard process of industrial restructuring for Romania began in 1990, which influenced directly the quantity of industrial wastes produced in the country, their content and their possibilities of recycling. In Romania and in the other former socialist countries the inefficient management and the operation of the productive assets under the pressure of some unachievable objectives led to the interrupted functioning of the production and to the inadequate management of resources, contributing to excessive pollution levels and generating a huge volume of industrial wastes.

The sustained development of the heavy industry combined with the intensely subsidized energy and the unjustified low prices of the raw materials led to a very low efficiency of the energy use, the extensive use of the natural resources and the production of some great waste quantities. In the region where we propose the recycling of the small and pulverous wastes there are found great quantities of such wastes proceeded from the steel, energetic and mining industries.

Among the industrial branches some are responsible for producing most of the wastes: coal and ore extraction and preparation, producing the energy, the metallurgy, the chemistry, etc. For the industrial products whose fabrication implies generating of great quantities of wastes, such as: coking coal, crude iron and crude steel, the physical production had a general decreasing tendency. At these products, a tendency of production stabilization at levels of about 30% of those recorded in 1989 is found [1].

From a theoretic point of view, the industrial waste volume produced depends directly of the physical production volume (less of its value). The industrial waste quantities that are reported in various publications and studies are not correlated very well with the physic volume of the industrial production in Romania (there is not respected the discipline in financial administration and technology).

In Romania, like in other countries, the waste impact upon the environment has increased alarmingly in the latest years, their uncorresponding administration generating the contamination of the soil and of the ground water and also emissions of methane, Carbon dioxide and noxious gases, having direct effects upon the population health. The storage spaces have arrived to saturation and finding other mew ones has become a major problem (in the context of privatization).

For Romania the waste recycling represents a priority of the strategy of lasting development from the following reasons:

- the natural resources at some categories of raw materials are poor and insufficient, the industrial processing of the poor resources is made in non-competitive conditions or at the limit of competitiveness, the import of complementary raw materials can be carried out only within the limit allowed by the current account balance;
- complementing the resources by recycling the wastes can be achieved with lower costs, as a result of the significant economy of specific consumptions of energy, water, other materials, labor and of the important reduction of pollution and mining wastes in comparison with the useful substance extraction from the ores.

In the countries having a developed steel industry, the ferrous pulverous wastes are practically used in a ratio of over 90% by their reintroduction in the steel industry circuit. From the study of the specialty literature it results that for their practical application several technologies are practiced, namely: practical application by sintering, practical application by pelletizing, practical application by briquetting, practical application by reduction without any initial processing, practical application by the CARBOFER method.

## 2. THE STUDY

The paper presents CARBOFER obtain in the shape of micropellets, the recipes suggested for experimentations in laboratory phase following the obtained of a recyclable product, usable as well as a slag foaming agent in the process of steel made in electric furnace as well as with component in agglomeration.

The recipes for the micropellets production were thus established that the obtained micropellets to can be used-up one in two processes previously mention; therefore there must have the following characteristics:

- the recipes components granulation (for laboratory phase experimentations) must to correspond for pelletizing process (respectively granulometric structure of the palletizing charge [2,3]);
- the $Fe_{total}$ contained must be is in the existing limits of in the used-up ores to agglomeration;
- the Carbon contained must to assure necessary of reducer element in case of using this product as slag foaming agent, and in case of using this product in agglomeration process of, must to fractionally replace an amount of coke from charge;
- contained of CaO must to assure, beside bentonite, the cementing material in order to obtaining adequate micropellets (incompressible) from behavior viewpoints to handle, transport and in the technological process.

The CARBOFER chemical composition (in micropellets shape) it's presented in table 1.

Table 1. CARBOFER (micropellets form) chemical composition

| Recipe no. | Recipe components, [%] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $SiO_2$ | FeO | $Fe_2O_3$ | $P_2O_5$ | S | C | $Al_2O_3$ | CaO | MgO | MnO | Other oxides |
| R1 | 6,74 | 3,97 | 38,32 | 0,10 | 0,44 | 13,94 | 3,53 | 20,98 | 1,14 | 1,37 | 9,47 |
| R2 | 7,45 | 3,97 | 38,34 | 0,10 | 0,44 | 14,92 | 3,65 | 19,10 | 1,13 | 1,36 | 9,53 |
| R3 | 9,01 | 3,83 | 32,68 | 0,09 | 0,47 | 19,19 | 4,06 | 18,38 | 1,19 | 1,16 | 9,93 |
| R4 | 8,45 | 4,11 | 34,94 | 0,10 | 0,49 | 17,59 | 4,06 | 17,54 | 1,20 | 1,19 | 10,34 |
| R5 | 8,15 | 4,11 | 40,10 | 0,10 | 0,44 | 14,92 | 3,76 | 16,25 | 1,11 | 1,37 | 9,68 |
| R6 | 8,37 | 4,19 | 36,38 | 0,10 | 0,48 | 18,39 | 3,98 | 15,53 | 1,15 | 1,19 | 10,24 |
| R7 | 7,80 | 4,34 | 34,19 | 0,09 | 0,50 | 21,69 | 4,00 | 14,68 | 1,16 | 1,04 | 10,51 |
| R8 | 7,89 | 4,28 | 33,60 | 0,09 | 0,51 | 22,84 | 4,08 | 13,81 | 1,17 | 1,07 | 10,66 |
| R9 | 8,03 | 4,41 | 33,25 | 0,09 | 0,53 | 21,24 | 4,21 | 14,93 | 1,22 | 1,04 | 11,04 |
| R10 | 8,03 | 4,59 | 36,79 | 0,09 | 0,53 | 20,26 | 4,20 | 12,05 | 1,19 | 1,14 | 11,14 |

After micropelletizing process, for each charge was determinates the following characteristics:

- the micropellets bulk weight, wet and dried state [kg/dm$^3$];
- the micropellets humidity, [%];
- the micropellets, raw state distribution on granulometric classes.

The results are presented in table 2.

Table 2. The main characteristics of micropellets

| Recipe no. | Recipe components, [%] | | | | Humi-dity, [%] | Bulk weight, [kg/dm$^3$] | | Granulometric classes, [mm] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | >5 + 5÷3 | >5 | 5÷3 | 3÷2 | 2÷1 | <1 | 3÷1 | 3÷1 + <1 |
| | Fe | CaO | C | $Al_2O_3$ | | wed | dried | Granulometric analysis, [%] | | | | | | | |
| 1 | 29,91 | 20,98 | 13,94 | 3,53 | 3,96 | 1,26 | 1,21 | 73 | 27 | 46 | 15,5 | 11 | 0,5 | 26,5 | 27 |
| 2 | 29,93 | 19,1 | 14,92 | 3,65 | 4,96 | 1,21 | 1,15 | 61 | 9,5 | 51,5 | 22,1 | 15,2 | 1,7 | 37,3 | 39 |
| 3 | 25,86 | 18,38 | 19,19 | 4,06 | 2,44 | 1,23 | 1,2 | 15 | 6,5 | 8,5 | 10,5 | 73,5 | 1 | 84 | 85 |
| 4 | 27,66 | 17,54 | 17,59 | 4,06 | 4,9 | 1,02 | 0,97 | 17 | 5 | 12 | 18 | 63,5 | 1,5 | 81,5 | 83 |
| 5 | 31,27 | 16,25 | 14,92 | 3,76 | 3,94 | 1,27 | 1,22 | 38 | 6 | 32 | 18,5 | 30,5 | 13 | 49 | 62 |
| 6 | 28,73 | 15,53 | 18,39 | 3,98 | 3,67 | 1,09 | 1,05 | 20,5 | 2 | 18,5 | 39 | 38 | 2,5 | 77 | 79,5 |
| 7 | 27,73 | 14,68 | 21,69 | 4,00 | 3,45 | 1,16 | 1,12 | 76,5 | 63,5 | 13 | 9,5 | 12 | 2 | 21,5 | 23,5 |
| 8 | 26,85 | 13,81 | 22,84 | 4,08 | 4,39 | 1,14 | 1,09 | 11,5 | 1,5 | 10 | 22,5 | 62,5 | 3,5 | 85 | 88,5 |
| 9 | 26,71 | 14,93 | 21,24 | 4,21 | 4,84 | 1,24 | 1,18 | 49,5 | 21,5 | 28 | 22,5 | 17,5 | 10,5 | 40 | 50,5 |
| 10 | 29,32 | 12,05 | 20,26 | 4,2 | 2,86 | 1,07 | 1,02 | 8,5 | 1 | 7,5 | 22 | 41 | 28,5 | 63 | 91,5 |

## 3. ANALISES, DISCUTIONS, APPROACHES, INTERPRETATIONS

In figure 1 its presented appearances from palletizing process (with a laboratory dish pelletizing installation) and the obtained micropellets, base on micropellets CARBOFER technological flux.



Figure 1. Aspects from CARBOFER technological process

From viewpoint of the three main components: Fe, C, Ca, we have determinate that is covered the whole variation interspaces (area), what demonstrates the method flexibility, through the possibility of choose which recipes can contain one or many pulverous residues, dependency of the enforced chemical composition for recycling the obtained products (steelwork or agglomeration process), as the amount of residues generate in currently way on a certain distance, as well as depending on the amount of pulverous residues (inclusively small once) stored in ponds (placed around of the unit which generates the pulverous residues).

## 4. CONCLUSIONS

From the results analysis, we considered as the optimum recipes, from viewpoint of granulometric composition (that must to satisfy the condition of uniformity and prevalent in

1-3mm limits - granulation recommended as much in the steelwork process as slag foaming agent as well in agglomeration process), the recipes no. R3, R4, R6, R8.

Analyzing the results obtaining in the wake of our experimentations, is recommended the CARBOFER utilization as slag foaming agent and used at the electric furnaces, no influencing the steel and slag chemical composition.

Also, by utilizing CARBOFER, we obtained economic and ecological effects, through the rendition busy surfaces with these residues to the natural frame.

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# POSIBILITY TO RECYCLING OF DEFERRIZED STEELSHOP SLAGS IN AGRICULTURE

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**ABSTRACT:**
The use in agriculture of the deferrized slag allows the development of some existing methods regarding the influence of the slag addition in the soil upon the plant growing and development.
The proposed technology does not generate other pollution sources and it is efficient from the economic point of view, it can be implemented in practice either by the producers of such wastes or by other firms using deferrized slag. The use in other sectors of the steel shop slag leads to release the surfaces occupied by these wastes and to render them to the respective natural landscape, there takes place a reduction of the pollution degree in the regions having steel industry.

**KEY WORDS:**
slag, recycling, agriculture, pollution, industry

## 1. INTRODUCTION

The siderurgic industry produces a series of specific wastes (slags, iron scales, dust and furnace slime, electro filter dust from steel plants, et.) which are recovered in a very reduced proportion, the remainder being deposited in dumps and clarifying) settling ponds. Considering the iron contents and the fact that without recovery, they are a source of pollution for the environment (water, air, soil), there is a need to find solutions to process them, in order to be brought to a favorable state for use as raw or auxiliary material in the metallurgical field or in other sectors of economy. The most adequate solution adopted for ferrous waste extraction from slags is the electromagnetic ore, after a proper sequence of crushing and sorting of the slag. At the present moment, these slags are successfully used in siderurgy, agriculture and constructions.

Processing steel plant slags is beneficial for environment protection, community and agricultural welfare as well as from the technical point of view: metallurgical slags are non-toxic materials, with physical and chemical properties that are similar to rocks, so they represent a viable alternative, sometimes preferable to the natural variants for usage in constructions.

The activity of metallurgical slag processing meets the requirements of environment protection and the European Directives related to environment protection, stipulated in Law 73/2000, republished with the further alterations and completions. From this point of view, metallurgical slag processing aims, directly and indirectly, at two targets included in the community acquis: the control and reduction of soil pollution by using clean technologies involving the turning of metallurgical slag wastes into recycled materials to be used in several domains: road and railway construction, hydro-technical and civil constructions, in the cement, glass and refractory materials industry, as well as in agriculture (improving soil acidity and re-mineralizing it).

According to the available data related to the slag dump at Buituri, the first deposits were made in year 1967 the in the area known as “the old slag dump”, and reached an average elevation of 255 m (fig.1). The latest information shows that, at this moment, the maximum dumping elevation at the slag dump in Buituri (fig.2), in on average 340 m, and its area of about 80 ha, which sums up to about 100 million ton of slag deposited next to the old dump. The chemical composition of steel plant slag from Buituri is presented in fig.3.

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Fig.1. The old slag dump



Fig.2. The slag dump in Buituri

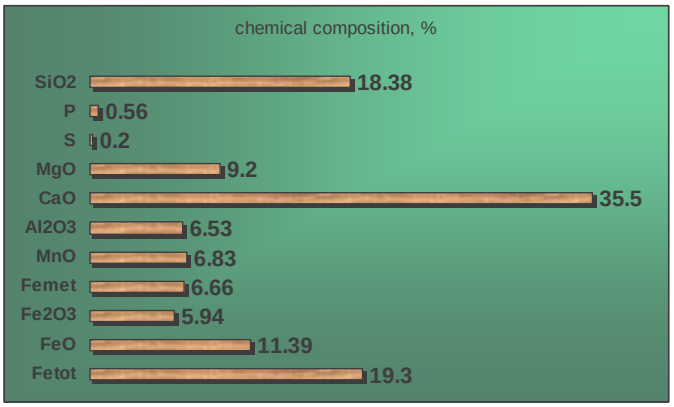



Fig.3. Chemical compositions of slag from slag dump Buituri

The experiments, which are to be put into practice, aim a use of de-ferromized slag in the agricultural area. Following the industrially obtained results and the economic calculi, the producer may choose either the proposed technologies to be put into practice or to co-operate and support other metallic waste processors.

## 2. THE STUDY

In order to obtain the slag powder needed in the pilot experiments, the ferrous slag was processed in the laboratory of the Faculty of Engineering of Hunedoara.



Fig.4 The screening installation „Analysette 3" Fritsch, the grain size 25µm-2mm

Laboratory experiments have been carried out in the Laboratory of Ore Preparation, which is endowed with an installation of screening, grinding, and magnetic separation.

The steel plant slag was screened, using the jigger for the grain size of 10-50mm respectively the screening installation shown in fig.4. The steel plant slag was crushed in the Kollergang mill and for the magnetic separation we used the belt-type magnetic separator.

Figure 5 shows the percentage distribution for the types of metallic waste, ferrous, respectively non-ferrous slag, resulted from the processing of the steel plant slag.

The slag powder obtained by crushing the non-ferrous slag (the grain size fractions 0-0,4 mm) was packed in sacks and shipped to the experimental lots in Commune Peştişul Mic.

As to the quality characteristics of the products we obtained, the chemical structure of the resulting slag powder is given in figure 6.

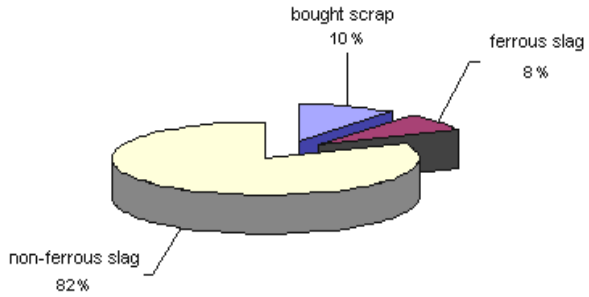



Fig.5. The percentage distribution for the types of metallic waste, ferrous, respectively non-ferrous slag

In parallel with the slag processing operations, we decided upon two experimental lots (one experimental lot – plowing land, respectively one experimental lot – grazing area). Also, depending on the quality of the soil and its destination, we decided upon the surface of the experimental lots, which is given in table 1. The limits of the agro-chemical plots were determined according to the degree of complexity of the relief and the top soil.

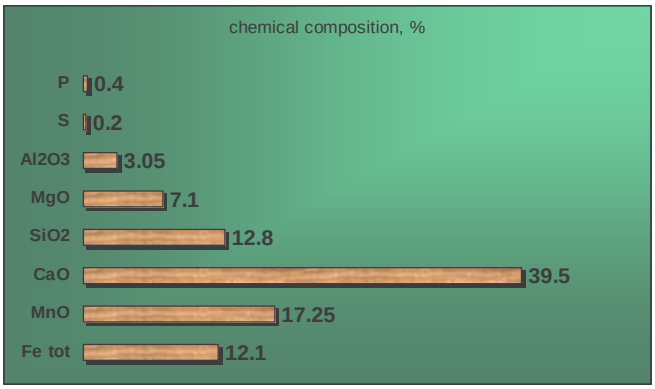



Fig. 6 The chemical structure of the slag powder

Table 1.

| No. | Experimental lot | Area | The surface [m²] |
|---|---|---|---|
| 1 | Experimental lot – plowing land | Peştişul Mic | 400 |
| 2 | Experimental lot – grazing area | Peştişul Mic | 100 |

The experimental lots have a slightly acid pH reaction. It is required that they should be treated and acidity reduced. In order to do that, calcareous addings are necessary. Taking into consideration the theme of the project, we will use powdered non-ferrous steel plant slag. The dosage of the addition quantities has been calculated by the project research team and the result consisted of three experimental values: 0,4kg/m², 0,5kg/m² and 0,6kg/m². As ammonium nitrate favors the increase of soil acidity, it is recommended that fertilization should be done with chemical fertilizers based on nitro-limestone or with complex ternary ones. As to the content in phosphorus of the experimental lots, the chemical analyses showed that they have an average content. The administration of phosphorus has to be associated with nitrogen and potassium. It is recommended that acid soils be fertilized with phosphorus on an annual base. The content of potassium is in deficit on the surfaces under study, its values being extremely low. According to experts, pastures are great potassium consumers. For maximum efficiency, it is recommended to apply potassium alongside with nitrogen and phosphorous. The lots under analysis have average amounts of humus.

The content of nitrogen, established according to NI (nitrogen index) calculated according to the content of humus and the saturation degree of bases shows average values.

Table 2 shows the experimental recipes (the doses of additive – slag powder) and the doses of chemical fertilizers needed by the experimental lots in order to grant their productive potential. For comparison reasons we also considered a witness lot (with no slag additive).

Table 2.

| No. | Experimental lot | Slag powder, kg/m² | | | | Chemical fertilizers, kg/ m² | | |
|---|---|---|---|---|---|---|---|---|
| | | Recipes 1 | Recipes 2 | Recipes 3 | Recipes 4 | P | K | N |
| 1 | plowing land -A | 0 | 0,4 | 0,5 | 0,6 | 0,0058 | 0,007 | 0,0142 |
| 2 | grazing area - P | 0 | 0,4 | 0,5 | 0,6 | 0,0054 | 0,008 | 0,0147 |

## 3. ANALISES, DISCUTIONS, APPROACHES, INTERPRETATIONS

***Pilot Researches – plowing land***

In order to enable the pilot researches, the experimental lot – a plowing area of 400m² was divided into four plots: A1-A4 shown in fig.7.

| A1 | A2 | A3 | A4 |
|---|---|---|---|
| Surface 100m² | Surface 100m² | Surface 100m² | Surface 100m² |
| Slag powder 0,4kg/m² | Slag powder 0,5kg/m² | Slag powder 0,6kg/m² | Slag powder 0kg/m² |

Fig.7. The experimental lot – a plowing area

Plots A1, A2 and A3 were added a quantity 0,4 kg/m², 0,5 kg/m² respectively 0,6 kg/m² of slag powder. Plot A4 was used for comparison during the experiments, so it was not added any slag.

After the addition of slag, the adequate agricultural works were done (plowing, chisel plowing, seeding, fertilizing, mechanic and hand weeding). For the experimental plot, the culture of choice was maize.

During the experiments, we monitored the effect of slag addition upon the development of the plants. The results obtained two months after tilling and seeding are given in figure 8. One can notice the positive influence of slag addition upon the growing and blooming of the maize.




Fig.8. The experimental lot – a plowing area, after two months adding the slag

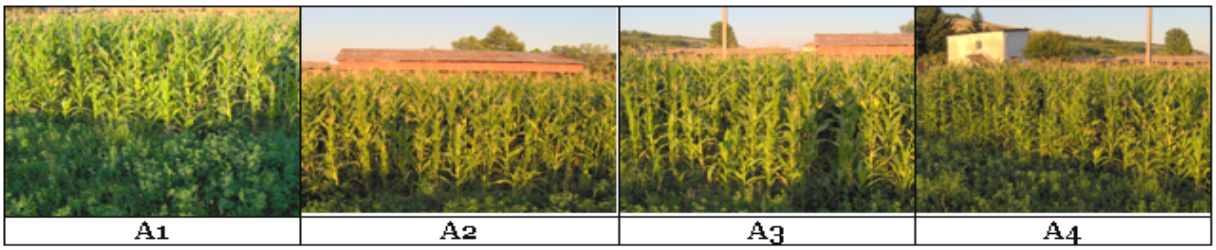



Fig.9. The experimental lot – a plowing area, after four months adding the slag

During the experiments, we monitored the effect of slag addition upon the development of the plants. The results obtained four months after tilling and seeding are given in figure 9. One can notice the positive influence of slag addition upon the growing and blooming of the maize.

***Pilot researches – pasture***

The experimental lot – pasture, was divided into four plots: P1-P4 shown in fig.10.

| P1 | P2 | P3 | P4 |
|---|---|---|---|
| Surface 25m² | Surface 25m² | Surface 25m² | Surface 25m² |
| Slag powder 0,4kg/m² | Slag powder 0,5kg/m² | Slag powder 0,6kg/m² | Slag powder 0kg/m² |

Fig.10. The experimental lot – pasture

The quantity of slag powder added to plots P1, P2 and P3 was 0,4 kg/m², 0,5 kg/m² respectively 0,6 kg/m². Plot A4 was used for comparison along the experiments, so it was not added any slag. The state of the pasture at the moment of adding the slag is shown in fig.11. The way in which slag powder addition influenced the development of the plants after two months is shown in fig.12. The way in which slag powder addition influenced the development of the plants after four months is shown in figure 13.

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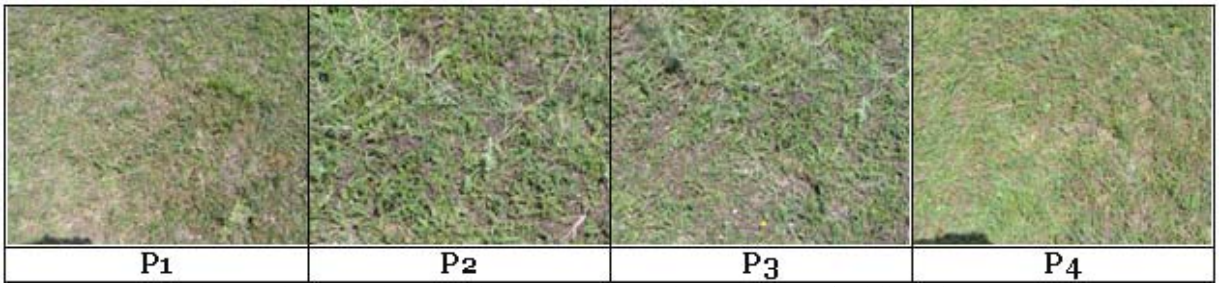



Fig.11. The experimental lot – pasture at the moment of adding the slag

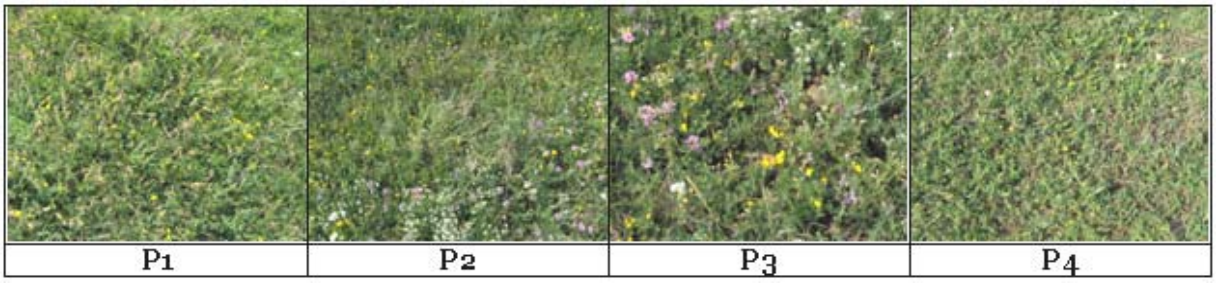



Fig.12. The experimental lot – pasture after two months adding the slag




Fig. 13 The experimental lot – pasture after four months adding the slag

The steel plant slag used in the experiments comes from the Martin steel plant, particularly in the smelting phase, a slag that is rich in CaO (35-46%) and P (0.2-0.9%). To the total content of iron in these slags, we should add crusts, splashings and other metallic inclusions, which, in virtue of the production flow, reach the slag taps and end up on the dump. Thus, one can notice that the total quantity of iron in a dump is practically equal with that in the slags existing in the furnace, but the amount of iron increases in the detriment of FeO and Fe2O3 as well as other components of the slag.

After processing, the total content of iron in the non-ferrous slag obtained is about 13,4% where FeO, $Fe_2O_3$ and metallic iron are prevailing. The iron content of the non-ferrous slag is still quite high, as there are metal inclusions, missed by the metal separator, within the slag lumps. The other components of the non-ferrous slag have approximately the same level as in the non-processed slags. The non-ferrous steel plant slag (slag powder) has a basic character. It contains about 42% calcium oxide. This element is a lot more active from the chemical point of view, than any other lime additive. Added to the soil, it reduces its acid character and leads to its re-mineralization.

## 4. CONCLUSIONS

The proposed technology does not generate other pollution sources and it is efficient from the economic point of view, it can be implemented in practice either by the producers of such wastes or by other firms using deferrized slag.

The use in other sectors of the steel shop slag leads to release the surfaces occupied by these wastes and to render them to the respective natural landscape, there takes place a reduction of the pollution degree in the regions having steel industry.

From this point of view, metallurgical slag processing aims, directly and indirectly, at two targets included in the community acquis: the control and reduction of soil pollution by

using clean technologies involving the turning of metallurgical slag wastes into recycled materials to be used in several domains: road and railway construction, hydro-technical and civil constructions, in the cement, glass and refractory materials industry, as well as in agriculture (improving soil acidity and re-mineralizing it).

Processing steel plant slags is beneficial for environment protection, community and agricultural welfare as well as from the technical point of view: metallurgical slags are non-toxic materials, with physical and chemical properties that are similar to rocks, so they represent a viable alternative, sometimes preferable to the natural variants for usage in constructions.

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# STUDIES REGARDING OF SIDERITIC RESIDUE UTILIZATION FOR CEMENT PRODUCTION

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**Abstract:**
The paper presents the experimentations made in the laboratories of Faculties of Engineering from Hunedoara and also in the frame of Carpatcement Holding Deva laboratories, looking at the introduction of the sideritic residue along with the clinker, for obtain of cement. For suggested recipe, were determinate the specific surfaces, setting time, compression strength. Result obtained in the laboratory condition proven as the proposal is viable as much from economic and ecologic point of view, through the recycling of manufactured residue existing in very big amounts in approach of Hunedoara area.

**Keywords:**
Sideritic residue, clinker production, cement, polluted surface, recycling.

## 1. INTRODUCTION

The Portland cement is the most used binding material into construction, due to its properties, which are depending upon the chemical and mineralogical composition, manufacturing conditions etc. Portland cement has, normally, the following chemical composition:

$CaO = 60 – 65\ \%$; $SiO_2 = 18 – 24\%$; $Al_2O_3 = 5 – 10\%$ ; $Fe_2O_3 = 1 - 4\%$; $MgO < 0$.

From the point of view of the formal constituted elements, the chemical composition is presenting as follows:

- tricalcic silicate ($3CaO \cdot SiO_2$) symbolized $C_3S$, in ratio of 47%;
- tricalcic silicate ($2CaO \cdot SiO_2$) symbolized $C_2S$, in ratio of 28%;
- tricalcic aluminates ($3CaOAl_2O_3$) symbolized $C_3A$, in ratio of 11%;
- ferialuminat tricalcic ($4CaO \cdot Al_2O_3 \cdot Fe_2O_3$) symbolized C4AF, in ratio of 8%;
- $CaSO_4$ (3%); MgO (2%); $CaO_{liber}$ (0,5%); $Na_2O$ (0,5%).[2]

The cement is obtained by raw material burning and smelting into the special installation: by dried, semi-dried, semi-wet and wet proceedings.

The raw material that is used for Portland cement manufacturing is composed by:

- calcareous rocs, with an calcite content of 75- 80%;
- clay, with content of $SiO_2$, $Al_2O_3$ , $Fe_2O_3$;
- adjustment adding, like: bauxite, for increasing $Al_2O_3$ content; diatomite, for increasing $SiO_2$ content; ferric disulphide ashes, witch bring $Fe_2O_3$ and decreasing temperature of clinkerization process; metallurgical slag, witch bring $Fe_2O_3$, thermo-central ashes and others wastes.

We are considering with a fundamental base technological solution of recycling the sideritic waste material, resulted on the cement producing.

## 2. THE STUDY

Aspects concerning the sideritic residue sludge beds are presented in figure 1.

The sideritic residue granulometric composition is presented in table 1. The simple granulometric curve is presented in figure 2 and the cumulate granulometric curves are presented in figure 3.



a. b.



c.

Figure 1. Aspects concerning the sideritic residue sludge beds
a) sludge bed 1; b) sludge bed 2; c) sludge bed 3.

Tab.1. The sideritic residue granulometric composition

| Material | Granulometric classes, [μm] | | | | | | |
|---|---|---|---|---|---|---|---|
| | < 25 | 25-56 | 56-90 | 90-180 | 180-315 | 315-500 | > 500 |
| Sideritic residue | 2,19 | 3,30 | 6,42 | 32,79 | 50,72 | 3,97 | 0,61 |

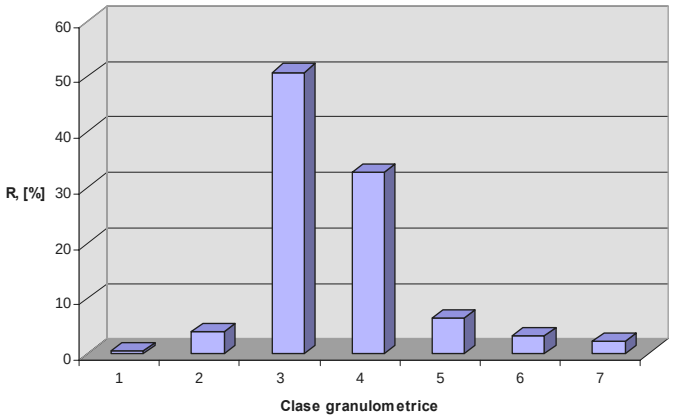



Figure 2. The simple granulometric curve

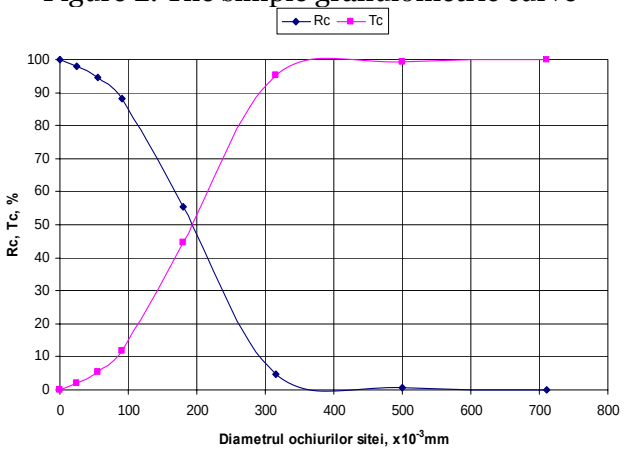



Figure 3. The cumulate granulometric curves

For experimentations, in order to obtained cement (fig.4), we elaborated 7 cement recipes, introducing various quantities of clinker and sideritic waste, as well as 5% burnt plaster (fig.5). The details are shown in tab.2 and graphically in fig.6.

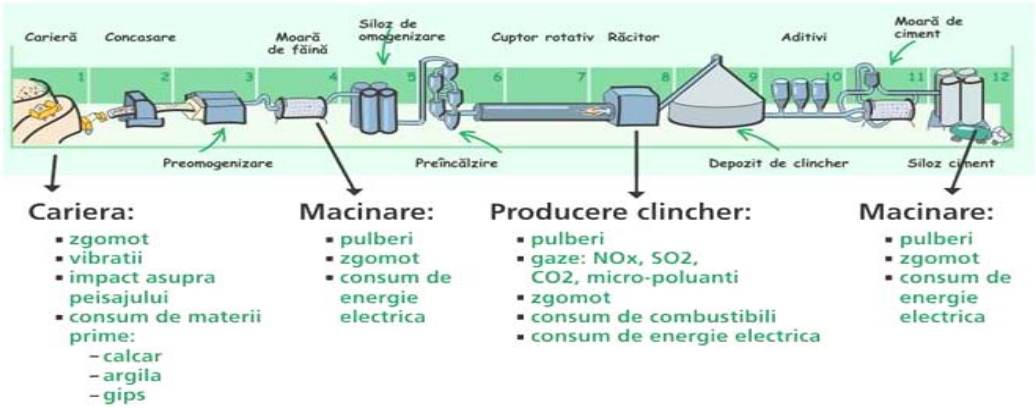



Figure 4. Cement production flux.

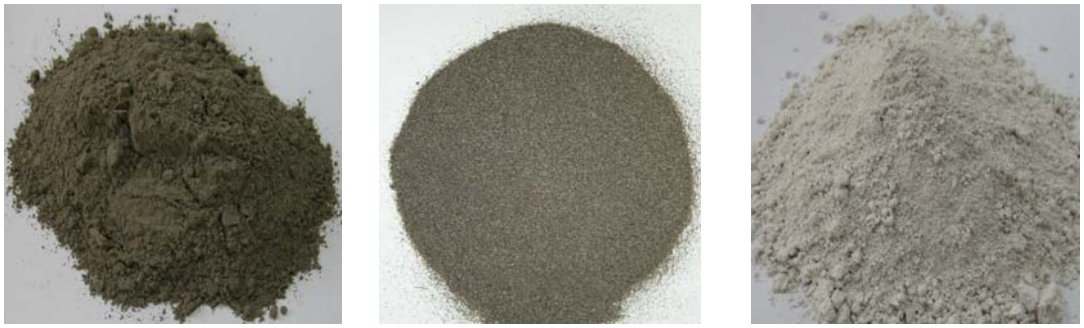


Figure 5. The raw materials: clinker, sideritic waste, calcined gypsum.

Tab.2. The experimented cement recipes components

| Component, [%] | Recipe no. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Clinker | 90 | 85 | 80 | 75 | 70 | 65 | 60 |
| Sideritic residue | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
| Calcined gypsum | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

In order to determine the quality of our recipes we elaborated a 1 kg sample for each of them, according to the procedures shown in fig.7. We used in this scope the installations existing in the laboratories of our Faculty [3].

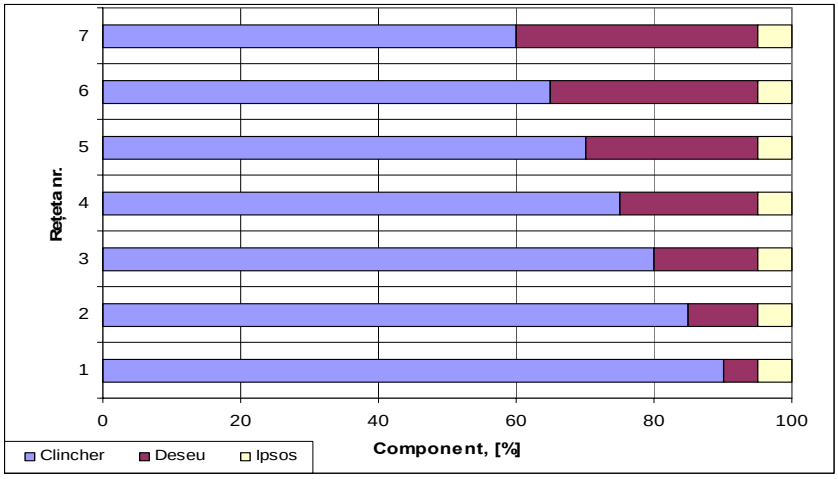



Figure 6. Used recipes

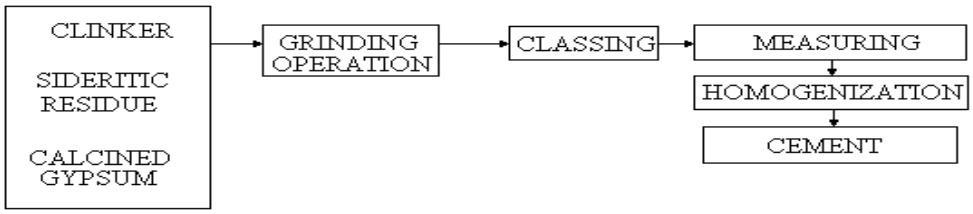



Figure 7. Cement technological flux in laboratory condition

## 3. ANALISES, DISCUSIONS, APPROACHES, INTERPRETATIONS

The determination of quality has been done as follows:

- we performed the chemical analysis of the samples, the results being given in tab.3;
- we determined the specific surface of the cement mixture, tab.4;
- we carried out cement specific tests and determinations such as: the determination of water for the normal consistence paste, the binding time, resistance to pressure after 1, 2 and 7 days from binding – tab.5.

The tests have been done both in our laboratories and with the help and participation of our contract partner: CARPATCEMENT HOLDING, Deva branch. The chemical structure varied as shown in tab.3.

Tab.3. Chemical composition for our cement recipes

| Recipe no. | Chemical composition, [%] | | | | | | |
|---|---|---|---|---|---|---|---|
| | CaO | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | Others oxides | P.C. | $CaSO_4*0,5H_2O$ |
| 1 | 60,53 | 20,78 | 5,00 | 3,64 | 3,97 | 1,17 | 4,90 |
| 2 | 58,04 | 21,44 | 4,88 | 3,85 | 4,54 | 2,35 | 4,90 |
| 3 | 55,54 | 22,10 | 4,75 | 4,06 | 5,12 | 3,52 | 4,90 |
| 4 | 53,04 | 22,76 | 4,62 | 4,28 | 5,70 | 4,69 | 4,90 |
| 5 | 50,54 | 23,42 | 4,50 | 4,49 | 6,28 | 5,87 | 4,90 |
| 6 | 48,04 | 24,08 | 4,37 | 4,70 | 6,86 | 7,04 | 4,90 |
| 7 | 45,55 | 24,74 | 4,24 | 4,91 | 7,44 | 8,21 | 4,90 |




Figure 8. Permeabilimetrul Blaine - automat
1 - piston; 2 - celula de permeabilitate; 3 - display; 4 - panou comandă

In order to determine the specific surface, we used the Blaine permeability meter shown in fig.8 – from the laboratories of CARPATCEMENT HOLDING, Deva branch. The data we obtained are given in tab.4 and in figure 9.

Tab.4. Resulting data for specific surface

| Specific surface [cm²/g] | Recipe no. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | 2597 | 2435 | 2453 | 2368 | 2532 | 2486 | 2466 |

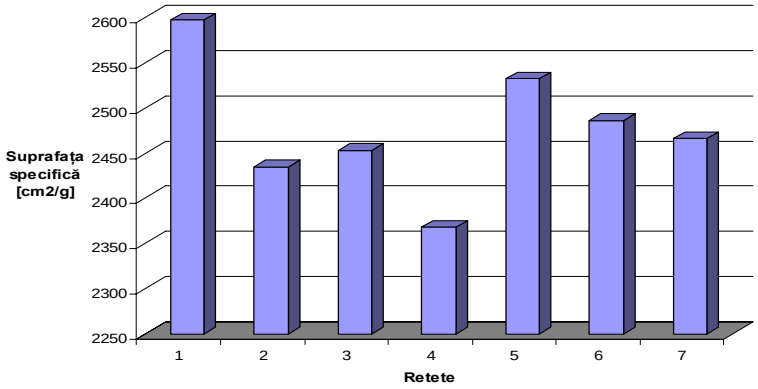



Figure 9. Specific surface for our cement recipe

The experiments meant to determine the amount of water in the normal consistency paste and of the binding start time have been done in the laboratories of the Faculty of Engineering of Hunedoara, using a Vicat apparatus, shown in fig.10. We mention that the determinations were done according to all the norms in force. The data we obtained are given in tab.6 and in figure 11.






Figure 10. Vicat apparatus for determination of water for the normal consistence paste and resulting proofs.

Tab.6. The quality characteristics for our cement recipes

| Characteristics | | Recipe no. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Water for the normal consistence paste, [cm³] | | 75 | 74 | 73 | 65 | 67,5 | 67 | 66 |
| The binding time, [min] | | 16 | 19 | 14 | 13 | 15 | 18 | 18 |
| Resistance to pressure, [N/mm²] | 1 day | 2,30 | 2,10 | 1,80 | 1,40 | 3,30 | 2,50 | 2,50 |
| | 2 days | 4,00 | 3,50 | 3,10 | 2,30 | 5,40 | 3,90 | 3,90 |
| | 7 days | 7,00 | 7,25 | 7,81 | 6,25 | 9,80 | 7,00 | 6,87 |

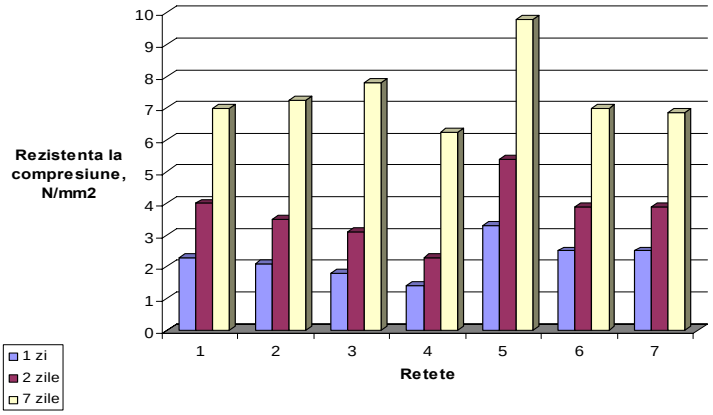



Figure 11. The resistance to pressure variation of cement proofs




The resistance to compression has been tested by means of the device shown in fig.12, existing in the testing laboratories of CARPATCEMENT HOLDING Deva branch.

Figure 12. Compressing testing machine for cement sample
1 – machine bench; 2 – test specimen; 3 - panel.

## 4. CONCLUSIONES

The resulting experimental data have lead to the following obvious conclusions:

- the resistance to pressure of the cement test samples, where part of the clinker has been replaced by siderite waste, is comparable to that of regular cements;
- the specific surface has a high influence upon the resistance to pressure and one can see that the larger the specific surface, the larger the resistance to pressure.
- the resistance to pressure of experimental cements increases with time, so that one can notice that, after 7 days, resistance is 3 times higher than the resistance determined after 1 day;
- the highest resistance to pressure after 7 days was obtained for recipe no. 5, to which we added 25% siderite waste;
- particular attention should be paid in further researches to the fine grinding of cement, so as to obtain a specific surface above 3000 $cm^2/g$;
- the quantity of water for the normal consistency paste is smaller than the one usually recommended for cement: 70-90 $cm^3$;
- the binding start time obtained in laboratory conditions recommends the use of experimental cements for road leveling layers, as they harden fast (with a higher addition of water).

At present, the acquisition price of cement is about 115€/t, out of which 22€/t represents the value of raw materials. The partial replacement of clinker by siderite waste leads to about 21% cut down on raw materials (the calculation referring to recipe 5, which has the best characteristics), respectively 4% of the price of cement.

Moreover, one has to consider the ecological impact, resulted from the removal of the waste ponds.

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# RESEARCHES CONCERNING TO THE POSSIBILITY OF USE THE SIDERITIC RESIDUE FOR PRODUCTION OF CLINKER

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**Abstract:**
The work presents some researches regarding to utililisation in cement industry of the sideritic residue, stored in the ponds near from Hunedoara. Thus, on the chemical and granulometric compositions is obtained a number of 10 recipes of clinker, and finally are presented an optimum recipe. The purpose of this researches was reused a manufactured residue, which momentary is stored on large ground surfaces. Through suggested variant are desired the rendition to natural area of this polluted surfaces, parallel with economic effect for reducing quantities of calcite and clay in clinkers production from the cement industry.

**Keywords:**
Sideritic residue, clinker production, cement, polluted surface, recycling

## 1.INTRODUCTION

The metallurgical industry represents a strong source of environment pollution related through the amounts of gas and dust emanates in atmosphere and the through residues quantities stored in ponds on dumps.

In this the sense the iron ore the type siderite with ferric contents of 25-40% and roasted in the sight of carbon oxide eliminate, what causes concentration of iron ore and transformation of mineral from carbonate in iron oxide with magnetic property. Behind of magnetic concentration operations, in result concentrate the iron arrives at concentration of 51-53%, can be used in agglomeration process, and sterile is stored in ponds.

Suchlike this technological process it was at ore preparation plan of Teliuc- Hunedoara, within 1998 when the primary elaboration steel flux (coke plant - Siemens-Martin steelwork) from S.C. Siderurgica S.A it was complete deallocated.

In afferent ponds ore preparation plan of Teliuc- Hunedoara it was remained stored in ponds huge quantities of siderite sterile (cca 12 mil. tons)

Sterile can be submitted to a concentration operations, and resulted sterile (secondary sterile) can be used-up as the correction addition for obtains of clinker (the chemical composition permits this thing).

## 2. THE STUDY

In order to be determined the quantities of the waste materials deposited into the ponds within Hunedoara aria the topographic measurements have been performed in the system of 1970`s stereographic coordinates and for reference system of Black Sea quotes. In the fig. 1 it is presenting the design of framing in the aria of the studied emplacements. The fig.2 presents the framing design in the aria of 1 Pond, respectively the fig. 3 for the 2-nd and the 3-rd Ponds [3].

The data obtained by measurements were worked in AUTOCAD adding program resulting the situational plans from which is caused the amounts of existing residues.

Analyzing the measurements and situational plans obtained for the objective taken under consideration results the next amounts of stored residues:

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- Sludge bed no.1 – Teliuc excavation: the sludge bed deals a surface of 25 hectare, the amount of residues (sideritic concentrate) 7 million tons.
- Sludge bed no.2 – Teliuc excavation: the sludge bed deals a surface of 18 hectare, the amount of residues (sideritic concentrate) 5 million tons.
- Sludge bed no.3 – Teliuc excavation: the sludge bed deals a surface of 32 hectare, the amount of residues (sideritic concentrate) 9 million tons.



Figure 1. The integration plan in studious emplacement zone.

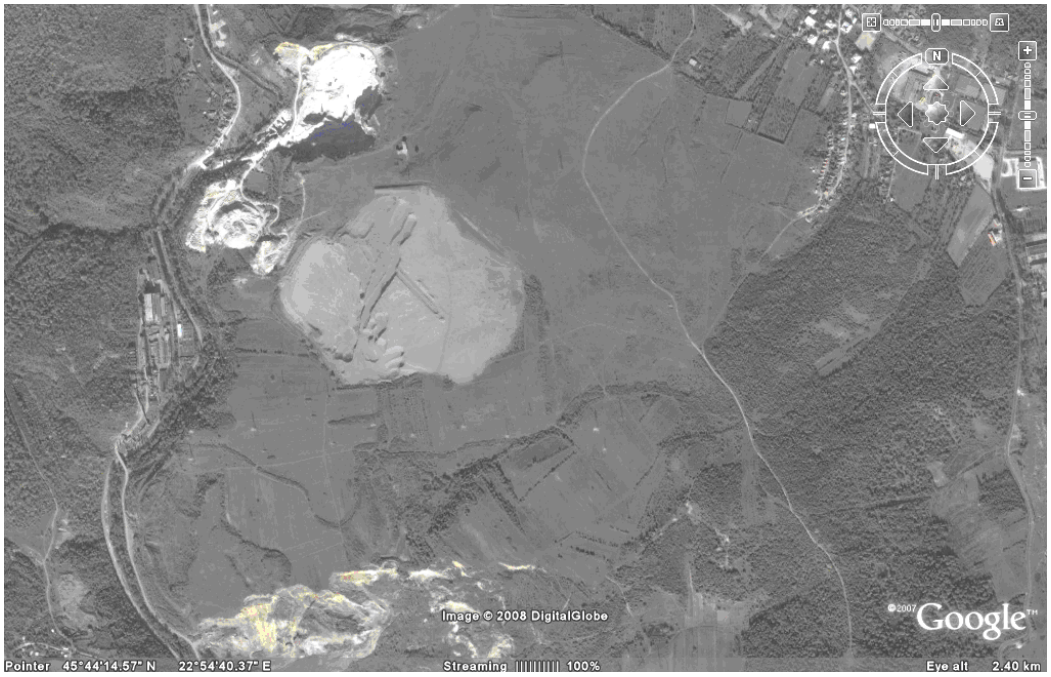


Figure 2. The integration plan in sludge bed no.1 Teliuc area.




Figure 3. The integration plan in sludge bed no.2 and 3, Teliuc area

The sideritic residue chemical composition (the 10 proofs taken and average value) is presented in table 1 and the chart, in figure 4.

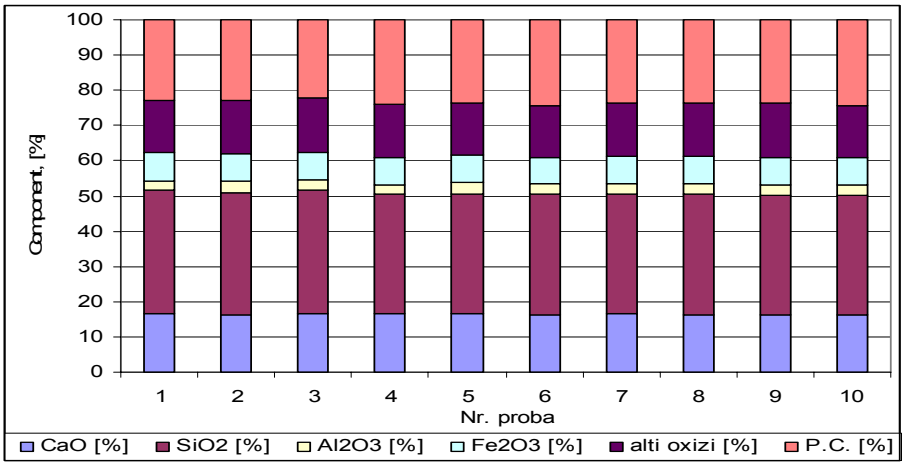



Figure 4. Taken samples chemical composition

Table 1. The sideritic residue chemical composition from sludge beds, [%]

| The sideritic residue from sludge beds | CaO | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | Others component | P.C. |
|---|---|---|---|---|---|---|
| 1 | 16,54 | 35,02 | 2,84 | 7,8 | 14,98 | 22,82 |
| 2 | 16,27 | 34,8 | 3,04 | 7,94 | 15,22 | 22,73 |
| 3 | 16,59 | 34,91 | 3 | 8,04 | 15,46 | 22 |
| 4 | 16,55 | 33,89 | 2,68 | 7,8 | 15,01 | 24,07 |
| 5 | 16,48 | 34,22 | 3,07 | 7,9 | 14,63 | 23,7 |
| 6 | 16,34 | 34,25 | 2,88 | 7,54 | 14,75 | 24,24 |
| 7 | 16,44 | 34,28 | 2,75 | 7,85 | 15,21 | 23,47 |
| 8 | 16,4 | 34,19 | 2,81 | 8,01 | 14,95 | 23,64 |
| 9 | 16,22 | 34,1 | 2,85 | 7,88 | 15,15 | 23,8 |
| 10 | 16,07 | 34,24 | 2,78 | 7,64 | 15,04 | 24,23 |
| Average | 16,39 | 34,39 | 2,87 | 7,84 | 15,04 | 23,47 |

We experimented a number of 10 recipes with component presented in table 2; the chemical composition of the recipes with and without the loss to calcinations it presented in figure 5 and 6 [3].

Table 2. Recipes component, [%]

| Component | Recipe no. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 |
| Calcite | 72 | 72 | 75 | 73 | 74 | 74 | 75 | 75 | 76 | 76 |
| Clay | 14 | 15 | 13 | 14 | 13 | 14 | 12 | 13 | 12 | 13 |
| Sideritic residue | 14 | 13 | 12 | 13 | 13 | 12 | 13 | 12 | 12 | 11 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

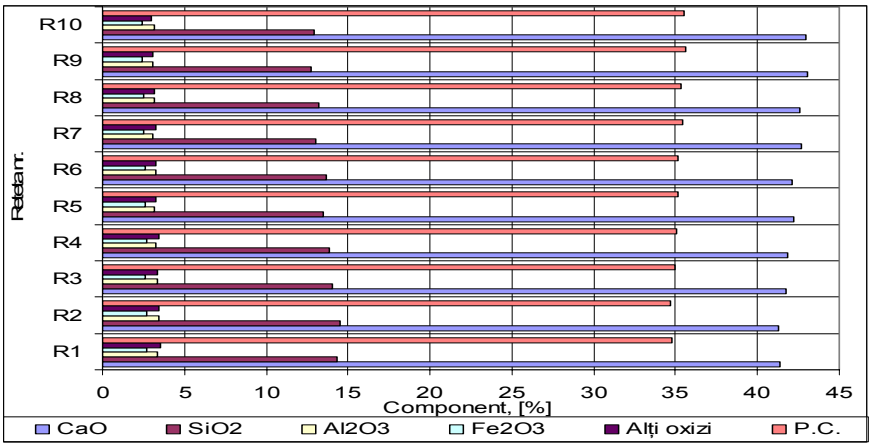



Figure 5. Chemical compositions of started recipes

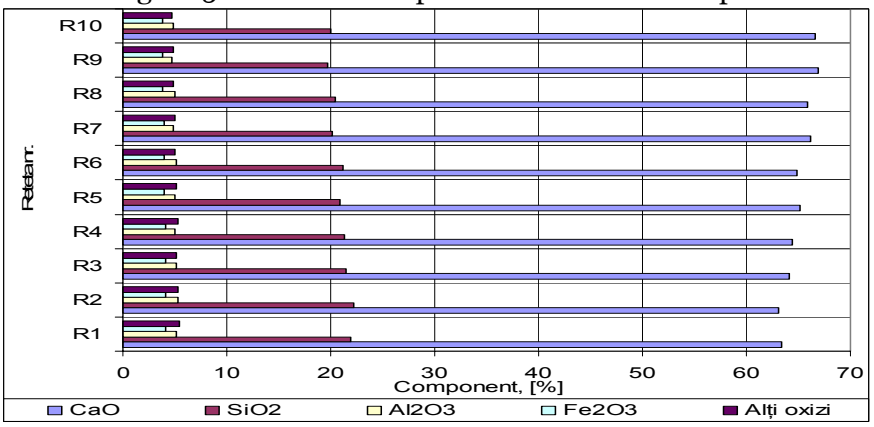



Figure 6. Chemicals composition of recipes without losses by calcinations

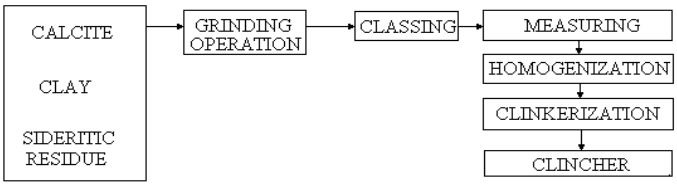



Figure 7. The raw materials worked technological flux in order to obtained clinker

The raw materials was worked, base of the technological flux presented in fig. 7. The crushing (the clay and the limestone came in bunches), we used a ball mill, existing the Metallic Smelting Laboratory. After crushing (the resulting grain size being below 250μm), the materials were graded in the laboratory installation, dosed, by means of analytical scales and homogenized in a homogenizing drum. Fig. 8 shows aspects of these experiments.




Figure 8. The installations used for clinker production

After the recipes have been obtained, the materials were clinkerized in a Tamman resistance furnace, each sample weighing 200g. The resulting samples showed a degree of reduction ranging between 30-42,5%.

## 3. ANALISES, DISCUSIONS, APPROACHES, INTERPRETATIONS

The Portland clinker represents the product obtained by calcinations till to the partial smelting, of a homogenous mixture, fine crushing, of the calcareous and as clay raw materials, and, eventually, different for correction additions. In the technology of the Portland cement manufacturing, the clinker represents a semi-finished product.

The clinker chemical composition of Portland cement represents the percentage content shown in the chemical elements, computed as oxides. The chemical composition is expressed in oxides because the chemical transformations ,which the raw materials are suffering during the clinkering, do not involve the destruction of the liaisons between the respective elements and Oxygen, so, in the new formed constituted elements, the oxides are coming into as the molar well constituted units.

The clinker characterization, from the oxides composition point of view, can be made using the ***modules***. The modular system is based on the co-relations that are established between the oxidic composition and mineralogical one, of the clinkers, simplifying by this the computation of the gross mixture and deduction of some characteristics of the cements will follow to be manufactured [1]. The main modules used in there cement industry are: the module of silica, module of alumina and grade of saturation in calce.

*The module of silica* ($M_{Si}$) represents the ration between the percentage content of $SiO_2$ and percentage content of $Al_2O_3$+$Fe_2O_3$ from the clinker.

$$M_{Si} = \frac{\%SiO_2}{\%Al_2O_3 + \%Fe_2O_3} \quad (1)$$

The clinkers of Portland cement have, normally, $M_{Si}$=1,5...4. The silica module value is given the information regarding mineralogical composition of the clinker, respectively upon the content of silicates and aluminates: ($C_3S$+$C_2S$)/($C_3A$+$C_4AF$), as well as upon the conduct of the gross mixture on burning, regarding the content into the liquid phase (the silicates remained into the solid phase, and in the meantime aluminates, merely ferrite-aluminates passed into the liquid phase). In case of a high module of silica, the clinkering is realized in more difficult conditions; for the values of silica module higher than 2.5 the clinkering is made harder, with a great consumption of energy; for $M_{Si}$ =2...2,5 the clinkering is going normally, and for $M_{Si}$ lower than 2, the clinkering is making easy. The clinkers with $M_{Si}$ lower than 1,5 give the cements with very speedy connection/bind.

*The module of alumina* ($M_{Al}$) is the ration between the percentage content of $Al_2O_3$ and $Fe_2O_3$ of the clinker:

$$M_{Al} = \frac{\%Al_2O_3}{\%Fe_2O_3} \quad (2)$$

For the common clinkers, the module of alumina has the values comprised between 0.2 and 5. Its value gives the information regarding the percentage of aluminates phases. Ferrite and ferrite-aluminates phases from the clinker:

- at $M_{Al}$ higher than 0.64, all quantity of $Fe_2O_3$ appears as binded in ferrite-aluminate solid solution, the over plus of de $Al_2O_3$ is forming $C_3A$;
- la $M_{Al}$ lower than 0.64, all quantity of $Al_2O_3$ appears as binded in ferrite-aluminate solid solution, the over plus of $Fe_2O_3$ is forming $C_2F$;
- $M_{Al}$=0.64, all quantity of $Al_2O_3$ and $Fe_2O_3$ is binded with CaO as $C_4AF$ [2].

*The degree of saturation in calce* ($S_K$) represents the ration between the percentage content of CaO that exists in the clinker and the quantity of CaO that is necessary for the saturation of $SiO_2$, $Al_2O_3$ and $Fe_2O_3$ at the mineralogical constituted elements that are characteristically to the clinker, with the condition that CaO to not remain un-binded (free):

$$S_K = \frac{\%CaO}{2,8\%SiO_2 + 1,1\%Al_2O_3 + 0,7\%Fe_2O_3} \quad (3)$$

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Table 3. Oxides chemical composition of raw materials

| Raw materials | Oxides chemical composition of raw materials, [%] | | | | | |
|---|---|---|---|---|---|---|
| | CaO | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | Others oxides | Losses by calcinations |
| Calcite | 53,2 | 3,0 | 1,5 | 1,0 | 0,5 | 41,8 |
| Clay | 5,51 | 52,56 | 13,21 | 6,32 | 7,44 | 14,96 |
| Sideritic residue | 16,39 | 34,39 | 2,87 | 7,84 | 15,04 | 23,47 |

The standard calce ($K_S$) is used to us, also, that coincides with the formulation given by German scholarly Kühl for the saturation grade in calce, but the value $S_K$ will be multiply with 100.

In order to obtain in the laboratory a clinker of the cement there were used as the raw materials the calcareous stone and clay from CARPATCEMENT HOLDING – Deva factory and sideritic waste material from Teliuc pond. The chemical composition of these raw materials is given in the table 3.

Table 4. Blends of raw materials for clinker production

| No. proof | Blend compositions, [%] | | | Modular compositions | |
|---|---|---|---|---|---|
| | Calcite | Clay | Sideritic residue | $S_K$ | $M_{Si}$ |
| 1 | 72 | 14 | 14 | 0,905 | 2,376 |
| 2 | 72 | 15 | 13 | 0,893 | 2,371 |
| 3 | 75 | 13 | 12 | 1,012 | 2,318 |
| 4 | 73 | 14 | 13 | 0,932 | 2,355 |
| **5** | **74** | **13** | **13** | **0,98** | **2,34** |
| 6 | 74 | 14 | 12 | 0,961 | 2,335 |
| 7 | 75 | 12 | 13 | 1,025 | 2,322 |
| 8 | 75 | 13 | 12 | 1,008 | 2,318 |
| 9 | 76 | 12 | 12 | 1,058 | 2,300 |
| 10 | 76 | 13 | 11 | 1,04 | 2,296 |

Based on the composition of the clinker obtained at CARPATCEMENT HOLDING SA –Deva Factory, the computations have been done for the determination of the percentage composition of the gross mixture formed by calcareous stone, clay and sideritic waste material and which from must result a clinker that will follow to have $S_K$=0.98 and $M_{Si}$ = 2.34. We made modular calculus for all blends of raw matters; the results are presented in table 4.

## 4. CONCLUSIONES

There can be observed that the optimum mixture is from the **sample 5**, because at the samples 3, 7, 8, 9 and 10 (to which the percentage of calcareous stone is more than 74%), the grade of saturation in calce has a value higher than 1, and it means that from the mixture of the raw materials, after clinkering, will remain free CaO that is damaging the quality of the clinker. At the samples 1, 2, 4, and 6, the value of the saturation grade into the calce is lower than that one of the clinker we like to obtain.

Referring to the values of the silica module, there can be observed that they do not present significant variations for the samples are analyzed.

So, in order to obtain an adequate clinker, the blend of raw matters must content the follow: 74 % calcite; 13% clay; 13 % sideritic residue.

The analysis of the results has lead to the following conclusions:

- the process has a low economical efficiency, as this solution requires a further clinkering process and replaces only partially some quantities of clay and limestone by sideritic waste;
- considering the actual economical context, we are looking for solutions meant to reduce the amount of clinker used in cement production, which have direct implications on its cost, and which also have a positive ecological impact;
- the aspect of the lab samples shows that there is a large quantity of vitreous mass surrounding the alite and belite crystals, which determines the clinker hydrating process to slow down and a reduction of the mechanical strength of the resulting hardened cement.

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# THE IMPORTANCE OF NON-CONVENTIONAL BIOFUEL UTILIZATION FOR POLLUANT EMISSIONS REDUCTION

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**Abstract**

In this paper are presented aspects concerning biofuels utilization as a result of traditional fuels disadvantages. Global depletion of oil resources and global warming has caused the occurrence and development of biofuels market although the production of energetic plants competes with crops for food products. Combining the benefits of economic, environmental and energy security resulting from the utilization of biofuels, attracts the interest and support of the population, but also of many governments, and the result will probably be the increase of biofuels utilization.

**Key words:**

biofuel, emissions, greenhouse effect, energetic plants, transport

## 1. INTRODUCTION

The reducing of global recoverable reserves of fossil hydrocarbons and successive increase of the oil barrel price, as a result of the oil crisis, have created favourable premises to approach other sources for obtaining fuels. The restrictive legislation on the environmental pollution caused by the combustion gases of conventional fuels also contributes to finding alternative energy sources. So, there are concerns for the production of biofuels from renewable feed stocks (biomass).

The fossils resources are worldwide distributed and quantitative limited while the annual consumption is growing. Analyzing the distribution of the world of crude oil reserves, an alarming situation has been discovered in some areas which are big petroleum derivatives consumers, such as Western Europe [5].

Oxides of nitrogen and sulphur, smoke and incompletely burned hydrocarbons from exhausted gases of engines using classic fuels, are major pollutants of the atmosphere. The accumulation in the atmosphere of carbon dioxide resulting from classic fuels combustion, also contributes to enhance the greenhouse effect. Therefore, is necessary to obtain alternative fuels, as by their combustion to reduce considerably the quantity of pollutants emissions exhausted into the atmosphere and by using resources from renewable raw materials to eliminate the greenhouse effect due to an accumulation of carbon dioxide in the atmosphere.

One of the most recognized and consumed biofuels is the biodiesel, which is a fuel of plant origin obtained from rape oil, sunflower, soy, palm, or of animal origin obtained from burned and UFO materials (animal scraps, fat, hair, etc.)

Biofuel represents any fuel with 80% minimum content of materials derived from living organisms harvested no more than 10 years before producing that fuel. [3].

## 2. THE BENEFITS OF BIODIESEL

### 2.1. EFFICIENCY OF BIOFUEL PRODUCTION

The market of classics fuel is one of the reasons for switching to biofuels. Great American auto manufacturers are already working on series engines with biofuels operation, and some European states are giving substantial subsidies to producers and importers of ethanol, a biofuel made mostly from corn.

Theoretically, any plant can be used for the production of biofuels. Practically, are preferred - from obvious economic reasons - plants that have a high content of oil or rich in starch. Americans, for example, are intensively cultivating mostly corn and soybeans; EU uses rape crops, and exotic countries as Brazil and the whole South-East Asia exploits at full the production of cane sugar and palm (palm oil is one of the cheapest raw materials for biofuel).

At present, the most efficient biofuel is produced from sugar cane or palm oil, therefore coming from the least developed countries in Africa, Asia and South America. Taxes imposed by certain powers to the biofuel import are excessive**,** making the profits of producers to be minimal, although they gave up on basic agriculture land for biomass crops. [5].

Biodiesel fuel is the first and only alternative fuel which has a full evaluation of the emissions produced by its combustion in internal combustion engines. The U.S. Environmental Pollution Agency (EPA) has evaluated in the "clean air" section, the effects on health caused by burning of diesel biofuel. Thereby, in the last 2 years were developed a series of programs related to the most stringent testing protocols required by EPA for certification of fuels and / or additives.

Many countries have a competitive advantage in producing biofuels. Meanwhile, many other countries are unable to meet their biofuel needs from domestic sources (Fig. 1).

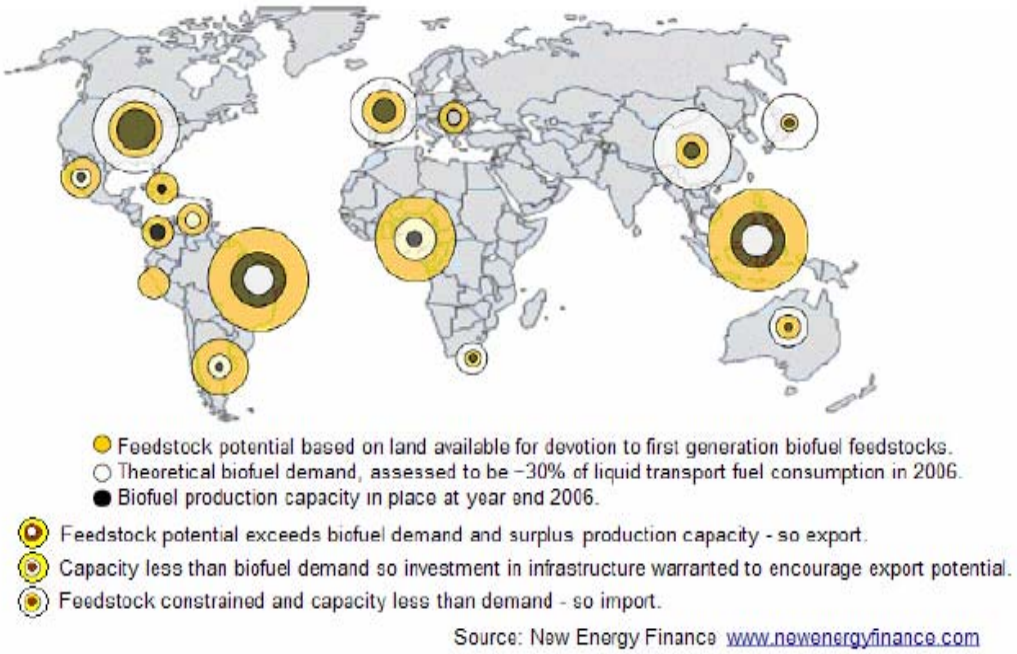



Fig.1 Biofuel demands and production capacities for selected world regions

Also, when bioenergy displaces fossil fuels, in transport and power generation, or is produced in conjunction with soil carbon storage in the form of bio-char for example, opportunities arise for trade in carbon emission reduction units. [2]

Benefits of biodiesel:

- The potential for altering the ozone layer by forming „smog" is 50% lower for diesel biofuel (B100 and B20) than conventional diesel fuel due to nitrate polycyclic aromatic hydrocarbons reduction.
- Emissions of sulphur are completely eliminated by using B100. Exhaust gases pollutant emissions no longer contain sulphuric oxides and sulphates (important components of acid rains), because in the molecular structure sulphur cannot be found in the case of B100 compared to the diesel one.
- Criteria for emissions estimations present a strong reduction of their values compared with conventional diesel fuel.
- Diesel biofuel reduce the disease risks that are usually caused by diesel. The emissions produced by biodiesel show the HCAP and nitrate-nHCAP reduction, both responsible for cancer [3], [1].

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## 2.2. REDUCING EMISSIONS AND THE GREENHOUSE EFFECT OF USING BIOFUEL

Biodiesel - an ultra-clean fuel - contains no sulphur or aromatics, which contributes to emissions reduction.

Biofuel is used mainly as a source of reduction pollution caused by cars. It is well known the fact that the largest source of greenhouse gases is the transport. Used as fuel, biofuel reduces oxides of nitrogen, monoxide and carbon dioxide pollution.

Transport and fuel production are responsible for one quarter of gas emissions with greenhouse effect, and the percentage is continuously increasing.

„Energy crops" for biofuels have the potential to decrease by over 10% the emissions of greenhouse gases (compared to gasoline and diesel) because such cultures retain the carbon in the ground as they grow. [4]

For example in Ireland, emissions of the different gases can be aggregated on the basis of their Global Warming Potentials which are a measure of their relative warming effect. The relative contributions of the different gases are shown in Figure 2.

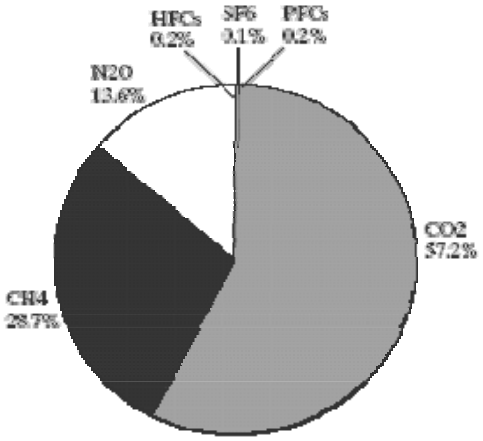



Fig.2 Contribution of different greenhouse gases to aggregate emission

The contribution of methane and nitrous oxide to total emissions is unusually high compared to that in other developed countries. This is because of the significance of agriculture in the economy; agricultural emissions represent 35% of total emissions. [6]

The development of biofuel industry in Romania provided an explosive progress in agriculture: in 2005 rape crops covered 88,000 hectares. In 2006, the area has reached to 160,000, and in the autumn of last year 370,000 hectares were sown with rape.

EU Commission White Book acknowledges that by 2010 the $CO_2$ emissions will reach a significant increase, their amount being of approximately 1113 million tones. The major responsible is the road traffic which causes from transports 84% of total $CO_2$ emissions. Therefore, from ecological point of view the White Book campaigns to reduce the oil dependence in transports (which is currently approximately 98%) by using alternative fuels such as biofuels. Using biofuels on a large-scale in transports constitutes only a part of the package of measures to be taken to achieve the reduction in $CO_2$ emissions. The increase of biofuels utilisation in the transport sector, without excluding other possible alternative fuels for the automotive industry, is one of the ways through which the dependence on energy imports can be reduced, can be influenced the fuel market for transports and can be ensured the security of energy supply on medium and long term.

## 4. CONCLUSIONS

The gradual transition from fossil fuels to biofuels involves both compromises and many risks, besides benefits and opportunities, under the circumstances of which there already exists a young but rapidly growing market. Simultaneously the political and economic interests around biofuels are immense. The mode of producing and using the alternative energy makes the difference.

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Even if Romania has resources of fossil hydrocarbons, the production and utilisation of biofuels has a great importance, both in the national and in European context.

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# RESEARCH ON THE RELIABILITY MODELING OF HYDRO MECHANICAL SYSTEMS

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**Abstract:**

The paper presents reliability evaluation models of the pumping system for slag and ashes discharge, from thermo-electric power plants (TPP). The paper it is structured in four parts. The first two parts present the system reliability modelling using the Markov model, respectively binomial model. The time and outflow availability modelling of analyzed system are represented in the third part. The last part presents the conclusions. In order to facilitate the understanding of the models it has been concretized with reference to the slag and ashes exhausting system from CET I Oradea, equipped with Bagger pumps.

**Keywords:**

hydro mechanical systems, reliability modeling, Markov model, binomial model, time and outflow availability.

## 1. INTRODUCTION

Usually, the slag and ashes which result from coal burning, are evacuated using the Bagger pumps. For thermo-electric power plants it has been established that the slag and ashes continuous evacuation directly conditioning the cauldron working. Therefore, the number of Bagger pumps establishment and their drive back connections, represent the subject for the technical and economic reliability and optimization calculus.

The reliability modeling, it has been made for the functioning configuration in which the Bagger pumps stations (BgPS) are "n+k" systems (n in work, k in reserve). For forecasting reliability analyzing the most used methods are [1, 2, 5, 6]:

- the binomial method, where the elements are characterized by states probabilities (p,q);
- the Markov method with continuous parameter, where the elements are characterized by fundamental reliability indicators ($\lambda_i$, $\mu_i$).

## 2. THE MARKOV METHOD USED TO RELIABILITY MODELLING OF SLAG AND ASHES PUMPING SYSTEM FROM CET I ORADEA

There are three Bagger pumps stations provided foe slag and ashes exhausting in CET I Oradea:

- the Bagger station 1: attends the 1, 2 and 3 cauldrons and it is equipped with 5 Bagger pumps;
- the Bagger station 2: attends the 4 and 5 cauldrons and it is equipped with 4 Bagger pumps;
- the Bagger station 3: attends the cauldron 6 and it is equipped with 3 Bagger pumps.

The continuous and safety functioning of Bagger pumps it is very important for continuous and nominal output functioning cauldrons.

For Bagger pumps dimensioning like ″n+k″ systems, the forecasting reliability indicators calculus are following presented.

**a). The Bagger station I** has 5 Bagger pumps, SIGMA 250-NBA-580 type and an outflow of Q = 800 m³/h. Functioning configurations is ″3+2″ (3 in work and 2 in reserve). Because the groups are identical it has been admitted the same values for reliability indicators. The total number states of a system with 5 elements are $2^5$=32. In this case

(identical elements) states are merged and RED (reliability equivalent diagram) is represented in figure [2, 3]:

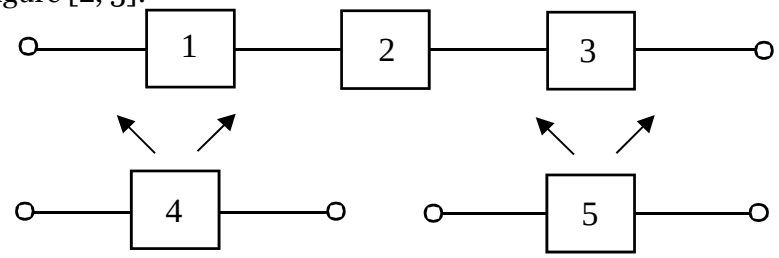



**Figure1.** The RED of "3+2" system

- The states graph is presented in figure 2:

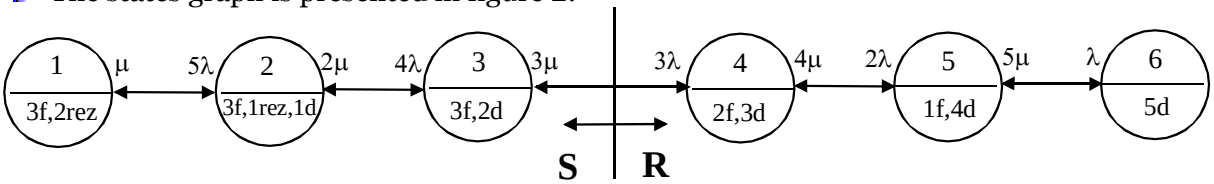



**Figure2.** The states graph of "3+2" system

- The transition intensities matrix $[q_{ij}]$ has the 6th rank and it is [1, 2, 3, 5, 6]:

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | $-5\lambda$ | $\mu$ | - | - | - | - |
| 2 | $5\lambda$ | $-\mu-4\lambda$ | $2\mu$ | - | - | - |
| 3 | - | $4\lambda$ | $-2\mu-3\lambda$ | $3\mu$ | - | - |
| 4 | - | - | $3\lambda$ | $-3\mu-2\lambda$ | $4\mu$ | - |
| 5 | - | - | - | $2\lambda$ | $-4\mu-\lambda$ | $5\mu$ |
| 6 | - | - | - | - | $\lambda$ | $-5\mu$ |

(1)

- The equations system:

$$\begin{cases} -5\lambda p_1 + \mu p_2 = 0 \\ 5\lambda p_1 - (\mu + 4\lambda)p_2 + 2\mu p_3 = 0 \\ 4\lambda p_2 - (2\mu + 3\lambda)p_3 + 3\mu p_4 = 0 \\ 3\lambda p_3 - (3\mu + 2\lambda)p_4 + 4\mu p_5 = 0 \\ 2\lambda p_4 - (4\mu + \lambda)p_5 + 5\mu p_6 = 0 \\ \lambda p_5 - 5\mu p_6 = 0 \\ \sum_{i=1}^{6} p_i = 1 \end{cases} \quad (2)$$

The system solution leads to probability vector determination $[p_i]$, i=1÷6 with which the reliability indicators are calculated.

Similarly the other Bagger pumps stations from slag and ashes exhausting system will be analyzed and the numerical data will be tabular represented.

**b) The Bagger station 2** has 4 Bagger pumps, SIGMA 250-NBA-580 type and an outflow of Q = 800 m³/h. Functioning configuration is "2+2" (2 in work, 2 in reserve).

- The states graph is presented in figure 3:

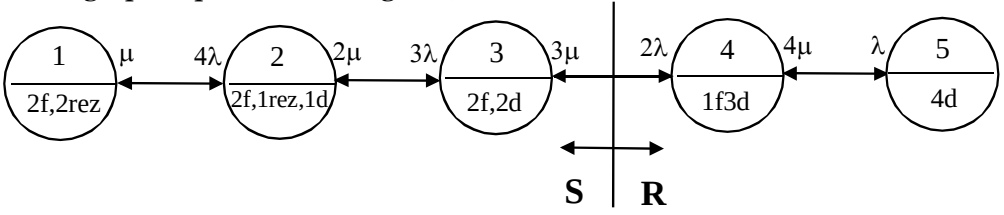



**Figure 3.** The states graph of "2+2" system

- The equations system:

$$\begin{cases} -4\lambda p_1 + \mu p_2 = 0 \\ 4\lambda p_1 - (\mu + 3\lambda) p_2 + 2\mu p_3 = 0 \\ 3\lambda p_2 - (2\mu + 2\lambda) p_3 + 3\mu p_4 = 0 \\ 2\lambda p_3 - (3\mu + \lambda) p_4 + 4\mu p_5 = 0 \\ \lambda p_4 - 4\mu p_5 = 0 \\ \sum_{i=1}^{5} p_i = 1 \end{cases} \quad (3)$$

The system solution leads to probability vector determination $[p_i]$, i=1÷5 with which the reliability indicators are calculated.

**c) The Bagger station 3** has 3 Bagger pumps, SIGMA 250-NBA-580 type and an outflow of Q = 800 m³/h. Functioning configuration is"1+2" (1 in work, 2 in reserve).

- The states graph is presented in figure 4:

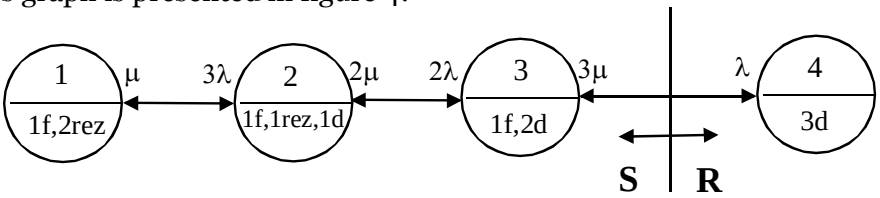



**Figure4.** The states graph of "1+2" system

- The equations system:

$$\begin{cases} -3\lambda p_1 + \mu p_2 = 0 \\ 3\lambda p_1 - (\mu + 2\lambda) p_2 + 2\mu p_3 = 0 \\ 2\lambda p_2 - (2\mu + \lambda) p_3 + 3\mu p_4 = 0 \\ \lambda p_3 - 3\mu p_4 = 0 \\ \sum_{i=1}^{4} p_i = 1 \end{cases} \quad (4)$$

The system solution leads to probability vector determination $[p_i]$, i=1÷4 with which the reliability indicators are calculated.

The states grouping for each one of the pumping stations is done in the following way:

BgPS 1 $\begin{cases} S = [S_1, S_2, S_3] \\ R = [S_4, S_5, S_6] \end{cases}$

BgPS 2 $\begin{cases} S = [S_1, S_2, S_3] \\ R = [S_4, S_5] \end{cases}$

BgPS 3 $\begin{cases} S = [S_1, S_2, S_3] \\ R = [S_4] \end{cases}$

The calculus expressions of reliability indicators for the Bagger pumps stations are represented in table 1.

**Table 1.** The calculus of states probabilities and reliability indicators for the Bagger pumps stations

| The reliability indicators | Bagger pumps stations | | |
|---|---|---|---|
| | BgPS 1 | BgPS 2 | BgPS 3 |
| 0 | 1 | 2 | 3 |
| $P_S$ | $\sum_{i=1}^{3} p_i$ | $\sum_{i=1}^{3} p_i$ | $\sum_{i=1}^{3} p_i$ |
| $P_R$ | $\sum_{i=4}^{6} p_i$ | $\sum_{i=4}^{5} p_i$ | $p_4$ |

**Table 1** (continuation)

| 0 | 1 | 2 | 3 |
|---|---|---|---|
| $\alpha(T_A)$ | $\sum_{i=1}^{3} p_i \cdot T_A$ | $\sum_{i=1}^{3} p_i \cdot T_A$ | $\sum_{i=1}^{3} p_i \cdot T_A$ |
| $\beta(T_A)$ | $\sum_{i=4}^{6} p_i \cdot T_A$ | $\sum_{i=4}^{5} p_i \cdot T_A$ | $p_4 \cdot T_A$ |
| $\nu(T_A)$ | $3p_3\lambda T_A$ | $2p_3\lambda T_A$ | $p_3\lambda T_A$ |
| MTBF | $\sum_{i=1}^{3} p_i \Big/ 3p_3\lambda$ | $\sum_{i=1}^{3} p_i \Big/ 2p_3\lambda$ | $\sum_{i=1}^{3} p_i \Big/ p_3\lambda$ |
| MTM | $\sum_{i=4}^{6} p_i \Big/ 3p_3\lambda$ | $\sum_{i=4}^{5} p_i \Big/ 2p_3\lambda$ | $p_4 / p_3\lambda$ |
| $\lambda_s$ | $3p_3\lambda \Big/ \sum_{i=1}^{3} p_i$ | $2p_3\lambda \Big/ \sum_{i=1}^{3} p_i$ | $p_3\lambda \Big/ \sum_{i=1}^{3} p_i$ |
| $\mu_s$ | $3p_3\lambda \Big/ \sum_{i=4}^{6} p_i$ | $2p_3\lambda \Big/ \sum_{i=4}^{5} p_i$ | $p_3\lambda / p_4$ |

Admitting the values of Bagger pumps fault mean rate, respectively recovery mean rate from [7]: $\lambda_{BgP} = 40 \cdot 10^{-4}$ h$^{-1}$; $\mu_{BgP} = 119 \cdot 10^{-4}$ h$^{-1}$ the following results in table 2 had been obtained.

Table 2. Numerical values of reliability indicators for Bagger pumps stations

| The reliability indicators | Bagger pumps stations | | |
|---|---|---|---|
| | BgPS 1 | BgPS 2 | BgPS 3 |
| 0 | 1 | 2 | 3 |
| $P_S$ | 0,8934395 | 0,9485405 | 0,9840781 |
| $P_R$ | 0,1065605 | 0,0514595 | 0,0159216 |
| $\alpha(T_A)$ [h] | 7826,53 | 8309,2148 | 8620,5242 |
| $\beta(T_A)$ [h] | 933,46998 | 450,78522 | 139,47322 |
| $\nu(T_A)$ [faults per year] | 27,8477 | 9,958424 | 4,979212 |
| MTBF [h] | 281,04692 | 834,39054 | 1731,3029 |
| MTM [h] | 33,520457 | 45,266723 | 28,011103 |
| $\lambda_s$ [h$^{-1}$] | $3,5581158 \cdot 10^{-3}$ | $1,1984796 \cdot 10^{-3}$ | $5,7759968 \cdot 10^{-4}$ |
| $\mu_s$ [h$^{-1}$] | 0,0298325 | 0,0220912 | 0,0357001 |

## 3. FORECASTING RELIABILITY EVALUATION OF BgPS USING BINOMIAL METHOD

The binomial method appeals to an easier mathematical model than the Markov method.

In this case for reliability indicators evaluation, we must start from the binomial theorem expression. For "n+k" BgPS type is:

$$(p + q)^{n+k} \tag{5}$$

The reliability indicators evaluation has been made by the following relations:

- The time safety of system with "n" groups in work (successfully probability) is:

$$P_S = \sum_{i=n}^{n+k} C_{n+k}^{i} \cdot p^i (1-p)^{n+k-i} \tag{6}$$

- The time safety of BgPS with "n+k-j" groups in work is:

$$P_{n+k-j} = \sum_{i=n}^{n+k-j} C^{i}_{n+k-j} \cdot p^{i}(1-p)^{n+k-j-i} \text{ cu } j \le k \quad (7)$$

The feasible states of BgPS I are presented in table 3 and 4. The functioning probability, respectively the failure probability for Bagger pumps, including the electrical equipment are [7], $p_{BgP}$=0,748; $q_{BgP}$=0,252.

Table 3. The feasible states of BgPS 1

| Analytical processing | | | | | | |
|---|---|---|---|---|---|---|
| State nr. | BgP state | | | State probability | Annual mean time [h/an] | Achieved mean outflow [m³/h] |
| | f | rs | d | | | |
| 1(s) | 3 | 2 | - | $p^5$ | $p^5 \cdot T_A$ | $3Q_{BgP}$ |
| 2(s) | 3 | 1 | 1 | $5p^4q$ | $5p^4q \cdot T_A$ | $3Q_{BgP}$ |
| 3(s) | 3 | - | 2 | $10p^3q^2$ | $10p^3q^2 \cdot T_A$ | $3Q_{BgP}$ |
| 4(sp) | 2 | - | 3 | $10p^2q^3$ | $10p^2q^3 \cdot T_A$ | $2Q_{BgP}$ |
| 5(sr) | 1 | - | 4 | $5pq^4$ | $5pq^4 \cdot T_A$ | $1Q_{BgP}$ |
| 6(r) | - | - | 5 | $q^5$ | $q^5 \cdot T_A$ | - |

Table 4. Numerical values of the BgPS 1 feasible states

| Numerical results for BgPS I | | | | | | |
|---|---|---|---|---|---|---|
| State nr. | BgP state | | | State probability | Annual mean time [h/an] | Achieved mean outflow [m³/h] |
| | f | rs | d | | | |
| 1(s) | 3 | 2 | - | 0,2341574 | 2226 | 2400 |
| 2(s) | 3 | 1 | 1 | 0,3944363 | 3455 | 2400 |
| 3(s) | 3 | - | 2 | 0,2657699 | 2328 | 2400 |
| 4(sp) | 2 | - | 3 | 0.0895374 | 784 | 1600 |
| 5(sr) | 1 | - | 4 | 0,0150825 | 132 | 800 |
| 6(r) | - | - | 5 | $1{,}01625 \cdot 10^{-3}$ | 9 | 0 |

rs – the reserve state; sp – the partial success (66,6 %); sr – the reduced success (33,3 %)
$Q_{BgP}$ – the pump outflow

The successfully probabilities expressions for the other pumping systems are given in table 5. The reliability indicators calculus are made according to the previous models.

Table 5. Numerical values of successfully probability for pumping systems

| Nr. | Bagger station | Configuration | | The indicator $P_S$ relation | Numerical results for $P_S$ |
|---|---|---|---|---|---|
| | | Established | Normal functioning | | |
| 1. | SPBg 2 | 4xSIGMA | 2+2 | $p^4 + 4p^3q + 6p^2q^2$ | 0,9480862 |
| 2. | SPBg 3 | 3xSIGMA | 1+2 | $p^3 + 3p^2q + 3pq^2$ | 0,9839969 |

Corroborating with groups outflow the availability indicators of BgSP can be calculated:

- The successfully probability is:

$$P_S = p^5 + 5p^4q + 10p^3q^2 = 0{,}8943636 \quad (8)$$

- The failure probability is:

$$P_R = 20p^2q^3 + 5pq^4 + q^5 = 0{,}1056364 \quad (9)$$

- The medium number of functioning groups, respectively the failures groups:

$$m_f = 5p \cong 4;\ m_d = 5q \cong 1 \quad (10)$$

- The standard deviation in comparison with the mean value ($m_f$):

$$\sigma = \sqrt{5pq} = 0{,}94248 \quad (11)$$

- The pumping volume during the analysis interval:

$$V_p = \sum_{i=1}^{5} Q_i \cdot T_i = 20 \cdot 10^6 \ m^3 / an \tag{13}$$

- The unavailable volume during the analysis interval:

$$\Delta V_I = V_N - V_p = 4 \cdot Q_{PBg} \cdot T_A - V_p = 8 \cdot 10^6 m^3 / an \tag{14}$$

- The availability and unavailability indicators:

$$D_Q = \frac{V_p}{V_N} = 0{,}7134703$$
$$I_Q = 1 - D_Q = 0{,}2865298 \tag{15}$$

## 4. CONCLUSIONS

**1.** In reference material one cannot find a specific treating (dedicated, adequate, distinct and profound) of BgPS forecasting reliability;

**2.** For Bagger pumps system reliability evaluation the following models are recommended:
- the Markov model for "n+k" system ("3+2", "2+2", "1+2"),
- the binomial model "n+k";
- the outflow availability and unavailability evaluation, using the binomial;

**3.** With reference to the numerical results obtained for CET I Oradea BgPS it has been ascertained a better behavior of Bagger station 3, from the reliability point of view.

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# FUZZY SIMULATION IN RELIABILITY ANALYSIS

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**Abstract:**
In the first part of this paper we present an introduction of fuzzy logic application in power systems and equipments reliability analysis. The second part considers the development of a computer simulation program for complex electric system's reliability study fuzzy algorithms, definition of asymmetric Gauss input and output membership functions, rule sets and results display methods. The third part is focused on the development of a case study for the electric station in Tileagd, Bihor County using the developed simulation program in the Matlab environment. The fourth part emphasis on the conclusions which show the importance and efficiency of fuzzy modeling in reliability analysis by comparative evaluation of fuzzy and Monte Carlo methods also shown in equivalent reliability diagrams, highlighting authors contributions. The last part of the paper presents the references which were consulted.

**Keywords:**
failure tree, reliability, fuzzy simulation

## 1. INTRODUCTION

Fuzzy logic represents an extremely useful tool in modeling the behavior of electrical equipment. Fuzzy set theory considers multi state systems and multi criteria decisions, the mathematical instrument is flexible and easily adaptable to reality. This theory is useful for modeling of power systems and equipment reliability evaluation [1, 9].

In reliability studies it is generally accepted a bivalent operational evolution mode: normal operation state and failure state. In reality the transition between states is not sudden, which implies a nuanced expression of system's performance (very good, good,..., median, poor). In this paper there is presented the development of reliability simulation software for electric plants based on the method of failure trees using fuzzy logic in the MATLAB environment. [2,6,8]

## 2. DEVELOPMENT OF SIMULATION SOFTWARE USING FUZZY LOGIC

A frequently used analysis method in a system's reliability study is based on the evaluation of failure probability. In this method the crisp values of failure probabilities for electrical components are generally used in order to compute the systems reliability, based on equivalent reliability diagrams. [5,7]

### 2.1. Definition of input membership functions.

The developed software is using Gaussian membership functions. For this kind of function the mean and standard deviation ($\sigma$) must be specified.

So for every component of the system 7 grades were defined, on a linear interval of failure and repair intensity values ($\lambda$ and $\mu$) and then the function values are established.

| | | |
|---|---|---|
| Not acceptable | N | 0 |
| Almost acceptable | AN | 0.167 |
| Close to acceptable | PS | 0.333 |
| Acceptable | S | 0.5 |
| Good | B | 0.667 |
| Almost very good | AFB | 0.833 |
| Very good | FB | 1 |

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The fuzzy method is presented schematically in figure 1. The fuzzy analysis program generates input membership functions (on basis of specified failure intensity λ and repair intensity μ) and then generates the output membership functions and the rule set. The flowchart of the algorithm is presented in fig. 2.

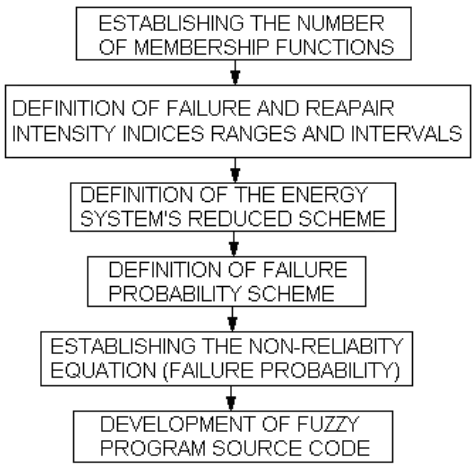



**Figure 1.** Schematic function blocks for fuzzy analysis set up

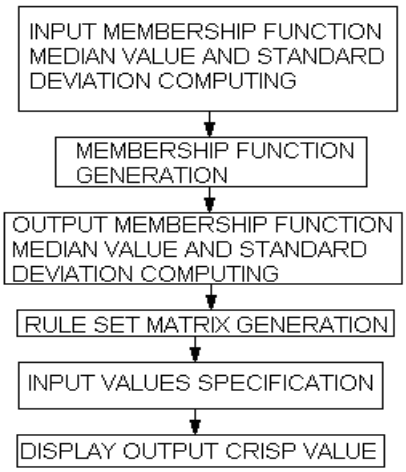



**Figure 2.** Flowchart of the fuzzy program




**Figure 3.** Main program GUI

All program functions are launched from the „d_fuzzy.m" module. The GUI window is presented in figure 3.

The „d_date.m" module is launched on action of „Input data" button. The simulation data input includes λ and μ specification, data saving and data reload.

The system equation is input from the "d_param" and λ and μ are input from a separate window which allows as many parameters as many components were specified. The program also allows data saving (the data are saved in a .mat type file) in files with optional names. The saved data can be reloaded in a separate interface from their files which contains all system parameters and also the system equation. Once established the system parameter values for specific runs can be input from the "d_param_intr.m" module.

Mean values for membership functions are computed on basis of the relation:

$$F_i = \frac{\lambda_i}{\lambda_i + \mu_i} \qquad (1)$$

where i = 1...7, is the number of the membership function according to the earlier defined grade.

Standard deviation (σ) is computed with asymmetric Gauss function based on relations (2):

$$\sigma_{i,1} = \frac{|F_{i-1} - F_i|}{3}, \qquad \sigma_{i,2} = \frac{|F_i - F_{i+1}|}{3} \qquad (2)$$

After the introduction or reload of data from saved files, we can reenter the main module which gives us two options:

- fuzzy simulation
- decision surfaces display

Choosing "Fuzzy simulation", after computing input membership functions parameters for each system component, the program generates these functions. Decision surface display facilitates the evaluation of the fuzzy outputs.

### 2.2. Definition of output membership function

In order to compute the output membership functions we start with the reduced system schematics from which the failure tree is generated. From the flowchart we can derive the

system's characteristic equation and then the program generates the output membership function.

### 2.3. Definition of the rule set

The rule set of the fuzzy inference system defines the way in which the inputs and outputs are linked. The rules are described in form of logical relations having as variables linguistic degrees of the inputs and as operators the "and" and "or" logical operators. An example of fuzzy rule is:

*If* $elem_1$ *is FB and* $elem_2$ *is B and* $elem_3$ *is S than the system is B.*

After the establishment of the rule set, the program can generate inference surfaces in the input-output space which are in fact the values of the outputs for the whole range of given inputs. Due to the limitations of 3D representation, these surfaces can be represented only as 2 inputs simultaneously, the remaining inputs being considered static for that case. The 2 inputs which are wanted to be represented can be selected in the program interface.

### 2.4. Simulation results

After generating the membership functions and rule sets the program also generates the so called "fuzzy inference system" information structure. If this structure is used for a single run, then the crisp values of inputs are specified and the "evalfis" function is used for the computation of crisp output values. The program displays this value in a separate window.

## 3. CASE STUDY. TILEAGD ELECTRIC STATION (SE) [2].

In [2] the normal form of SE Tileagd, Bihor County scheme is presented. Evaluation of reliability is realized considering the Săcădat user, positioned on BC - 20kV collector bar and the study criteria is considered in the absence of the consumer.

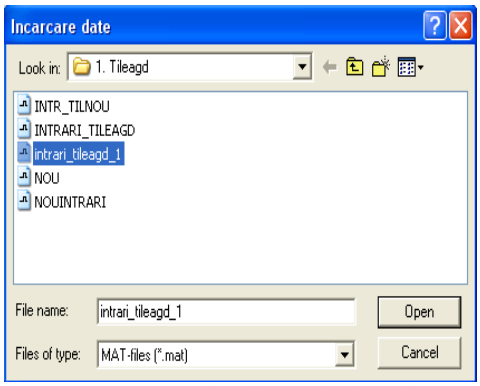



**Figure 4.** Data loading window for SE Tileagd

Using statistical data representing median values of reliability indicators for the equipments in Electric Stations (SE) and also using the equivalent reliability diagram we had reduced the SE Tileagd scheme to an equivalent reliability diagram (DEF) presented in figure 14 a. This diagram was then used to formulate the system equation for the fuzzy simulation. The reduction of normal scheme had been made by transposing it in a scheme in which the elements are connected in series or parallel considering the dimensioning and connection of elements. All feeds for Săcădat consumer, on all path, from the source had been considered. In figures 4-7 input data of analyzed electric station are presented.

In figures 8 -13 the obtained membership function diagrams are presented for SE Tileagd.

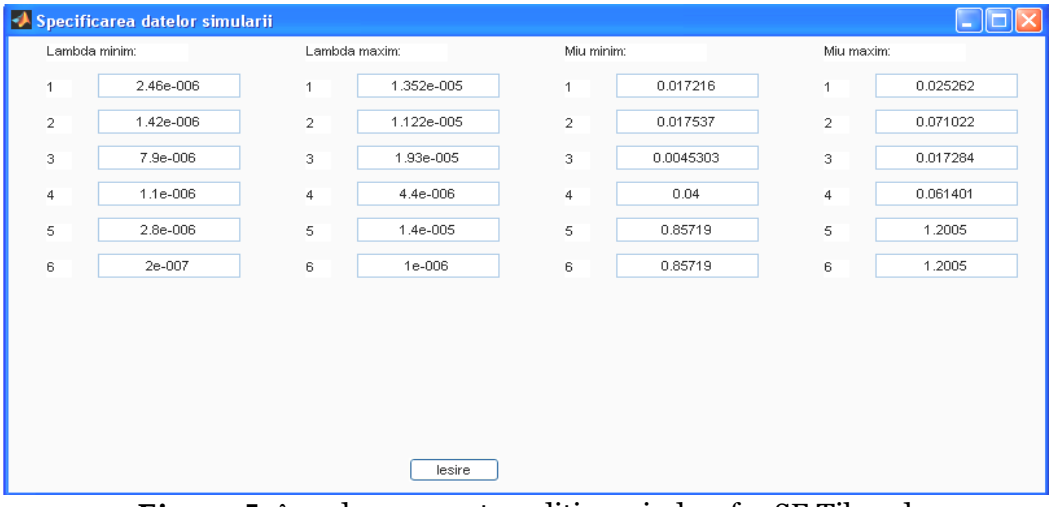



**Figure 5.** λ and μ parameter editing window for SE Tileagd

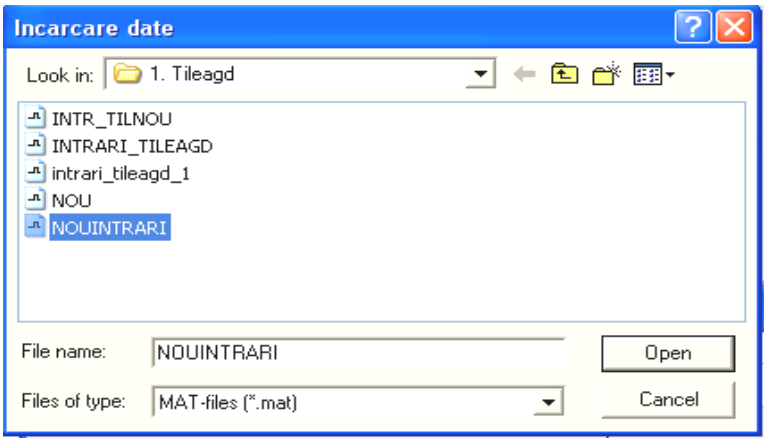



**Figure 6.** Input values loading window for SE Tileagd

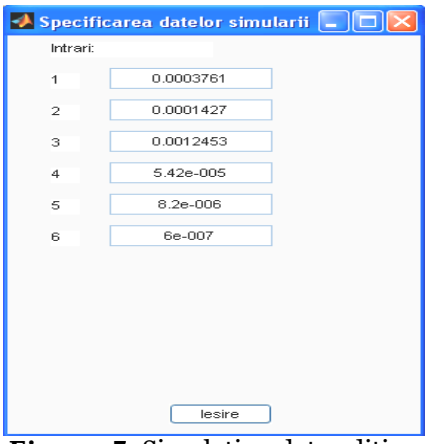



**Figure 7.** Simulation data editing window for SE Tileagd

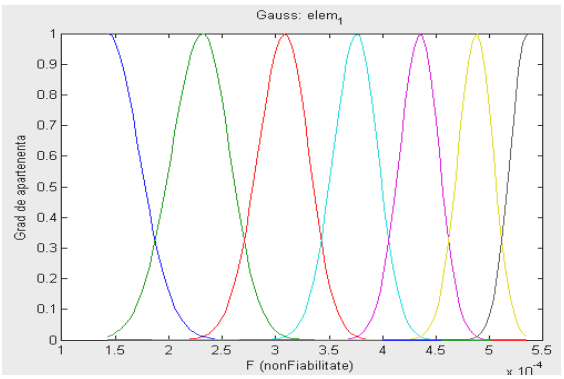



**Figure 8.**
Membership functions for element 1

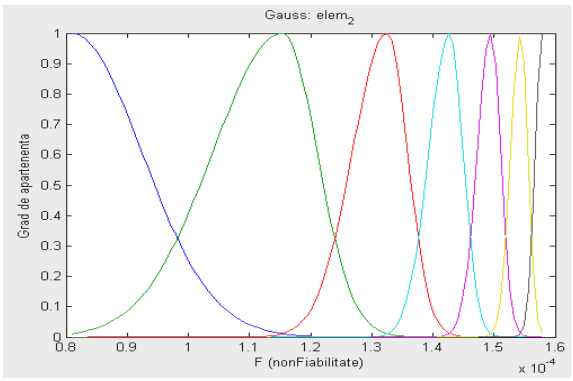



**Figure 9.**
Membership functions for element 2

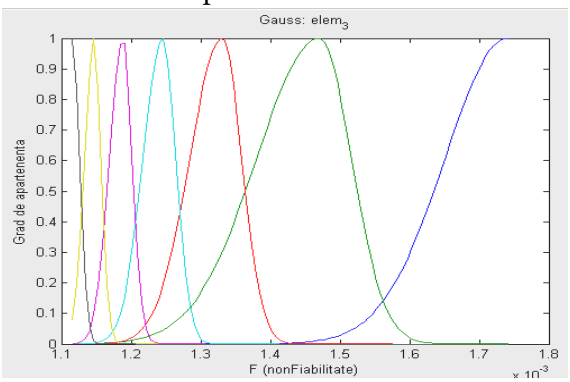



**Figure 10.**
Membership functions for element 3

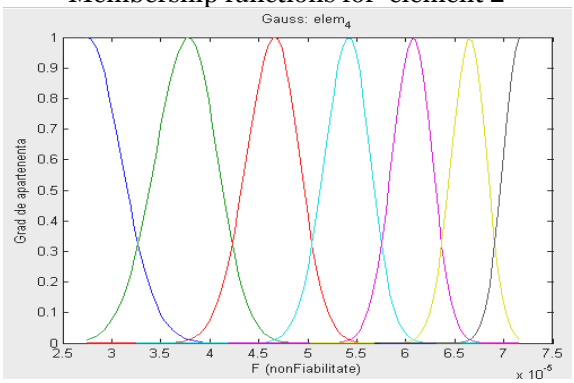



**Figure 11.**
Membership functions for element 4

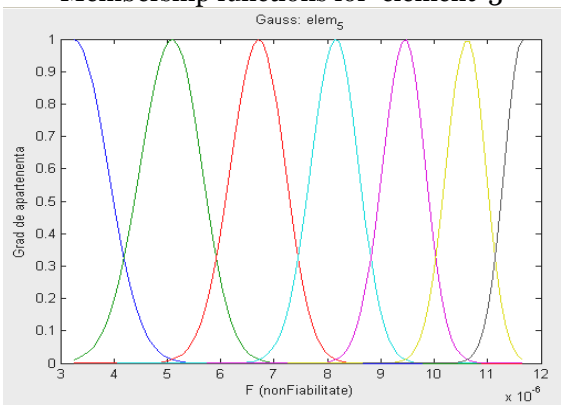



**Figure 12.**
Membership functions for element 5

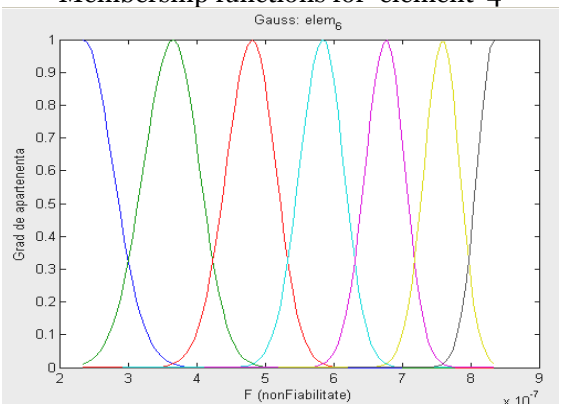



**Figure 13.**
Membership functions for element 6

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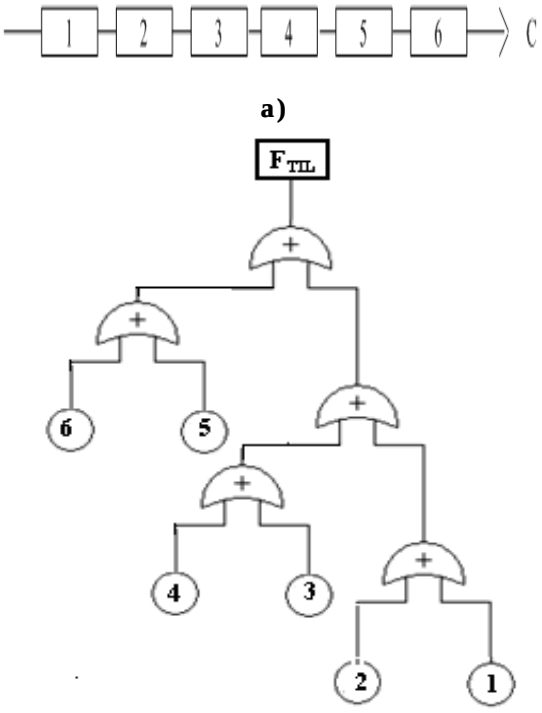



**Figure 14.** Reduced scheme (a) and scheme of system for SE Tileagd (b)




**Figure 16.** Reliability output window for SE Tileagd

For computing output membership functions we start from the system scheme from which the failure tree is generated - figure 14.

Characteristic equation of the system is deduced from the schemes presented in figure 14 and is given by relation (3):

$$F_{TIL}=1-\prod_{i=1,6}(1-F_i)=1-(1-F_1)(1-F_2)(1-F_3)(1-F_4)(1-F_5)(1-F_6) \quad (3)$$

Relation (3) is used by the program to generate the output membership function presented in figure 15.

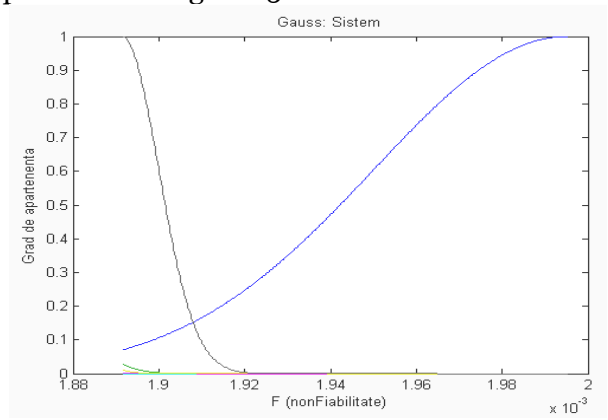



**Figure 15.** Output membership functions generated for SE Tileagd

The program displays the obtained output values in a separate window presented in figure 16. In figures 17 and 18 some decision surfaces are presented.

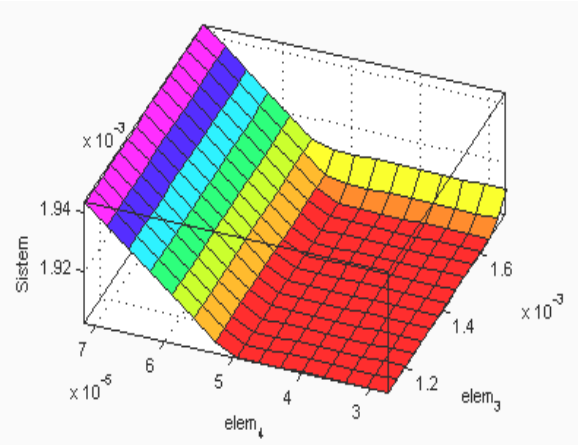



**Figure 17.**
Output values for inputs 4 şi 3

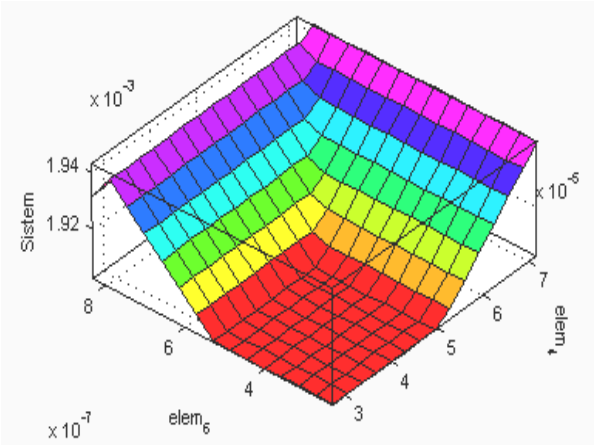



**Figure 18.**
Output values for inputs 6 şi 4

## 4. CONCLUSIONS

The use of "fuzzy sets theory" in the study of reliability of electric energy systems and equipments consists in the possibilities offered by quantification and modeling of qualitative enounces – incomplete and altered information, subjective appreciations – in flexible forms, more close to the way of thinking the engineers operates with.

The program developed under MATLAB environment for the fuzzy simulation of reliability of electrical equipments permits the step by step definition of the fuzzy model and it is realized in a versatile manner, object oriented and modular. The program can make diverse simulations, in small times, for a given scheme, in the analyzed fuzzy intervals making possible the visualization of values range in which the non-reliability and reliability of the system can evolve.

The realized evaluations, obtained with the SE reliability fuzzy simulation program, are accurate, in comparison with the values obtained by Monte Carlo method and direct DEF computation [2, 4].

Comparative results for fuzzy, Monte Carlo and DEF methods

| R / SE | FUZZY | MONTE CARLO 10000 simulări | DEF |
|---|---|---|---|
| TILEAGD | 0,99808771 | 0,99822 | 0,99808 |

Development of SE fuzzy reliability simulation program using the MATLAB programming environment, based on failure tree method, application of the program for SE Tileagd, Bihor County, and comparative evaluation with the Monte Carlo simulation method results and with DEF analytical method results, are contributions of the authors in this article.

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# VARIABILITY OF GAS-PARTICLE PARTITIONING OF POLYCYCLIC AROMATIC HYDROCARBONS IN A PILOT AREA OF VOJVODINA

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**Abstract:**
Polycyclic aromatic hydrocarbons consist of two to eight condensed aromatic rings and they are produced during incomplete combustion of organic materials. High atmospheric levels of polycyclic aromatic hydrocarbons are associated with industrial activities, energy production, and any type of combustion and traffic. In the atmosphere, PAHs are distributed between gaseous and particulate phase. Distribution of PAHs in the atmosphere controls removal processes and atmospheric degradation. During the June and July 2004 air sampling campaign was conducted in the region of Vojvodina, and concentration levels of 16 PAHs in gaseous and particulate phases were determined.

**Keywords**:
Polycyclic aromatic hydrocarbons; Gas-particle partitioning; Atmospheric distribution; Active air sampling

## 1. INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are the comlex group of organic compounds with planar structure, with C and H atoms organized in circlet structure with at least two aromatic rings. Primary natural sources of PAHs are fires and volcanic eruptions. The most important anthropogenic sources of PAHs in the atmosphere are wood combustion, energy production, and production of aluminium, incineration, catalytic cracking and exhaust gases from vehicles. Concentration levels and behavior of polycyclic aromatic hydrocarbons in the environment have been frequently monitored because of their long-term transport, global distribution and high toxicity [1, 2, 3, 4, 5].

In the atmospheric environment, PAHs are found in the gaseous phase or sorbed at the solid particles, depending mainly on ambient temperature and vapor pressures. Gas-particle partitioning process can be described using partitioning coefficient $K_P$:

$$K_P = \frac{1}{K_V} = \frac{\frac{F}{TSP}}{A} \quad (1)$$

where:
$K_P$ –partition coefficient between particle and gaseous phase in atmosphere ($m^3\ \mu g^{-1}$)
$K_V$ – partition coefficient between gaseous and particle phase in atmosphere ($\mu g\ m^{-3}$)
$A$ i $F$ – compound concentration associated with the gaseous and particle phase, respectively (ng $m^{-3}$ air)
$TSP$ – total suspended particulate matter concentration ($\mu g$ aerosol $m^{-3}$ air)

Atmospheric distribution of PAHs, can also be described with total amount of supstance proportion sorbed on atmospheric particles, $\phi$:

$$\phi = \frac{F}{A+F} = \frac{K_P \cdot TSP}{1 + K_P \cdot TSP} \quad (2)$$

During the period from June - July 2004, air sampling campaign was conducted in the region of Vojvodina, Serbia, and concentration levels of 16 US EPA PAHs were determined.

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## 2. MATERIALS AND METHODS

Concentration levels of selected polycyclic aromatic hydrocarbons have been determined in accordance with the sampling procedure and analysis of organic pollutants in ambient air, adopted by EPA [6, 7]. Active air sampling method is realized through flowing of definite quantity of air, controlled by compressor, through the sampler. In the first step, air is released through the horizontally placed single layer filter made of glass fiber (GF), which holds atmospheric particles over 0.1 μm in diameter. Air, then, passes through the sorbent made of polyurethane foam (PUF), placed behind GF, which collects gaseous phase of PAHs molecules.

The sampler used for the active sampling of air was GV2360 Thermo Andersen TSP, made of stainless steel boxes and equipped with 20.32 x 25.4 cm filter holder and PUF holder (9 cm in diameter and 30 cm long). Air was passed through using a 1200 watt motor controlled by an inverter (Hitachi L100-015NPE) and flow was measured by a Sierra 620 fast flow insertion mass flow meter with a totaliser. The average total sampled air was 1200 $m^3$/day. For each sampling period, per one Whatman grade G653 glass fiber filter (dimension: 20.32 x 25.4cm) and two polyurethane foam filters (dimension: 9 cm diameter and 5 cm long) were used.

Prior the sampling, glass fiber filters were burned in 400°C for 5 hours and polyurethane foam filters were Soxhlet extracted by 1:1 acetone/hexane (Merk suprasolv) by a Foss Tecator Soxtec 1045 HT-2 apparatus for 4 hours to 120°C.

After the sampling period (3 x 24h), GFs and PUFs were extracted and analzyed using GC/MS method. Analytical determination of 16 EPA PAHs in all samples was carried out in laboratories of Research Centre for Environmental Chemistry and Ecotoxicology (RECETOX), Masaryk University in Brno, Czech Republic.

## 3. RESULTS

Three 24-hour high volume samples were collected from each of three sampling sites in in the town of Pančevo, Vojvodina, Serbia. Air sampling campaign in Pančevo was conducted during the period from 27th – 30th June, 2004. Two samplers were placed within the industrial area, in the yard of the oil refinery and petrochemical complex (localities P1 and P2, respectively). The third HiVol sampler was placed in the city center, on the top of the Pančevo city hall (locality P3). Detailed information on the three sampling spots is presented in Table 1. Concentration levels of 16 EPA PAHs are presented in Table 2.

Table 1. Detailed information on the sampling sites

| Site ID | Latitude | Longitude | Elevation (m a.s.l.) |
|---|---|---|---|
| P1 | N 44°49' 56.3" | E 20°41' 25.4" | 82 |
| P2 | N 44°49' 57.0" | E 20°40' 17.0" | 85 |
| P3 | N 44°52' 12.8" | E 20°38' 24.1" | 130 |

Table 2. Average concentrations of PAHs in gaseous and particulate phase (ng/$m^3$)

| Sample type | PUF | GF | PUF | GF | PUF | GF |
|---|---|---|---|---|---|---|
| Locality | P1 | | P2 | | P3 | |
| Sampling period | 27-30th June 2004 | | | | | |
| Nap | 1.195 | 0.010 | 0.811 | 0.016 | 0.454 | 0.010 |
| Acy | 0.065 | 0.003 | 0.050 | 0.001 | 0.044 | 0.001 |
| Ace | 0.063 | 0.006 | 0.054 | 0.006 | 0.027 | 0.002 |
| Flo | 1.454 | 0.003 | 1.497 | 0.009 | 0.171 | 0.002 |
| Phe | 18.309 | 0.041 | 27.364 | 0.144 | 3.659 | 0.030 |
| Ant | 0.679 | 0.001 | 1.152 | 0.007 | 0.187 | 0.002 |
| Flu | 2.133 | 0.024 | 10.997 | 0.167 | 2.160 | 0.071 |
| Pyr | 1.521 | 0.020 | 3.773 | 0.095 | 1.831 | 0.077 |
| B(a)A | 0.023 | 0.008 | 0.017 | 0.018 | 0.070 | 0.028 |
| Chr | 0.120 | 0.018 | 0.146 | 0.066 | 0.206 | 0.088 |
| B(b)F | 0.041 | 0.045 | 0.019 | 0.220 | 0.029 | 0.380 |
| B(k)F | 0.022 | 0.030 | 0.010 | 0.122 | 0.012 | 0.144 |
| B(a)P | 0.021 | 0.016 | 0.006 | 0.102 | 0.000 | 0.130 |
| I(1,2,3-cd)P | 0.021 | 0.046 | 0.005 | 0.240 | 0.000 | 0.365 |
| D(ah)A | 0.000 | 0.002 | 0.000 | 0.013 | 0.000 | 0.024 |
| B(ghi)P | 0.035 | 0.066 | 0.009 | 0.320 | 0.000 | 0.500 |
| Total | 5.700 | 0.336 | 45.909 | 1.547 | 8.849 | 1.853 |

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Estimated distribution of polycyclic aromatic hydrocarbons between gaseous and particulate phase in the ambient air of Pancevo is shown in Figures 1 – 3.

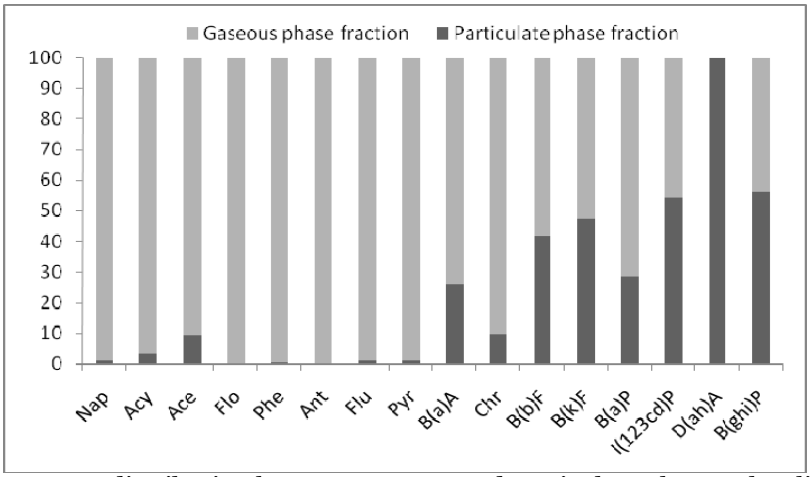



Figure 1. PAH distribution between gaseous and particulate phase at locality P1

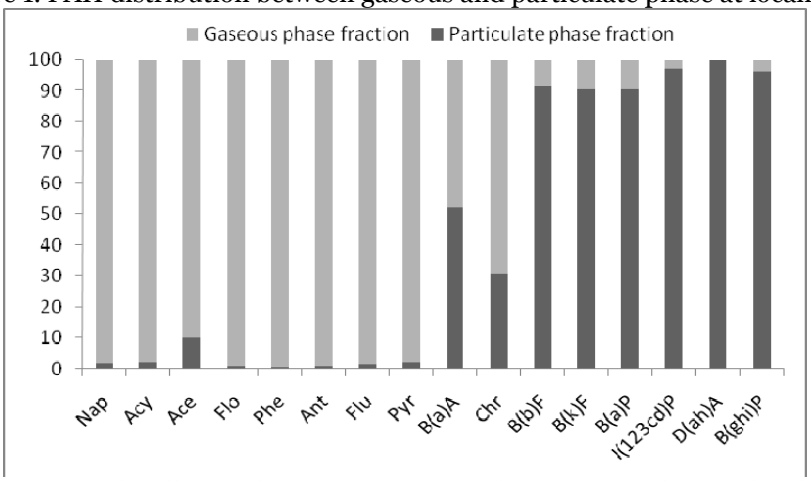



Figure 2. PAH distribution between gaseous and particulate phase at locality P2

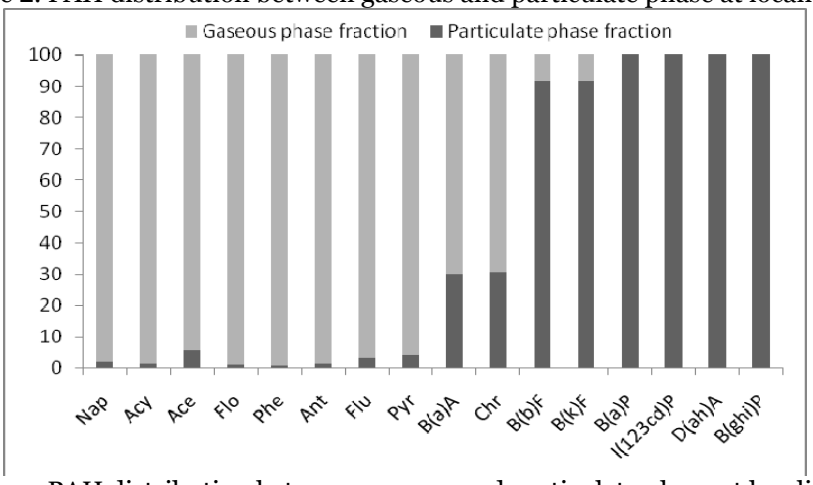



Figure 3. PAH distribution between gaseous and particulate phase at locality P3

In the city of Novi Sad, the highest total concetraton level of examined PAHs was detected on the locality P2 (Petrochemical complex Pancevo) and equals ΣPAH=47.456 ng/m$^3$. Total concentration of PAHs at the localities P1 (oil refinery) and P3 (city center) are ΣPAH=26.036 ng/m$^3$ and ΣPAH=10.747 ng/m$^3$, respectively.

In national legislation, maximum allowed concentration of examined group of persistent organic pollutants has not been defined, therefore comparison with legallly adopted values was not possible. Threshold value of ambient air quality for benzo(a)pyrene for 24-hour sample, 0.1 ng/m$^3$, has been

exceeded at the localities P2 and P3, with value 0.108 ng/m$^3$ for locality P2 and 0.130 ng/m$^3$ for locality P3.

Obtained experimental results point out on almost complete particle sorption of pollutants B(b)F, B(k)F, B(a)P, I(1,2,3-cd)P, D(ah)A i B(ghi)P, with exception of sampling site P1 (Oil Refinery Pancevo), where foregoing PAHs fractions, beside D(ah)A, are about 50%. Specific distribution of polycyclic aromatic hydrocarbons at oil refinery, does not manifest, apriory, low concentration of total suspended particles in the atmosphere. Increased concentration levels of PAHs in gasous phase or sorbed at ultrafine particles which can not be collected at glass fibre filters, issued from refinery, are probably responsible for atmospheric distribution of PAHs at site P1.

## 4. CONCLUSIONS

Results of analysis point out on the presence of residual quantities of PAHs in air samples from three localities in the town of Pančevo.

The highest concentrations of examined polycyclic aromatic hydrocarbons was detected at the petrochemical complex (47.456 ng/m$^3$).

Regulation defines limit value of ambient air quality only for benzo(a)pyrene (0,1 ng/m$^3$ for 24-hour sample). Limit value was exceeded at two selected localities in Pančevo – petrochemical complex (0.108 ng/m$^3$) and city center (0.130 ng/m$^3$).

Direct influence of atmospheric distribution on wet and dry deposition processes, long-range transport, as well as potential reactions of degradation of PAHs in the atmosphere, points out on an extreme importance of examination and determination of concentration levels and partition of pollutants in the atmosphere.

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# ADVANTAGE OF THE SUBSTITUTION ETHYLMERCAPTAN, COMPOUND FOR ODORIZATION NATURAL GAS, WITH TETRAHYDROTHIOPHEN

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**Abstract:**
This paper presents the advantage of substitution ethylmercaptan, compound for odorization natural gas, with other compound for odorization, tetrahydrothiophen. The physical - chemical properties of both compounds, ecological - toxic characteristics, odorization properties and evaluation of annual consumption odorization compounds in Serbia are discussed. The comparative analysis of these two odorization compounds from the aspect of chemical stability in the system of gas installations and economic acceptability have been described.

**Keywords:**
Ethylmercaptan, tetrahydrothiophen, odorization, substitution

## 1. INTRODUCTION

Natural gas, in particular, which is distributed for consumer goods, must be odorized up to level of one fifth of the lower flammable limit for security and health safety reasons.

Odorization compound with their physical - chemical properties should ensure first of all recognizable strong smell from a small portion of evaporation, or in a low concentration level to be detected leakage of gas and prevent unwanted consequences.

In Serbia as odorant, almost exclusively, used ethylmercaptan characterized with the best ability odorization, are no longer used in most European countries.

One of the main reasons for the termination of the use of ethylmercaptan as odorant its chemical instability (in the reaction with air and iron-oxide), which causes loss of smell intensity, as well as changes characteristic strong unpleasant smell.

Most frequently used compound for odorization natural gas is tetrahydrothiophen which has recognized intensive smell. It is the most stable of all gas odorants. Tetrahydrothiophen not react with iron oxides and bases and it does not change, nor the intensity or character of smell, for the most causes of loss of smell.

Unlike ethylmercaptan, which is extremely toxic to flora and fauna biosystem and the environment, tetrahydrothiophen belongs to the middle toxic group pollutant and there is no label danger for the environment according to the German classification for surface water pollutants. [4]

## 2. ETHYLMERCAPTAN (EM)

**Physical - chemical characteristics:**

- Chemical formula: $C_2H_6S$
- Appearance and the smell: colourless liquid – reminiscent of the smell of garlic
- Melting point: -148 °C
- Boiling point: 35 °C
- Density (g $cm^{-3}$): 0.839
- Flash point: -45 °C
- Explosion limits: 2.8 - 18.2 %
- Water solubility: slight

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**Other properties of ethylmercaptan:**

- In normal circumstances, a stable, but extremely flammable liquid;
- Incompatible materials: oxidans (can lead to flammable), strong acid (reaction can be violent), calcium chloride (react violently), corrosive effect on metals, reacts violently with alkaline metals;
- Classification, belongs to the 3rd group of toxins and is extremely toxic to flora and fauna and surface water;
- UN number 2363;
- Additional tag 336; [5]

**Ethylmercaptan as natural gas odorant**

Ethylmercaptan has a very strong and unpleasant smell reminiscent of the smell of garlic. Threshold of low sensitivity of smell defined EM, based on its odorization capacity, as the best odorization compound for the natural gas. However, the big problem is nonstability of ethylmercaptan because it easily reacts with oxides and bases giving disulfide, and in that case loosing smell properties.

In addition, irreversible adsorption of ethylmercaptan on the walls of steel and polyethylene gas pipes increases ethylmercaptan consumption.

Low flammablity and extreme toxicity, associate with environmental and contamination aspect are the problems, because increase the cost of transport and storage. For these reasons ethylmercaptan as odorant need to replace with other substances with a higher chemical stability and less or slightly toxicity for the environment. [4]

**Assessment of consumption ethylmercaptan in Serbia**

According to company for natural gas odorization "OD – JU" from Ruma, the total amount of odorized gas in 2007. year was about 517,500,000 $Sm^3$. Total consumption of ethylmercaptan was about 6700kg, with the average achieved concentration about 12.95 mg/$Sm^3$ of natural gas. [3]

## 3. TETRAHYDROTHIOPHEN (THT)

**Physical - chemical characteristics:**

- Chemical formula: $C_4H_8S$
- Physical state and appearance: Liquid.
- Odor: strong unpleasant
- Molecular Weight: 120.11 g/mole
- Color: Clear Colorless.
- Boiling Point: 284.5°C
- Melting Point: 27.4°C
- Density: 1.26 (Water = 1)

**Information about toxicity:**

- Acute oral LD50 (in rats) 2450mg/kg
- Acute inhalation LC50 (in mice) 27g/$Sm^3$ (2 hours)

**Environmental information:**

Information about toxicity for aquatic organisms: No data available

Toxicity to Animals:

Acute oral toxicity (LD50): 1900 mg/kg [Mouse].

Acute dermal toxicity (LD50): >3800 mg/kg [Rat].

**Tetrahydrothiophen as natural gas odorant**

Tetrahydrothiophen has recognizable characteristic strong smell that is different from other spices impurities that may appear in the natural gas. THT shows very small deviations from own specific fragrance and is very difficult to overdose.

Tetrahydrothiophen is the most stable of all gas odorants, as a result of heterocyclic chemical structure, what is unusual for other common odorants. Tetrahydrothiophen not react with iron oxides and bases, and is imperceptible to most of the causes of pad smell.

Adsorption of tetrahydrothiophen on the walls of the new pipe is almost completely reversible so that the amount of THT is a reserve of odorant. In the case of changes in the dosage THT, dynamic equilibrium adsorption and desorption are disturbing and THT is desorbed from the wall of pipes back into the gas.

THT is in the middle group of pollutants according to the German classification of pollutants surface water (W6K2) and not wearing the label of danger for the environment, which makes it easier for packaging, storage and transport. [1, 4]

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## 4. COMPARATIVE ANALYSIS OF ETHYLMERCAPTAN AND TETRAHYDROTHIOPHEN AS ODORANTS

**Stability**

The difference in stability ethylmercaptan and tetrahydrothiophen in the presence of corrosion on the walls of pipes is a significant benefit for the THT, which could be displayed in the chart (Figure 1).

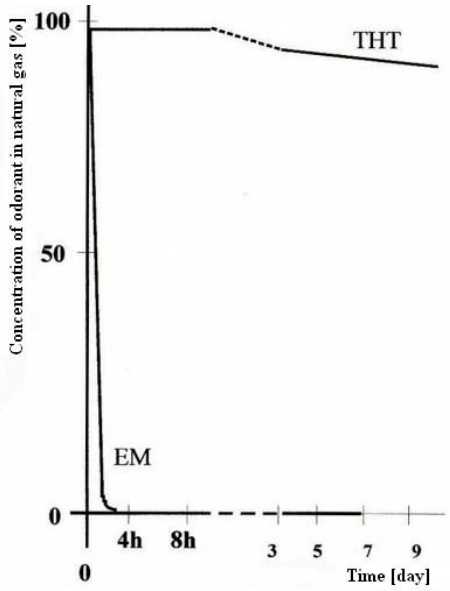



Figure 1. Graphic display depending on the concentration of odorant in function of time, in the natural gas in the presence of corrosion [4]

From the diagram it could be seen that the concentration of THT in the gas begins to decline significantly after the third day, while the concentration of EM decline in the "0" for about 2 hours. This means that the EM is totaly spent in the chemical reaction of oxidation, loosing completely smell in a very short time. [4]

**Economic effects**

Comparative analysis of the costs of the odorization with EM and THT in the following text is calculated for concentrations of odorant in the natural gas of 12.95 mg/Sm$^3$ for odorization 517.500.000Sm$^3$/yr, the average distance from odorants storage is about 80km.

**Odorant ethylmercaptan**

Total amount of required odorant is 517.500.000 Sm$^3$/yr • 0.00001295 kg/Sm$^3$ = 6700 kg/yr.
Price of charging for EM is 16.10 €/kg, (or 0.000241 €/Sm$^3$).
The annual price for EM is 16.10 €/kg • 6700 kg/god = 107,850 €/yr.

**Odorant tetrahydrothiophen**

Total amount of required odorant is 517.500.000 Sm$^3$/yr • 0.00001295 kg/Sm$^3$ = 6700 kg/yr.
Price of charging for THT is 31.02 €/kg, (or 0.000465 €/Sm$^3$).
The annual price for THT is 31.02 €/kg • 6700 kg/god = 207,850 €/yr. [3]

## 5. CONCLUSION

Replacement and substitution of ethylmercaptan by THT as the odorant for natural gas, is obviously required for the following reasons:

- For the protection of the environment bearing in mind its outstanding cumulative and biocumulativ toxic effect for flora, fauna, biosystem and environmental in general;
- Ethylmercaptan has unstable smell properties especially in the presence of oxide and base. This is particularly expressed in equipment and installations with compressed natural gas (LPG) for the cars;
- In Europe are generaly not used ethylmercaptan for odorization natural gas.
- The harmonization between national and international (EU) laws of regulations in the field of natural gas odorization with the EU.

According to real estimation, of the replacement procedure ethylmercaptan by tetrahydrothiophen can be completed in the next 3 to 4 years. [3, 4]

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# QUANTITY AND RECYCLABILITY OF Fe - METALS AT THE END-OF-LIFE VEHICLES IN REPUBLIC OF SERBIA

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**Abstract:**
The growth of the world's population has determined the need for faster, simpler and easier communication. Due to such communication, along with modern social - economic and industrial development, the number of vehicles has largely increased. At the end of life, vehicles represent a potential threat to the environment. This paper gives a statistical view of the number of registered vehicles by brands in Serbia. The amount of Fe – metals by vehicle dismantling, and the possibility of their recycling is shown. It was pointed out the necessity of harmonization of our laws which regulates this area with the laws of the EU, as well as the need for implementation of appropriate ISO standard in the Republic of Serbia.

**Key Words:**
Statistic data, ISO standard, Fe-metals, recyclability

## 1. INTRODUCTION

In order to minimize the impact of vehicles disposal on the environment, the End-of-Life Vehicles Directive (2000/53/EC) aims to promote the collection, reuse and recycling of their components. Generally speaking, there are few problems if the vehicles are disposed and not recycled, like occupying the landfill space, potential leakages of fuel and motor oil into water recipient and soil, emissions of volatile compounds, and possible fires. Some of the components are classified as harmful or either hazardous to the environment. Those problems are still present in recycling operation, if the dismantling operations are not handled by regulations, and this means that all fluids (oil, fuel, windshield washer fluid, anti-freeze, brake liquids, etc), batteries, and other nonmetal parts should be extracted.

In Serbia, the recycling business is present but the most of them are recycling just one sort of material or car parts. For now, the new products are being exported and some of these parts, like batteries, are reused. Fuels are being sent to oil refinery, tires are used in cement industry in combustion processes, but shredder dust, textiles, car seats, glass and some other parts are being landfilled. [2]

## 2. THE STATISTICS OF REGISTERED CARS IN SERBIA

According to data from project "Razvoj integrisanog i održivog sistema reciklaže motornih vozila na kraju životnog ciklusa u Srbiji", in Serbia are 1.534.658 registered passanger vehicles in 2008. [3]

In Serbia, almost one third of total population owns „Zastava" (31%), followed by „Opel" (18%), „Volkswagen" (16%), „Lada", „Fiat" and „Reno" (7%). [3]

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## 3. AMOUNTS OF FE-METALS AND RECYCLING POTENTIONAL BY VEHICLE DISMANTLING

The car is a product of high complexity for whose benefit in the production is used more than hundred different technologies and that are built around 15 000 parts. Car parts are produced from different materials. The total weight of the current passenger car is represented by iron and steel.

The European Union Directive said that the acquisition of vehicles at the end of the life cycle of vehicles and parts should be organized by the state. It is necessary to provide storage and the space to be made by the treatment of spent vehicles and their components.

International Standard ISO 22628 in 2002 very clearly define the issue of recycling of passenger vehicles, which is not the case in Serbia where there is no standard for this. ISO 22628 also defines and recyclability rate (percentage by mass of the new vehicle potentially able to be recycled, reused or both), and recoverability rate (percentage by mass of the new vehicle potentially able to be recovered, reused or both), as shown in the figure 2. [2, 4]

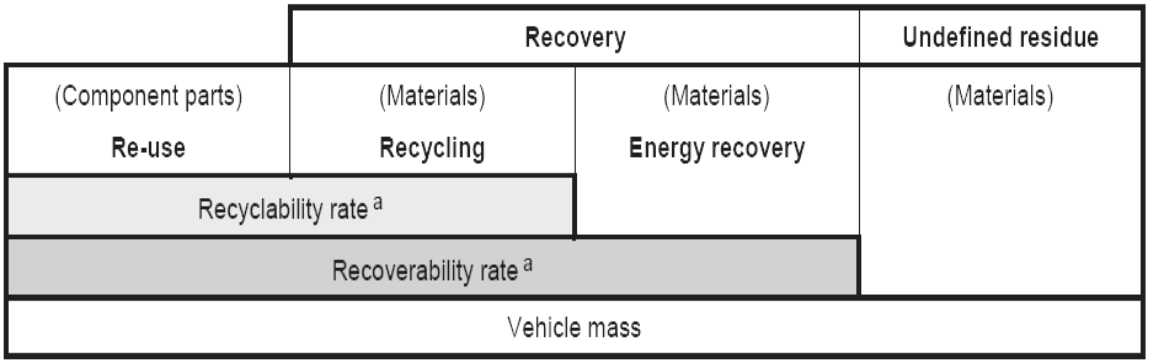



Figure 2. Material distribution of the total mass of vehicles for the further treatment [4]

Almost a third of passenger cars in Serbia are the brand "Zastava" (which is about 511.553 vehicles), which presents models "Koral", "Skala" and "Florida" by one-third (approximately 170.517 vehicles). [1, 3]

Potential for recycling Fe-metals from vehicles "Zastava" is calculated by the following formula:

Number of vehicles from particular model "Zastava" × vehicle weight
× percentage of Fe-metals in vehicle × rate of recyclability

Table 1. Recyclability potential of Fe-metals in "Zastava" vehicles [1]

| Model of Zastava car (Fiat Auto) | Number of vehicles | Vehicle weight [kg] | Percentage of Fe-metals [%] | Rate of recyclability [%] | Fe-Metals recyclability potential [kg] |
|---|---|---|---|---|---|
| Koral | 170.517 | 807 | 73.6 | 62.0 | 62.792.926 |
| Skala | 170.517 | 835 | 75.0 | 62.0 | 66.207.488 |
| Florida | 170.517 | 950 | 73.6 | 62.0 | 73.919.801 |
| | | | | Total | 202.920.215 |

**Zastava Koral**
Vehicle weight: 807 kg

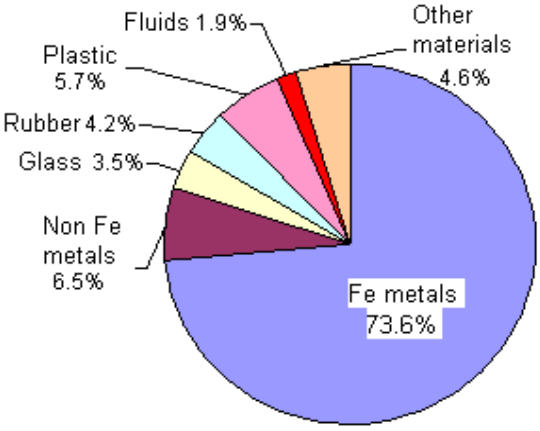



Figure 2. Participation of different types of material in the Zastava Koral [1]

**Zastava Skala**
Vehicle weight: 835 kg

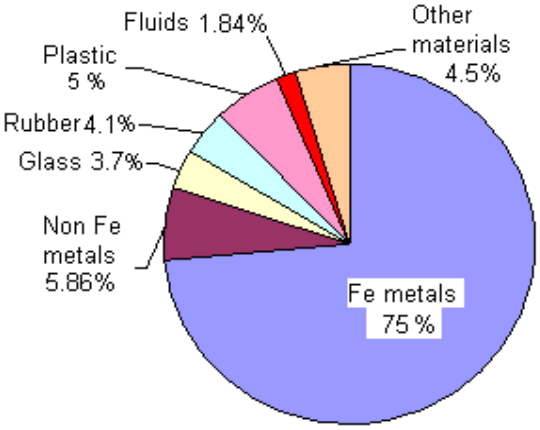



Figure 3. Participation of different types of material in the Zastava Skala [1]

**Zastava Florida**
Vehicle weight: 950 kg

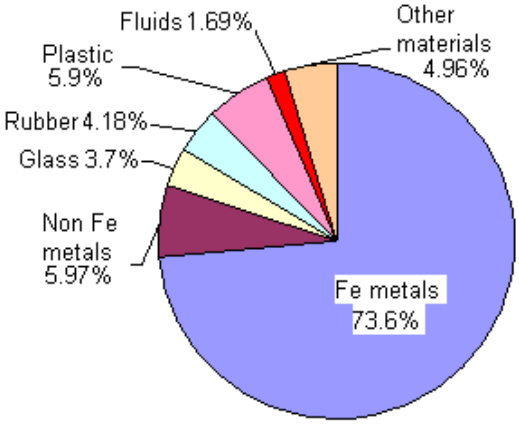



Figure 4. Participation of different types of material in the Zastava Florida [1]

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## 4. CONCLUSION

In this analysis is shown the potential for recycling Fe-metals only from vehicles brand "Zastava", which makes one third of the total number of registered passenger cars in Serbia (according to data for 2008. yr.). The remaining two thirds are foreign vehicle manufacturers with much greater potential for recycling, because they are more massive and have higher rate of recyclability. Serbia has significant capacity for processing Fe-metals, so vehicles for recycling are an important resource.

For accession Serbia to EU, it is necessary to enact a law that regulates this area, and harmonize it with EU legislation. [1, 3]

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# SLAG – UTILISATION IN ROAD CONSTRUCTION – EXPERIENCE AND SOLUTIONS

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**Keywords:**
Steel slag, waste recycling, by-product, road construction

## 1. INTRODUCTION

As the world population grows, so do the amount and type of waste being generated. Many of the wastes produced today will remain in the environment for hundreds, perhaps thousands, of years. The creation of nondecaying waste materials, combined with a growing consumer population, has resulted in a waste disposal crisis. One solution to this crisis lies in recycling waste into useful products. One answer to all of these problems lies in the ability of society to develop beneficial uses for these waste products.
The road-highway construction industry can effectively use large quantities of diverse materials. The use of waste by-products in lieu of virgin materials for instance, would relieve some of the burden associated with disposal and may provide an inexpensive and advantageous construction product. Current research on the beneficial use of waste byproducts as road-highway construction materials has identified several promising uses for these materials. Some of these materials include: Blast furnace and steel slags.

## 2. STEEL SLAG IN EUROPE

In Europe are produced annually around 15 Mil tones of steel slag, resulting from different type of steel technology (Figure 1),

More than 75 % of steel slag was recycled in Europe (Figure 2.) in different kind of utilization in especial like raw materials.

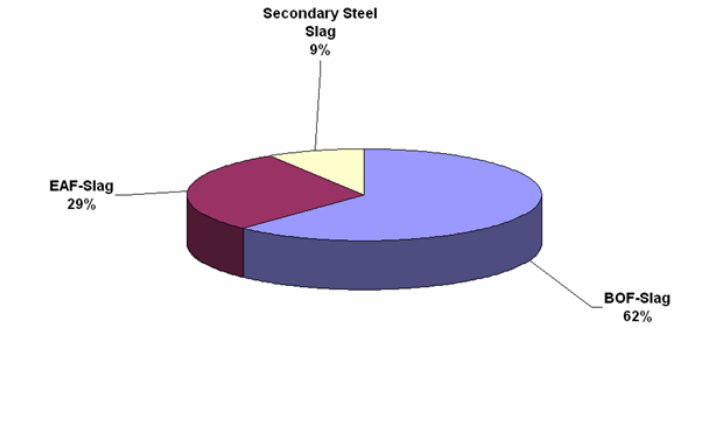



Figure 1. Type of steel slag

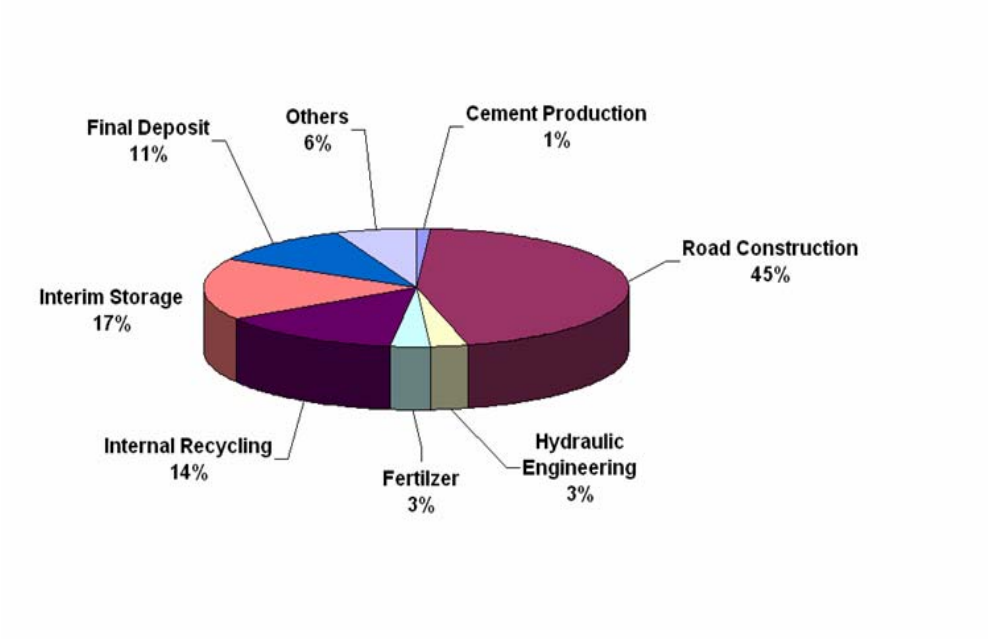



Figure 2. Slag utilization in Europe

2.1. European waste framework Directive

Present situation in the steel industry on material management give as an overview on the legal situation regarding the dealings with by-products such as slag and secondary raw materials on the basis of the European waste framework directive. Further on it describe the existing frameworks nebulous differentiation between waste and non waste (by products, when ceases waste to be waste) that lead to a flood of court procedures and to a discrimination of by-products and products made of recycled materials. Metallurgical slag is given as an example for a purposeful produced by-product in the steel industry which replaced primary raw materials and thus saving resources. Typical product criteria are described. Finally the proposal on the revision of the waste framework directive of the European Commission and those presently discussed in Parliament and Council is evaluated regarding the necessary clarification

- when a substance is excluded from the waste legislation as (by-)product, or
- when it creases to be secondary row material

A discrimination of by-products and products made of recycling material compared to products made of virgin material is not acceptable and contrary to the aim of sustainable management. On the contrary the usage of by-products and secondary row-materials must have priority.

European Waste Catalogue does only name unprocessed slag as a waste, European Waste Shipment Regulation (NO 259/93) - GREEN LIST, GC 070 exclude processed slag from the waste list:

"Slags arising from the manufacture of iron and steel (including low alloy steel) excluding those slags which have been specifically produced to meet both national and relevant international requirements and standards."

Green list substances shall be generally excluded from control procedures of the regulation since such waste should normally not present a risk to environment.

Principles of European Waste management say that steel slag has to be recycled (Figure 3.).




Figure 3. Waste management hierarchy

## 3. DESCRIPTION OF THE EXPERIMENTAL SETUP

3.1. Steel slag treatment process

| Steel slag type | Treatment | |
|---|---|---|
| Hot slag from EAF | Cooling by water spraying | Quick cooling is important for technical and environmental properties (Figure 4) |
| Raw slag with steel | Iron separation | Steel recovery pays for the slag treatment (Figure 5) |
| Raw slag | Crushing and screening | Crushing and screening gives different products (Figure 5) |
| Slag products | Road aggregates rip rap chippings | Products differ only in grain size distribution (Figure 6.) |

Table 1. Main slag processing

Main slag processing is mechanical treatment of cold slag, the principle of slag processing are in Table 1.



Figure 4. Cooling area with water spraying



Figure 5. Instalation of slag treatment SPS Hunedoara



50-150 mm 2-5 mm

Figure 6. Slag products

3.2. Steel slag in Road construction

CLOOS Luxemburg had more than 100 years experience in utilization of slag in road construction, an examples of road layers (Figure 6.)

Slag crushing aggregates can be used in all layers of the road, in Romania; SPS homologated the shape, foundation, basic and binder layers and are in course of homologation the utilization of slag in asphalt layer. Here will be used cold slag treatment procedure for obtain good results.

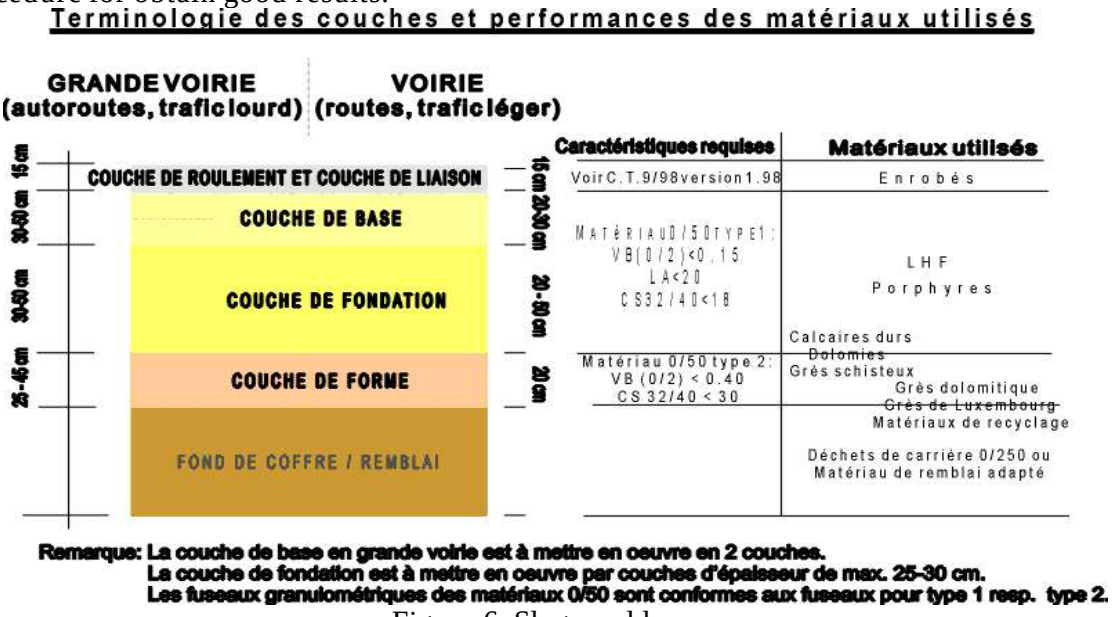



Figure 6. Slag road layers

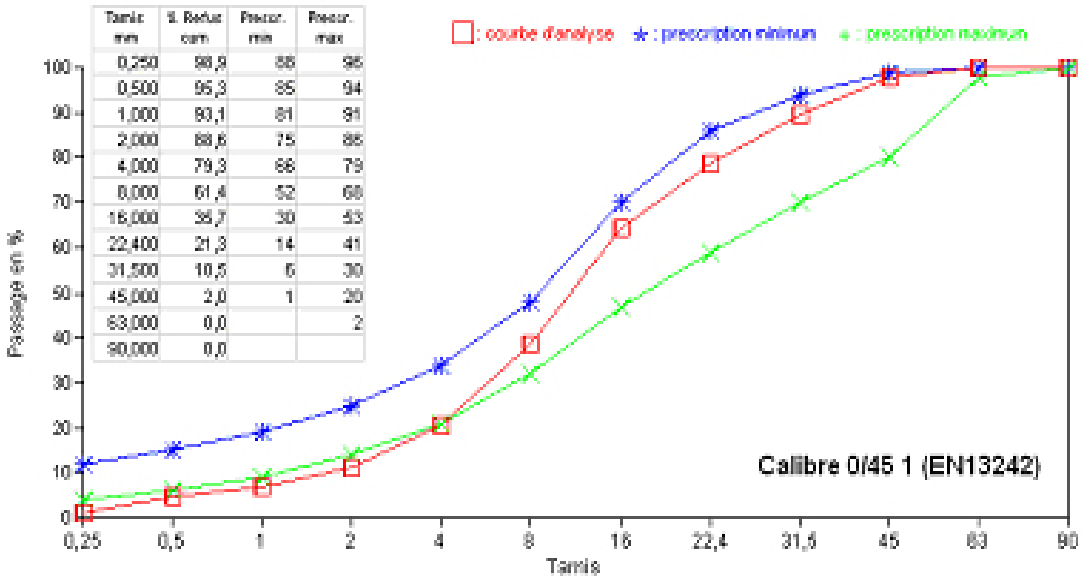



Figure 7. Slag aggregate 0/45

In Figure 7. we can see red line, property of slag product 0-45; and minimum and maximum requirement of EN 13242,

Example of slag utilization in road construction in Hinedoara is the 4 bands road between Deva and Hunedoara (Figure 8), where the basic, foundation and binder was made from slag aggregates from Buituri Slag Dump, processing by SPS. Unfortunately the Romanian road designers and constructors don't understand yet to use this waste; by-products existing in Hunedoara in Slag Dump in quantity of 70 Mill. Tones.

SPS continue the researches regarding slag utilization in road construction with University "Politehnica" Timisoara – Road Construction Department, now in researches of Slag roads comportment in different charges starting with County roads, Villages roads, technological roads, and sure Highway.



Figure 8. Slag road construction; Hunedoara - Deva

## 4. ANALYSIS OF RESULTS AND CONCLUSIONS

### 4.1. Product Certification and Quality Control

Steel slag has to undergo a quality control process like any other process (Table 2.), steel slag is an artificial stone, with the request property for road construction, and other utilizations: concrete production, fertilization, hydraulic construction, building foundation, etc.

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| No. | INDICATORS | VALUE |
|---|---|---|
| 1 | Bulk density according to DIN 52110 | Average value: 2,06 g/cm3 for grain size mixture 0/32 and 0/45 |
| 2 | Proctor density according to DIN 18127 | Average value: 2,47 g/cm3 for grain size mixture 0/32 and 0/45 |
| 3 | Fines | In grain size range 0,0 – 0,063 mm from 0,2 to 0,4 weight.-%. |
| 4 | Destruction by beating SZ 8/12 | Desired value 18,0 weight-% for chippings |
| 5 | Destruction by beating SD 10 | Desired value 26,0 weight-% |
| 6 | Polished stone value (PSV) | PSV 60, chippings for asphalt |
| 7 | Frost resistance | Limit value 3,0 weight.-% |
| 8 | Volume stability | Limit value 5,0 vol.-% |
| 9 | Inner angle of incline | Average value 40 ° |

Table 2. List of technical test

Slag Processing Service SA Hunedoara (CLOOS Luxemburg is main shareholders with 80% of shares), start the work in ArcelorMittal Hunedoara Slag Dump, with chemical and physical tests of the slag, make in Luxemburg (80 tones of samples taken from different places from slag dump was send with tracks). After this was start the treatments of old slag: crushing and screening, iron separation, aggregates rip rap chippings, with 500.000 tones/year capacity Installation.


QCERT Quality

CE - CERTIFICAT DE CONFORMITATE

Sistem de atestare a conformității 2+
NB 1870-DPC-98/598/EC-0484-07

AGREGATE CONCASATE DIN ZGURĂ DE FURNAL

S.C. SLAG PROCESING SERVICE S.A. București
Str. General Berthelot, Nr. 84, Ap. 3, Sector 1
Tel.:021/410.39.42, Fax: 021/323.53.73

Halda de zgura Buituri
Jud. Hunedoara

EN 12620/2002
EN 13242:2002/AC:2004

PRESEDINTE QUALITY CERT
Ing. BURTEA IOAN

PRESEDINTE CONSILIU DE CERTIFICARE
Ing. STAN GHEORGHE

Figure 9. Conformity Certificate

Conformity Certificate for slag aggregates utilization in Romania (Figure 5.), was obtain by SPS in 2006, was certificate that the products "Crashing Aggregates from Steel Slag" 0-4; 4-8; 8-16; 16-31,5; 31,5-63; si 0-63, produces by SPS in Slag Dump Buituri Hunedoara, are in accordance with: EN 12620/2002, EN 13242: 2002/AC:2004, Utilization domain: construction of: roads, civil and industrial buildings, hydraulic and earth construction.

4.2. Comparatives cost of slag roads and virgin materials roads

We analyze comparatives structure of road layers; classic and two alternatives for basic and foundation layers, (Figure10.) mentioned that wear layer in all three situations remain the same asphalt mixture and the existing shape also.

| Thickness | Layer – **CLASSIC** |
|---|---|
| 5 mm | **Wear - asphalt mixture** |
| 20 mm | **Basic - natural crash stone** |
| 30 mm | **Foundation -Ballast 0-63 mm** |
| X mm | **Shape - existing** |

| Thickness | Layer- **Alternative 1** | Layer- **Alternative 2** |
|---|---|---|
| 4 mm | **Wear - asphalt mixture** | **Wear - asphalt mixture** |
| 15 mm | **Basic - slag 0-63 mm** | **Slag - optimal mixture stabilizated with: 0.5 ciment and 8% water** |
| 20 mm | **Foundation -Slag 0-150** | |
| X mm | **Shape - existing** | **Shape - existing** |

Figure 10. Comparative layers classic-slag roads

The comparative costs in "LEI" of all three variants (Figure 11.):

1. Classic system road (virgin materials)
2. Alternative 1 road system with slag
3. Alternative 2 road system with slag and cement

Sow as that the partial slag roads analyze are with 24% chipper that classic roads. If the road will be executed integrally by slag products like in Luxemburg, Germany, France, etc. the cost reduction is around 40%.

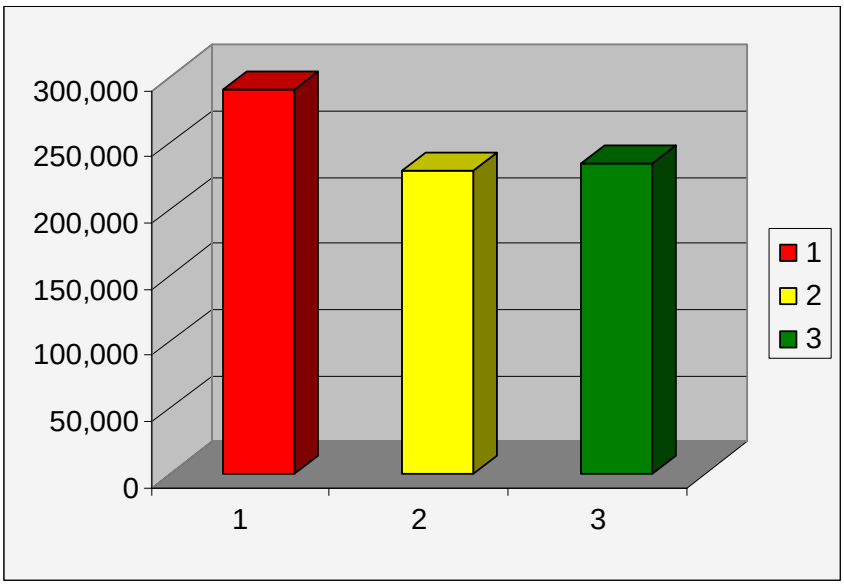



Figure 11. Comparatives cost of the roads

Conclusions: We can construct with the same amount 140% more roads.

This is not the single reason for using slag, the durability, stability of the roads is better and not the last we save virgin materials, recycling the slag and ensuring the slag dump disappear.

Use of steel slag is absolutely necessary in Europe to reduce costs and to comply with environmental laws

- Slag use in Europe has a long tradition.
- European law asks for recycling of steel slag.
- European legislation makes it sometimes difficult to bring slag products to the market.
- Process technology is known and proven.
- Slag products can be certified and have to undergo a quality control procedure.

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# ENERGY STORAGE IN SOLAR COLLECTOR SYSTEMS WITH PCM SOLAR TANK

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**ABSTRACT**

The one of the most important parts of a solar collector system is the solar tank. The correct type and capacity of the solar tank is a requirement of the good operation of the system.
It is necessary to apply a solar tank because the period of the sunshine does not coincide with the time of the hot water consumption generally.
According the current architectural tendecies the boiler rooms are smaller, so the putting of the currently available solar tanks are very difficult. It is necessary to solve the energy storage in a little space. The solution of the problem is the solar tank particularly filled with phase change material. This tank has smaller dimensions and bigger heat capacity than the conventional tanks.
We have made several conception plans to analyze and compare the advantages and disadvantages.

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# CONTRIBUTION TO REDUCE DEFECTS IN PRODUCTION OF PLAIN BEARINGS

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**Abstract:**

DAIDO METAL KOTOR AD (DMK) is a Japanese company dealing with production of plain bearings for vehicle engines. There are four highly productive automatized machining lines in DMK for bearings production. During production, some measures can deviate from the required ones. For this purpose, I have made a resolving concept, designed, had it made and tested a device-machine for checking bearings production and reached excellent results. The device is installed on the line consisting of: machine construction, electro-pneumatics, optical sensors, other sensors, PLC operation. After treatment, the bearing comes into device, it is checked, and if defected, it is rejected, the line is stopped and the operator searches the cause. This ensures quality of production, eliminates defected bearings, reduces costs, making customers more satisfied. Some of many high rating customers are: Honda, Volvo, Mercedes,..

Keywords:
Plain bearing, sensors, electro-pneumatics, PLC operating

## 1. INTRODUCTION

DAIDO METAL KOTOR AD (DMK) located in Kotor, Montenegro is one of the affiliated companies of DAIDO METAL Ltd. Co, which is the head company located in Nagoya – Japan, dealing with the production of plain bearings for vehicles engines. There are four automatized highly productive machining lines and two lines of presses in DMK, for OEM (Orginal Engine Manufacturing) mass production of plain (slide) bearings.

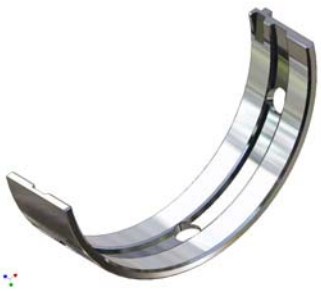


Figure 1 Typical example of plain bearing

DMK supplies top world companies with its products, such as: Volvo, Honda, Mercedes, Ford, etc. Figure 1 shows typical example of plain bearing. Products, that are made for the famous customers on the machining lines herein noted, are connrod and main bearings.

This production, as much as any other, is followed by appearance of defected products, which has to be identified, located, controlled, reduced or, if possible, to be completely eliminated.

## 2. DEVELOPMENT OF DEVICE FOR CHECKING PLAIN BEARINGS

Plain bearing, as a mechanical element, appears simple, on the first sight. However, this is a very important, precise product for vehicles engines, which has specific characteristics of materials made of. Figure 2 shows location of plain elements-bearings.

Materials used for making plain bearings for vehicles engines of bimetal strip, are mostly alloys of aluminium, bronze and tin. Figure 3 shows bimetal strip- material for production of plain bearings.

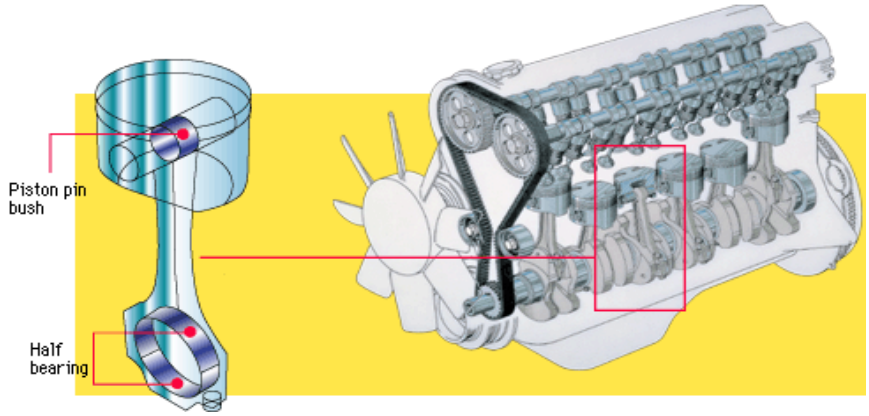



Figure 2. Plain elements as parts of vehicles engines




Figure 3 Bimetal strip

Elements characteristic for plain bearings are: wall thickness, height of half bearing, including its height crush, nick, oil groove, lubrication holes, free spread, relief, etc.

Technology of manufacturing plain bearings from bimetal strip involves the operations on the pressing machines and the machining lines.

There are four operations carried out on the pressing machines: stamping the blanks, cutting the blanks off the bimetal strip which is coiled, then operations of bending and forming.

There are 11 operations carried out on the machining lines: face and chamfering, corner chamfering, piercing the lubrication holes, nick milling, nicking, grooving, counter sinking, back side brushing, height crush finishing, auto checking and wall thickness finishing.

On the operations carried out on the lines of presses and the machining lines, from different reasons there comes to production of defected bearings. A list defining the causes of defected (rejected) bearings was made, according to the records and analysis of defected bearings.

The reject causes are: indents on back steel, set - up pieces, thickness, length, height crush, corrosion of back steel, indents on inner surface, mechanical damages of back steel on bm – strip, roundness, inside chamfering, position of nick, damage of inner surface, position of lubrication holes, position of oil grooves, outside chamfering, countersinking, free spread, bad blue contact, twisting, bad nick shape, bad stamp, etc.

Control of some elements (dimensions) of each bearing is carried out during the machining process. Former control refers to the elements of bearings that are checked on Autochecker machine: height, nick protrudence (if the bearing has nick, according to drawing), detection of lubrication holes, but not the position (if the bearing has any, according to drawing), and wall thickness which is controlled on the boring machine.

According to the analysis of plain bearings, proposals for improving production process and reducing reject, aiming to cut down expenses, upgrade satisfaction of customers and employees, in conformity with ISO standards, the Device for checking plain elements which is installed into the machining line Y-01 has been developed.

According to my conception and project, the Device for checking plain bearings working *in-line* and controlling certain elements of each bearing being machined on the line Y-01, has been developed within the company DAIDO METAL KOTOR AD.

The elements that have to be checked are the following: length of plain bearings (Figure 4a), position of lubrication holes in respect to the angle and length of bearings (Figure 4a) and free spread of plain bearings (Figure 4b).

The elements noted have not been so far controlled on every bearing made, having as a consequence considerable amount of rejected-bad bearings. Figure 4 shows the elements of plain bearings which have to be controlled.

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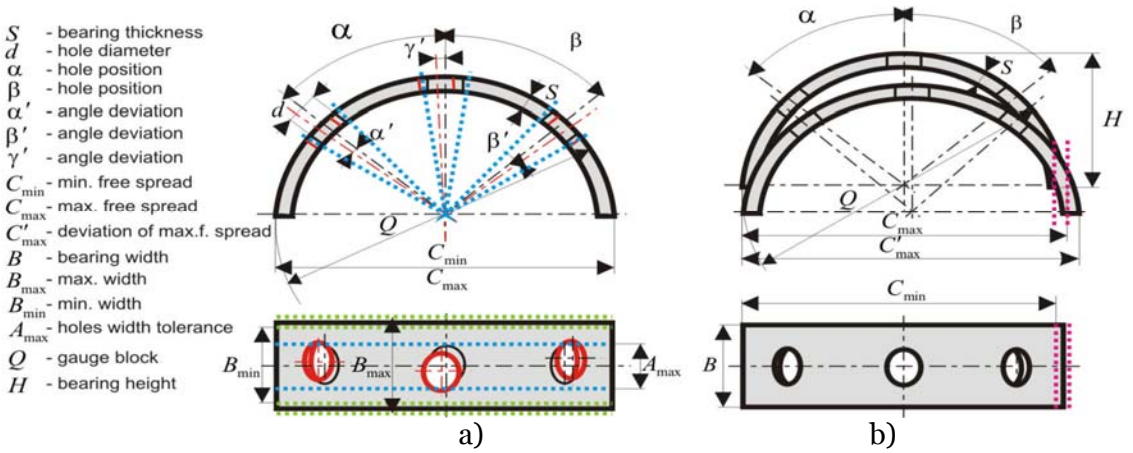



Figure 4 Elements of plain bearing which is checked

Deviation of position of lubrication holes, length and free spread of bearings from the dimensions required by the drawing, can be caused by the following: bad set up of machines and tools, mishap of tool, change delay, etc.

Projected and made device (Figure 7) for checking three elements of plain bearings (holes, width and free spread), will be installed on the most suitable location in the line Y-01 and it will be working in-line. When projecting, the following parameters were used: velocity (cycle) of Y-01 operation, 1.8 sec. , diameter of bearing which can be reached on the line, and which is 30-80 mm, length of bearing which is to be checked, 13-30 mm, number of holes for checking, 0-3, positiong is after Autochecker machine.

**Construction**

Construction is made of steel costisting of: control assembly (Figure 7), conveyor belt, support and stand, energetic-driving box, operating-commanding box, pneumatics and electropneumatics, and technique of sensors.



Figure 5 Device for checking plain bearings

**Driving**

Driving is microcontrolling-PLC MITSUBISHI Fxon-60MR , shown in Figure 6.

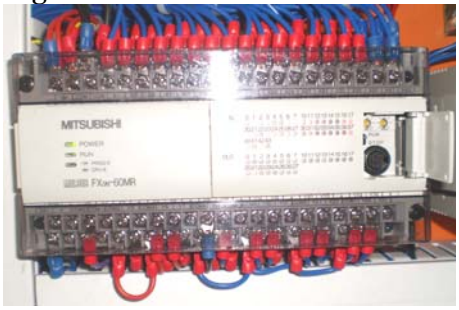



Figure 6. PLC of device for checking plain bearings

**Description of operation**

Before activating the Device for checking bearings to automatic operation, the option for checking plain bearings, ie., bearing with a hole, number of holes, is chosen by switches. Of course, before starting automatic operation, the Device for checking bearings is set up manually.

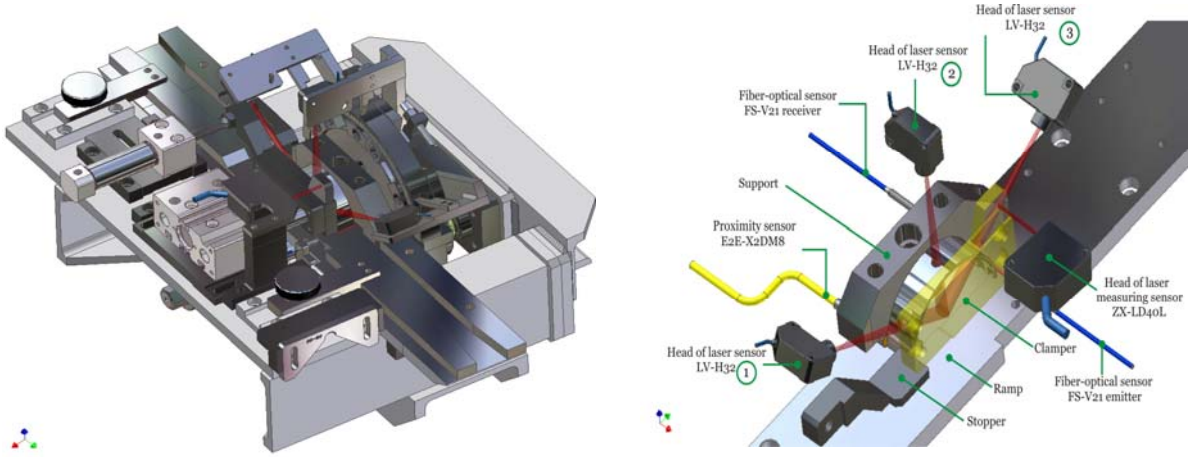
After having been checked in autochecker machine in the line Y-01, plain bearings (one by one) are driven by a conveyor belt to the separator (assembly activated by a pneumatic cylinder) which stops them making „magazine" (row of 2-8 bearings). Receiving the command from PLC (Programabil Logic Controler), the separator passes one by one bearing into Device for checking where the check is carried out in the control assembly (Figure 7a). When the bearing is let through by the separator, the conveyor belt takes it to the entry of the Device for checking, goes down the ramp between the guides (one guide is fixed, and the other one is movable depending on the lentgh of the plain bearing being machined) and gets stopped by a stopper to the checking position.

When the bearing is stopped, its presence is detected by an inductive proximity sensor, and according to the program, PLC provides an instruction ie. an outgoing signal which activates a pneumatic valve 5/2 of a clamper. The clamper is a plate linked to the pneumatic cylinder and clamps the bearing to the plate which makes it fixed and ready for control.

In the same time, checking is performed, ie., comparing the values with input tolerances on amplifiers for lubrication holes, width and free spread.

After checking, which lasts for 0.4 ms, the bearing is released by the clamper and the stopper, anf if any of checked values is not good ie., is not in conformity with the input tolerances, a lamp switches on through PLC, giving a signal to the pneumatic valve of the pusher, that after the bearing goes under the second inductive proximity sensor, it is detected and pushed to the box for bad-rejected bearings. However, if the bearing is good, it goes freely down the ramp to the conveyor which is horisontal. The conveyor then takes it towards the machine for the final treatment (wall thickness finishing).

The Device contains the following electro-pneumatic and pneumatic elements: Electro-pneumatic valve, type SMC SY7120-1MZ-02, SMC VS3115-021DBL, noise bumper SMC ANA 1-02, clamping switch NISCON BN-121B-10, pneumatic cylinder KOGANEI DA 20x15-12, pneumatic cylinder SMC MGPM-20-20-Z7BW, pneumatic cylinder KOGANEI DA 20x50-12, pneumatic cylinder SMC CM2RK-A20-25, bumping irretrievable valve SMC AS 2201 F 1/8.




a) b)

Figure 7. Control assembly
Figure 7a – Control assembly of device for checking plain bearings
Figure 7b – Sensor control of plain bearings elements

The following checks are done by selecting the sensors shown in Figure 7b: checking position of lubrication holes in relation to the angle and width KEYENCE LV-H32, checking the plain bearing width OMRON ZX-LD40L and checking free spread of plain bearing KEYENCE FS-V21.

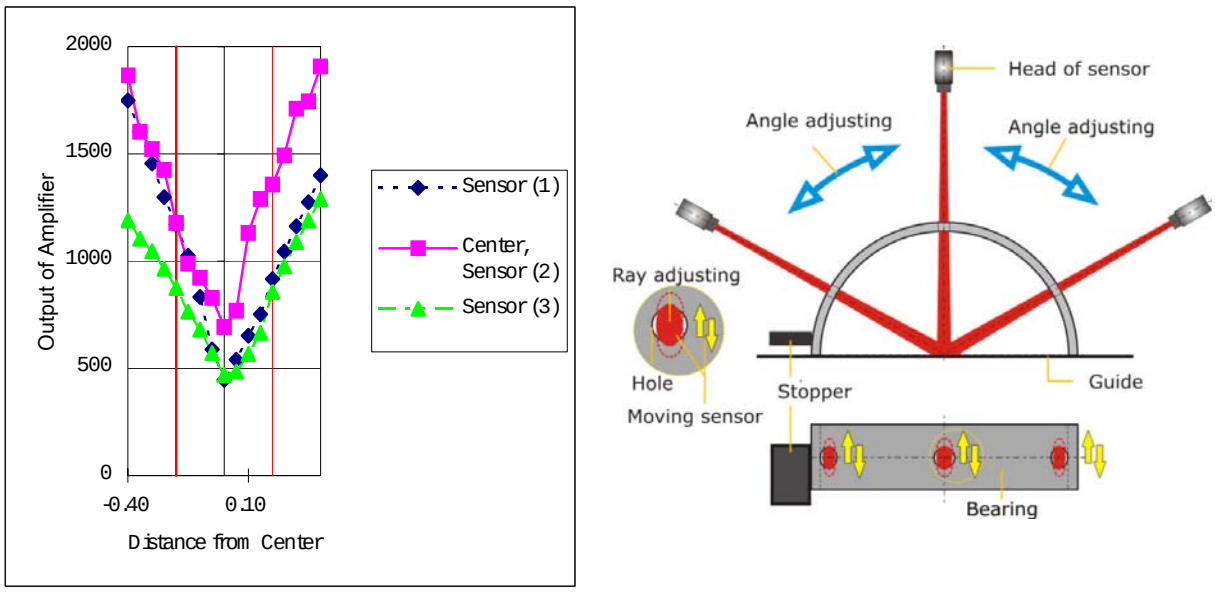
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### 2.1 Testing device for checking plain bearings

Testing the head of the laser optical sensors LV-H32 (1), (2), (3) and amplifiers LV-21A. Sensitivity and sensing the amplifier to the change of positions of the holes for lubricating bearings. Sensing the amplifier LV-21 A

Table 1 Sensing the amplifier for different holes out of position

| Distance from hole centre | Sensing the amplifier | | | Note |
|---|---|---|---|---|
| | Sensor (1) | Centre, sensor (2) | Sensor (3) | |
| 0,40 | 1400 | 1908 | 1290 | Forward |
| - | - | - | - | |
| 0,05 | 540 | 768 | 485 | |
| 0,00 | 446 | 692 | 469 | Centre |
| -0,05 | 588 | 828 | 572 | Backward |
| - | - | - | - | |
| -0,40 | 1750 | 1865 | 1190 | |




a) b)

Figure 8 Testing sensitivity of laser optical sensor LV-H32 and amplifier LV-21A

Figure 8a shows a diagram of results reached by testing sensitivity of sensing the amplifier KEYENCE LV-21A, to the changes of positions of holes related to width. Figure 8b shows set up of the control assembly for this testing and laser light beam previously adjusted, holes deviation rating 0.0 do ±0.4 mm by step of 0.05 mm in direction of bearing axis, on the diagram, sensing the amplifier is shown (with enough accuracy) by linear dependence.

### 2.2 Testing device for checking – Position of holes for lubricating plain bearings

Testing Device for checking plain bearings, regarding the position of holes for lubrication, was done using forty plain bearings with three holes, prepared in advance. Also, all measuring pieces were measured, marked, and all required measures were entered into the diagram (Figure 10).

After setting Device for checking plain bearings, all measuring pieces-bearings are let through device where sensing the amplifier is done and data are entered into the table 2 and diagram in figure. These data are taken for all measuring pieces for different adjustments (size of laser beam) of head of laser sensor LV-H32.

After having these data, the diagrams for every sensor (1,2,3) were made, which resulted with a final analysis.

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Table 2 Sensing the amplifier for beam adjusted as in Figure 9

| r/b | Head 1, amplifier 1 | Head 2, amplifier 2 | Head 3, amplifier 3 |
|---|---|---|---|
| No.1 | 163 | 177 | 147 |
| No.2 | 197 | 181 | 156 |
| - | - | - | - |
| No.40 | 787 | 442 | 739 |

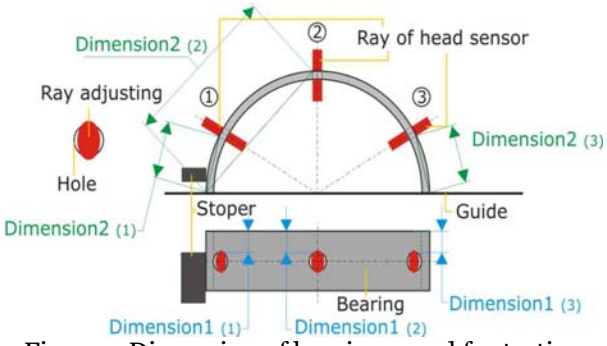



Figure 9 Dimension of bearings used for testing

Figure 10 shows the diagram of testing the device for the hole 1, all 40 bearings, for adjusted beam of laser light of senor head LV-H32, as in Figure 9. Also, this diagram presents sensing the amplifier and measured Dimension 1 and Dimension 2, as well as rejected pieces marked with x, for 40 measuring pieces.

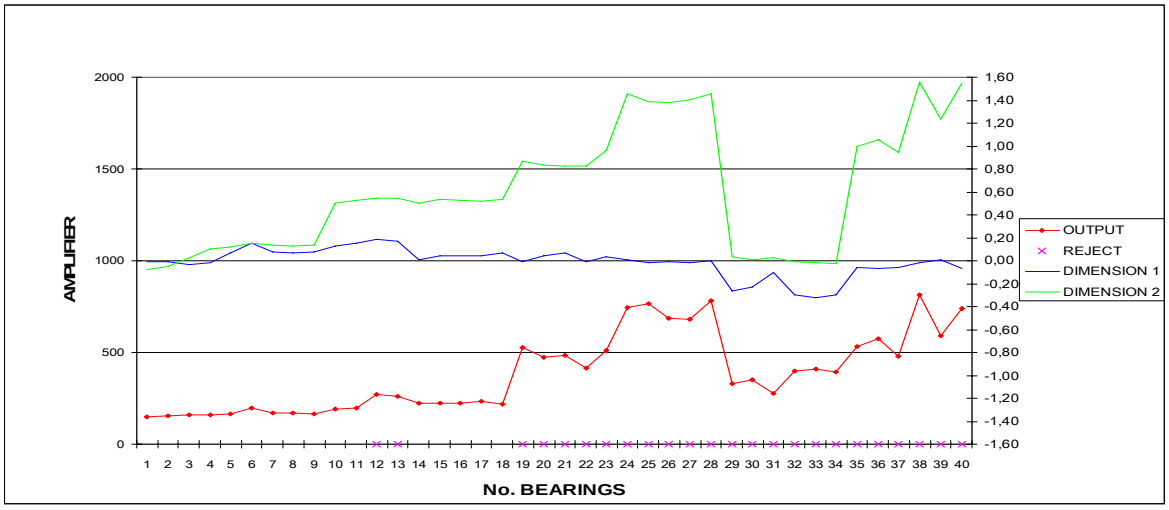



Figure 10 Diagram of results got by testing device regarding the position of holes for lubricating bearings

Figure 10 shows that changes of Dimension 1, Dimension 2 cause changes in sensing the amplifier. If you input the sensing limit corresponding the values of amplifier sensing good pieces or if it is greater enough, the rejected bearings (x) will be detected (value of sensing the amplifier exceeds the limits) and device for checking will eliminate them, according to the program defined in PLC.

### 2.3 Testing device for checking – Width of plain bearings

For testing the device regarding width of bearings, 10 measuring pieces were prepared.

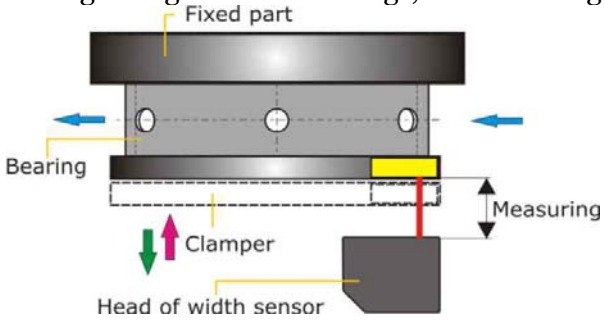



Figure 11 Layout of checking width of bearings in device

Table 3 Dimensions and results of testing with measuring pieces for checking width of bearings

| Measuring pieces | Mark | Measured values | Sensing the amplifier | Bottom value, by drawing | Peak value by drawing | Bottom value of amplifier | Peak value of amplifier |
|---|---|---|---|---|---|---|---|
| No.1 | 1 | 19,00 | 19,03 | 19,10 | 19,60 | 19,15 | 19,55 |
| - | - | - | - | - | - | - | - |
| No.10 | 10 | 19,70 | 19,689 | 19,10 | 19,60 | 19,15 | 19,55 |

Figure 12 shows the diagram of results got by testing for 10 bearings prepared in advance whose dimensions were measured and shown in table 3.

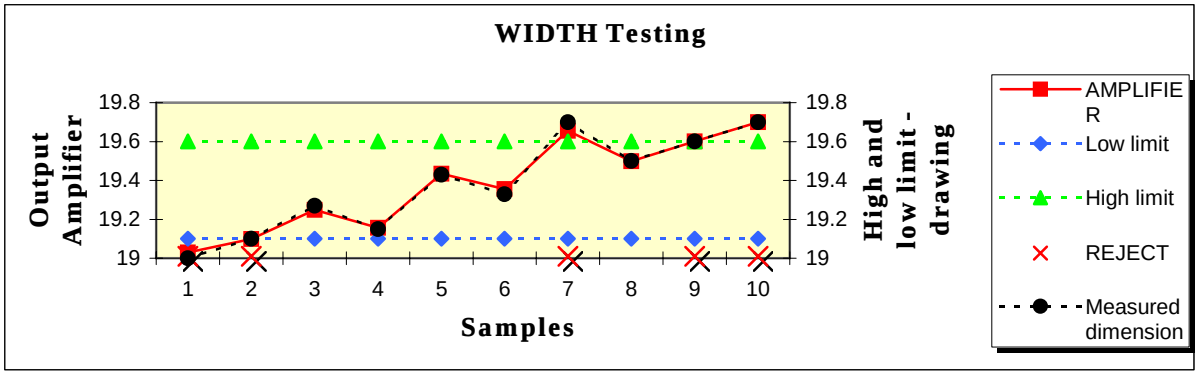



Figure 12 Diagram of results got by testing device regarding bearing width

Highly precise optical OMRON laser sensor ZX-LD40L and amplifier OMRON ZX-LDA 11-N, were previously adjusted to the device and the bearings drawing, sensing the width values of measuring pieces (Figure 11) which were later on entered into the diagram. Bottom and peak values set on the amplifier, correspond to the tolerance field being a little bit more narrow in respect to the tolerance field defined by the drawing, because of those bearings whose values are on the limit of tolerance field – for sake of assurance. The amplifier detects those bearings whose width is out of tolerance field and according to PLC program, the elements of device eject them as defected.

### 2.4 Testing device for checking – Free spread of plain bearings

For testing the device in respect to the bearing free spread, 10 measuring pieces were prepared.

Firstly, the Control assembly of device (figure 7a) is set for a certain product ie., measuring pieces, according to Figure 13, as well as the position of a fiber optical sensor KEYENCE FS-V21 (emitter and receiver). Measuring pieces are let through device and the amplifier reads the values for every part. Values got are shown in Table 4 and on diagram. Diagram also shows that dimensions which were previously measured (given in Table 4) follow the values read on the amplifier. If you set peak value of the amplifier sensing, in accordance with the initial value on the amplifier and the bearing drawing, measuring parts exceeding the limit set on the amplifier, are ejected from device. Dependence of values of sensing the amplifier and changes of free spread dimensions is linear.

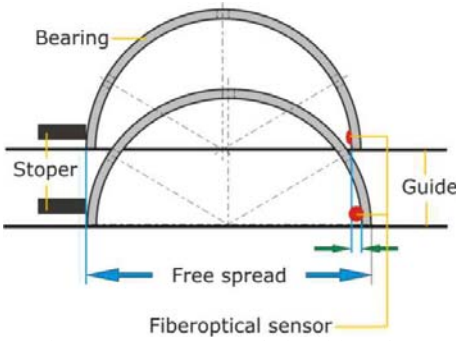



Figure 13 Layout of checking free spread in the device for checking

Table 4 Dimensions and results of testing with measuring pieces for checking free spread of bearing

| Measuring pieces | Mark | Measured values | The amplifier sensing | Bottom value by drawing | Peak value by drawing | Peak value of amplifier |
|---|---|---|---|---|---|---|
| No.1 | 1 | 71,00 | 445 | 69,5 | 71 | 430 |
| - | - | - | - | - | - | - |
| No.10 | 10 | 70,75 | 367 | 69,5 | 71 | 430 |

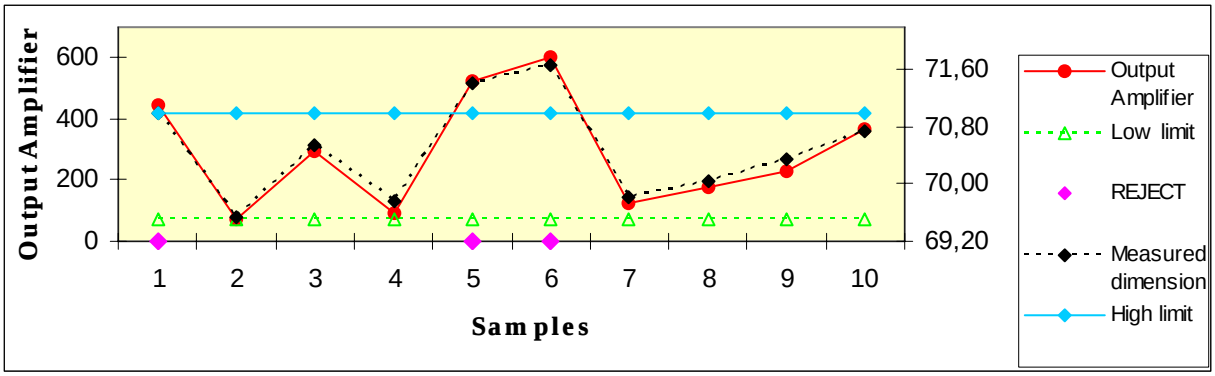



Figure 14 Diagram of results got by testing device in respect to free spread of bearings

## 3. ANALYSIS

Using the most modern laser technique and constructive design of the device – adjusted to the selected sensors, PLC driving, has contributed to control of products elements in this type of industry. Testing results, previously described, confirm possibility of checking the elements of bearings with selected sensors (wide range of adjustments) and assurance that a rejected bearing, caused by these three elements being controlled, will be detected.

After individual testing, testing of operation stability of Device for checking was also performed, including coexistence of results got by individual testing. All measuring parts were mixed and let through device, which exactly selected and ejected all defected parts into the reject box. Process of testing was repeated for 10 times.

## 4. CONCLUSION

This paper describes the device which was projected with intention to work in-line and to check three parameters of each bearing during the production process. In case of detecting defected parts, it stops the process of bearings production on the machining line Y-01. The device for checking incorporates: electro-pneumatics, the most modern sensor technique and its application in industry, including complete driving by PLC.

Reduction of rejects, based on three elements noted in total reject amount, is also reflected in cutting down production costs, price of manufacturing, final price of product. This also results in providing profit for the company, therefore affecting the employees`salaries and their satisfaction , as well.

This project is important, not only for reducing defects in production, but also to assure that the final customer will get well controlled and high quality product.

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# SLIDING MODE CONTROL OF A ROBOT ARM DRIVEN BY PNEUMATIC MUSCLE ACTUATORS

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**Abstract:**
As an important driver element, the pneumatic artificial muscle (PAM) is widely used in industrial applications for many automation purposes thanks to their variety of advantages. The design of a stable robust position controller for PAM is difficult since it is a very nonlinear time-variant controlled plant because of the compressibility of air, air mass flow rate through the valve, etc. The main contribution of this paper is a robust position control method based on sliding mode for a robot arm, driven by pneumatic muscle actuator. Finally, it presents experimental results.

**Keywords:**
Pneumatic artificial muscles, PAMs, sliding mode control

## 1. INTRODUCTION

This work is the first fundamental step of a wider project, aimed at studying the humanoid robot. Muscles only generate a force via contraction, i.e. a muscle can only "pull" and does not "push." One muscle (agonist) contracts and simultaneously the other muscle relaxes (antagonist, which increases in length), thus producing a force and motion on the mass. The same effect can be realized in a rotational sense by generating a rotation or torque on the robotic joint through the contraction of the agonist and relaxation of the antagonist muscle.

Many researchers have investigated the precise position control of pneumatic muscles during the past several years. Most of them dealt with the control of single or antagonistic pneumatic muscles.

Due to the fact that the results obtained with a classical PI controller were not good, robust control techniques were considered. For pneumatic muscles, the application of different control techniques is found in the literature, but a good performance requires the use of robust or non-linear control techniques. A variety of approaches, with varying success, have been attempted. PID control, neural networks, and adaptive control, among others, have been utilized [1, 2, 3, 4]. While PID control is well known, the results are particularly sensitive to errors in the feedforward term. Adaptive and neural network control may be more robust, but suffer from slow convergence and long training sessions respectively. Thus, adaptive control is not well suited for the fast movements required of an orthotic actuator. Analogously, neural control, with its training workspace, does not handle unique or unexpected situations well.

Therefore, a non-linear robust control technique, sliding-mode, was applied to design a position controller.

## 2. MATERIALS AND METHODS

The pneumatic valve is the key element in the system. There are two types of valves used in the pneumatic positioning, servo-valves and on-off valves. With conventional on-off valves accurate position control is difficult to achieve because of the limitation of the valve

response time. In the past few years there has been a wide interest in the use of cheap high speed solenoid valves [7]. The most of applications are on pulse with modulation (PWM). By the advent of DSPs with high computation power, the precise and robust control of pneumatic actuators has become possible.

Sliding mode control was introduced in the late 1970's [8] as a control design approach for the control of robotic manipulators. Among experimental studies, a few succeeded in showing closed-loop system behaviour which was predicted by the theory [9].

Another solution is to employ the advanced nonlinear control strategies developed in recent years (soft computing) [10].

The design of a sliding mode controller consists of three main steps. One is the design of the sliding surface, the second step is the design of the control which holds the system trajectory on the sliding surface, and the third and key step is the chattering-free implementation. The purpose of the switching control law is to force the nonlinear plant's state trajectory to this surface and keep on it. When the plant state trajectory is „above" the surface, a feedback path has one gain and a different gain if the trajectory drops „below" the surface.

Consider a single-input, single-output second-order nonlinear dynamic system:

$$\ddot{x} = f(x, \dot{x}, u). \qquad (1)$$

Where $x$ is the output signal (position) of the controlled plant, $u$ is the control signal. If $x_d$ denotes the desired value, then the error between the reference and system states may be defined as

$$e = x_d - x. \qquad (2)$$

### 2.1. Sliding surface design

Classically, a scalar variable $s$ is calculated as a linear combination of the error and its derivative.

$$s = e + \lambda \cdot \dot{e}. \qquad (3)$$

Let $s(\dot{e}, e) = 0$ define the „sliding surface" in the space of the error state. The purpose of sliding mode control law is to force the state trajectory of the error to approach the sliding surface and then move along the sliding surface to the origin (Fig.1.).

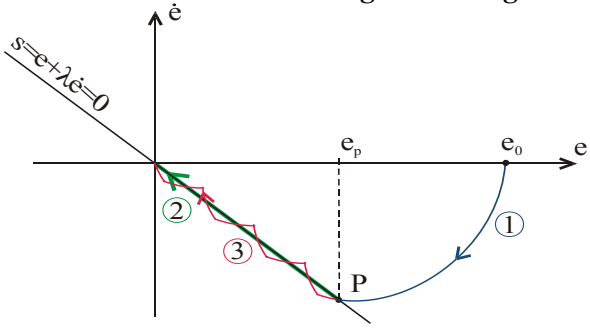


Figure 1. Sliding motion in the state space

The process of sliding mode control can be divided into two phases, that is, the approaching phase with $s(\dot{e}, e) \neq 0$ and the sliding phase with $s(\dot{e}, e) = 0$. If the system is in sliding mode the error is decreasing exponentially, where $\lambda$ is a time constant type parameter. If $\lambda$ is big than the system response is slow but accurate. If it is small than the system response is fast but the system might chatter.

### 2.2. Selection of the control law

In order to guarantee that the trajectory of the error vector $e$ will translate from approaching phase to sliding phase, the control strategy must satisfy the sliding condition

$$s(\dot{e}, e) \cdot \dot{s}(\ddot{e}, \dot{e}) < 0. \qquad (4)$$

This means that $e$ will always go toward the sliding surface. A proper control should be selected to satisfy the condition (4) in any time instant. The simplest control law that might lead to sliding mode is the relay.

$$u = \delta \cdot sign(s). \qquad (5)$$

### 2.3. Chattering free implementation

Chattering is the main problem of sliding mode control and chattering free implementation is the key step in design of a sliding mode controller. A quite general solution is that the relay (which changes its output value suddenly) is replaced by a saturation

function. There is a boundary layer around the sliding surface where the control signal is changing continuously. If the system trajectory is close to the sliding surface and the control signal is small, than the system might stick before the goal.

To avoid it a modified saturation function shown in Table 1. is proposed. When the limitation of the position is satisfied, all high-speed on-off solenoid valves are ON to stop the overshoot. The control will be finished when $|e_s|$ is smaller than $e$.

## 3. THE SERVOPNEUMATIC POSITIONING SYSTEM

The experimental set-up, is shown in Fig.2. and Fig.3. consists of a slider mechanism. One side of the muscle is fixed to a load cell, while the other side is attached to the movable frame. The load cell (7923 type from MOM) is a 4 bridge element of strain gauges. It is mounted inline to the PAM on the fixed surface. The load cell measures the force exerted by the PAM. The linear displacement of the actuator is measured using a LINIMIK MSA 320 type linear incremental encoder. Velocity and acceleration are obtained by numerical derivation. During each test, slider position, muscle force and applied gauge pressure are recorded. Since PAMs are one-way acting, two are needed to generate bidirectional motion: as one of them moves the load, the other one will act as a brake to stop the load at its desired position. To move the load in the opposite direction the muscles change function. The PAMs were installed horizontally such that the only force present during activation was the small friction force of the slider mechanism. In the test-bed, two DMSP-20-200N-RM-RM type fluidic muscle (from FESTO) can controlled by tree-way and two-way solenoid valves (MATRIX HX 751.102 C 324 3/2 NC and PX 861.9E4C2KK fast switching types).

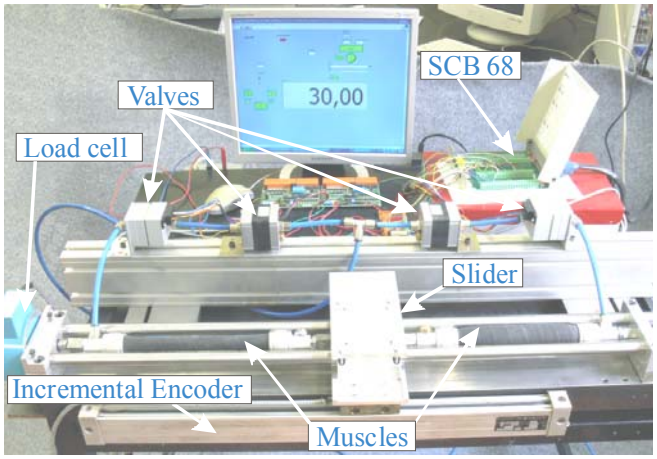



Figure 2. The photo of the experimental setup

We repeated experiments for several levels of pressures in the range from 0 to 5 bar. To measure the air pressure, two Motorola MPX5999D pressure sensors were plumbed into the pneumatic circuit. A National Instruments data acquisition card (NI 6251/M) reads the signal of force, pressure sensors and incremental encoder into the PC. National Instruments LabVIEW will be used to monitor and collect the data imported through the DAQ card. It will also dispatch the control profiles for the PAMs. (Fig. 4 and Fig. 5)

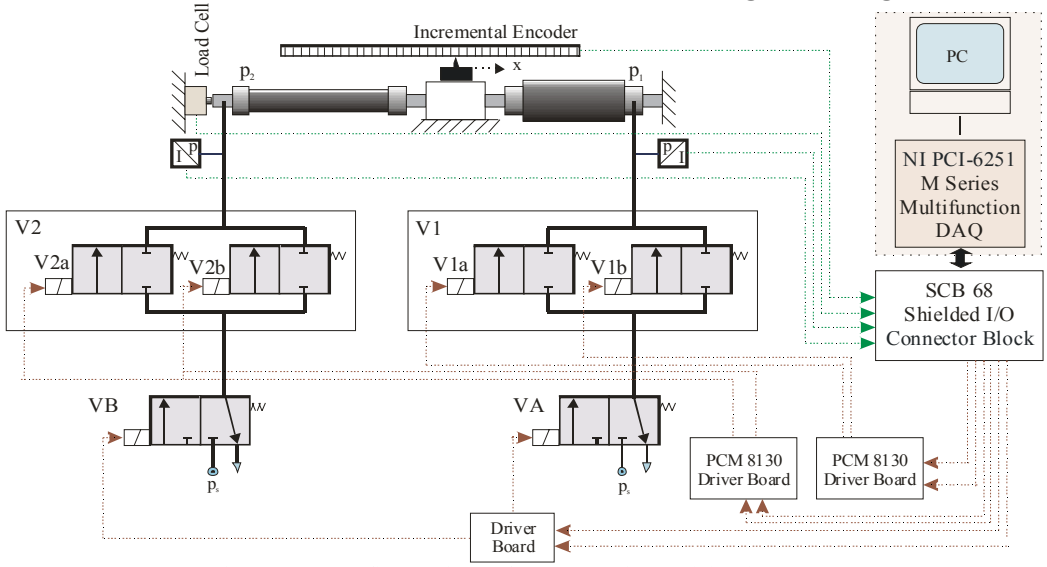



Figure 3. Configuration of pneumatic positioning system

Table 1.

| | | Fast Forward | Slow Forward | In Position | Slow Backward | Fast Backward |
|---|---|---|---|---|---|---|
| VA | | 1 | 1 | 1 | 0 | 0 |
| VB | | 0 | 0 | 1 | 1 | 1 |
| V1 | V1a | 1 | 1 | 0 | 1 | 1 |
| | V1b | 1 | 0 | 0 | 0 | 1 |
| V2 | V2a | 1 | 1 | 0 | 1 | 1 |
| | V2b | 1 | 0 | 0 | 0 | 1 |

The system pressure is set to be 6 bar, the sampling time is 10 ms. In order to analyze the positioning methods a real-time data acquisition program was designed. The control program is based on Table1.




Figure 4. Front Panel of the LabVIEW program

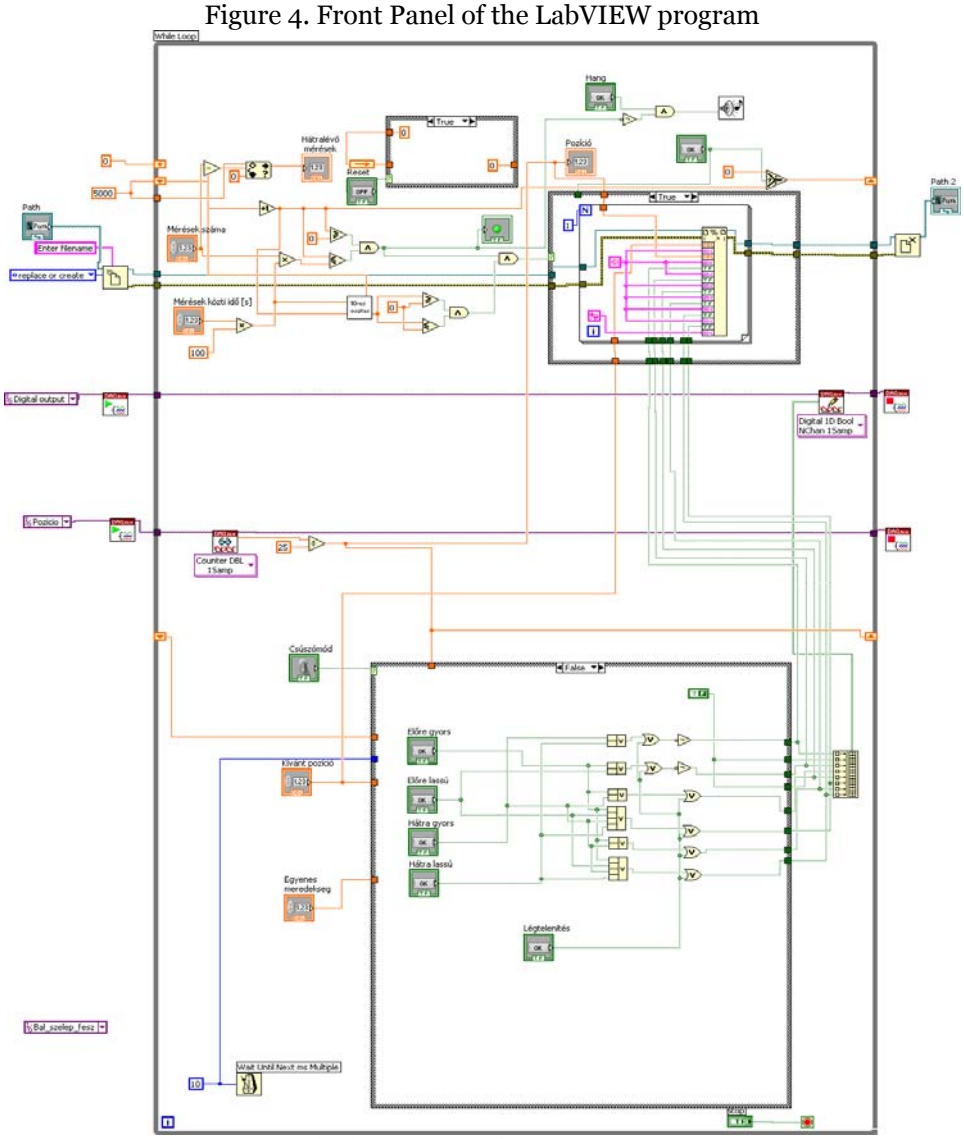



Figure 5. Block Diagram of the LabVIEW program

## 4. EXPERIMENTAL RESULT

The conventional, single stage solenoid operated on–off valves are very bulky and their dynamic performances are low. With these valves fine motion control is difficult to achieve because of the limitation of the valve response time. With on-off control the system will never reach a steady state value.

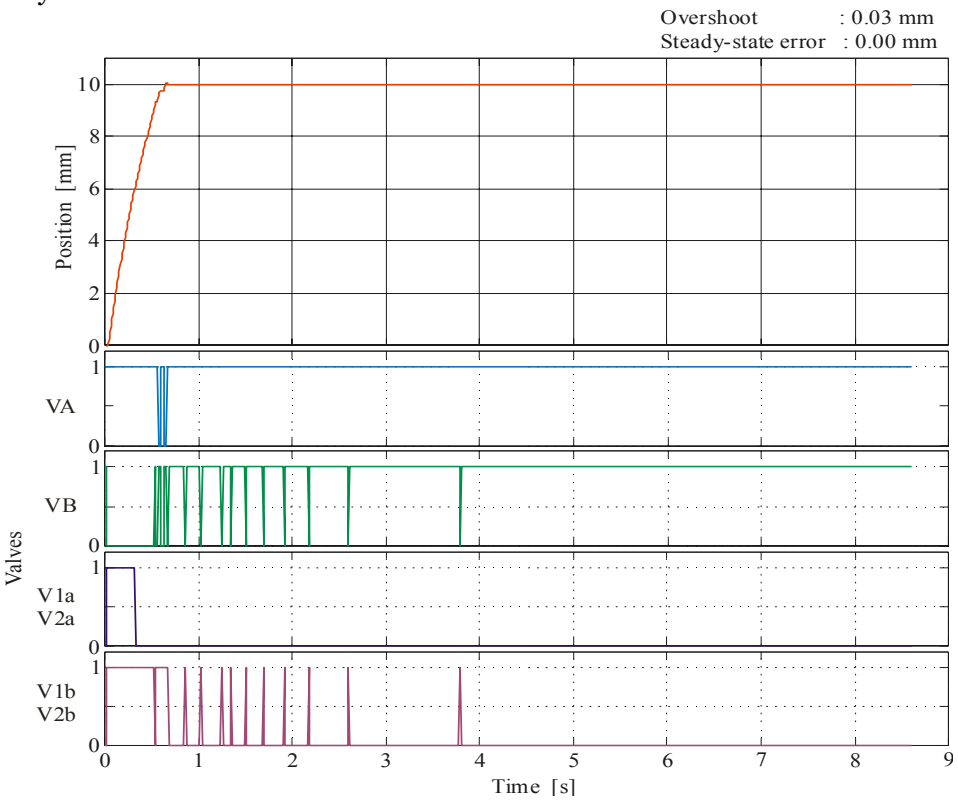



Figure 6. The time functions of the position and control signal

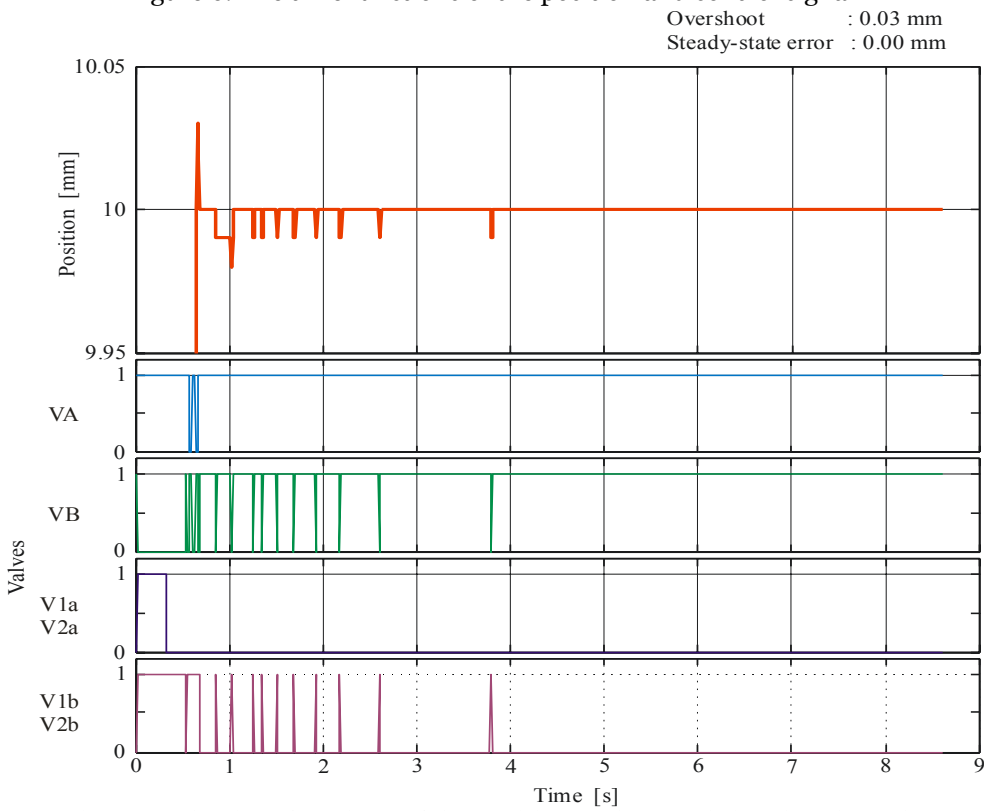



Figure 7. The time functions of the position and control signal (enlarged)

The actual position will tend to oscillate around the desired position. The second measurement is a positioning with high-speed on-off solenoid valves. The time functions of the position, and control signal is shown Fig.6. and Fig.7. The position error of the LabVIEW-based relay type sliding mode control is within ±0.02 mm.

The experimental results show en excellent control performance and that the sliding mode control is an effective methods to develop a practically available human-friendly robot by using the PAM manipulator.

This behavior is in absolute contrast to that of a pneumatic cylinder: a cylinder develops a force which depends only on the pressure and the piston surface area so that at a constant pressure, it will be constant regardless of the displacement.

## 5. CONCLUSIONS AND FUTURE WORKS

This work is the first fundamental step of a wider project aimed at studying the PAMs. With the help of this test-bed we can carried out several static and dynamic investigations and control methods. Based on the laboratory measurements we can conclude that the pneumatic servo-systems can be used for precise robust position control. The sliding mode control is a promising tool for controlling such systems. The proposed modified saturation function can eliminate the chattering, which is the main problem in case of sliding mode control.

Further works we have done with applying the input shaping method. Once the system has reached the setpoint, the residual oscillation will degrade positioning accuracy and may cause a delay in task completion. Input Shaping is a feedforward control technique for reducing vibrations in computer controlled machines. The method works by creating a command signal that cancels its own vibration. That is, vibration caused by the first part of the command signal is canceled by vibration caused by the second part of the command. Input shaping is a command generation technique that is used to reduce command-induced vibration (as opposed to disturbance-induced vibration) [11]. Input shaping is implemented by convolving a sequence of impulses, called an input shaper.

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# DESIGN AND FABRICATION OF A TEST-BED AIMED FOR EXPERIMENT WITH PNEUMATIC ARTIFICIAL MUSCLE

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**Abstract:**
Pneumatic artificial muscles (PAMs) are contractile or extensional devices operated by pressurized air. Similarly to human muscles, PAMs are usually coupled antagonistically. PAMs were first developed (under the name of *McKibben Artificial Muscles*) in the 1950s for use in artificial limbs. There is growing interest in the use of pneumatic artificial muscles for robotic applications due to their high power to weight ratio and the adaptable compliance. To control the actuator, we have to know its properties. The objective of this project was to design an apparatus which would enable experimental investigation of PAMs.

**Keywords:**
Pneumatic artificial muscles, PAMs, test-bed

## 1. INTRODUCTION

The stand described in this paper is a didactic laboratory stand, which task is to enable investigations and gather knowledge of construction and the way of working such elements as: a Fluidic Muscle, a PLC controller, DSP systems as well as proportional pressure control techniques. It offers many didactic and investigative possibilities and thanks to applied solutions its development is easily available. The module structure of the research stand gives possibility to make its further development by adding extra modules that can be easily mounted on plates.

## 2. MATERIALS AND METHODS

The stand was designed and visualised by utilisation of professional CAD software – Autodesk Inventor. Figure 1 shows a schematic representation of the experimental set-up that was used to carry on the research presented in this paper.

The experimental set-up consists of a slider mechanism. One side of the muscle is fixed to a load cell, while the other side is attached to the movable frame. The load cell (7923 type from MOM) is a 4 bridge element of strain gauges. It is mounted inline to the PAM on the fixed surface. The load cell measures the force exerted by the PAM. The tests are performed by changing the displacement of this slider. The linear displacement of the actuator is measured using a LINIMIK MSA 320 type linear incremental encoder. During each test, frame position, muscle force and applied gauge pressure are recorded. Since PAMs are one-way acting, two are needed to generate bidirectional motion: as one of them moves the load, the other one will act as a brake to stop the load at its desired position. To move the load in the opposite direction the muscles change function. This opposite connection of the muscles to the load is generally referred to as an antagonistic set-up: the driving muscle is called the flexor or agonist, while the brake muscle is referred to as the extensor or antagonist. The antagonistic coupling can be used for either linear or rotational motion. The PAMs were installed horizontally such that the only force present during activation was the small friction

force of the slider mechanism. In the test-bed, two DMSP-20-200N-RM-RM type or two DMSP-10-250N-RM-RM type fluidic muscle (from FESTO) can mounted, with a pre-tension of about 15% (half of the maximum contraction ratio which is 30%). This work is the first fundamental step of a wider project, aimed at studying the humanoid robot.

Instead of second PAM a bias spring or an external load can attached with a flexible steel cables, producing the necessary counter force to pull the actuator back when it is not activated. In a spring, the stiffness is constant within a definite field.

We repeated experiments for several levels of pressures in the range from 0 to 5 bar. The air pressure applied to the actuators can regulated with two adjustable regulator type Festo VPPM-6L-L-1-G1/8-0L6H-V1N-S1C1. The proportional pressure regulators (PPRs) are controlled by voltage inputs. The main purpose of the PPR is to regulate the pressure entering the PMA. To measure the air pressure, two Motorola MPX5999D pressure sensors were plumbed into the pneumatic circuit. A National Instruments multi-IO card (Lab PC 1200) reads the signal of force, pressure sensors and incremental encoder into the PC. National Instruments LabVIEW will be used to monitor and collect the data imported through the DAQ card. It will also dispatch the control profiles for the PPRs. LabVIEW allows for the dynamic collection of data.

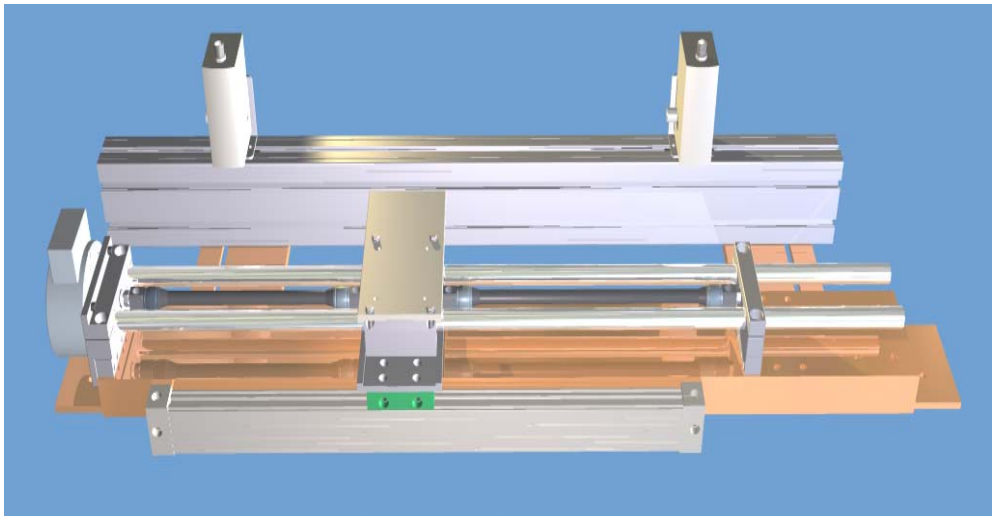


Figure 1. The view of the stand for Fluidic Muscle investigations

With the specially constructed dynamic testing machine, we are able to measure the static and dynamic characteristics of several versions of these actuators. The photos of the set up are shown in Fig. 2-5.

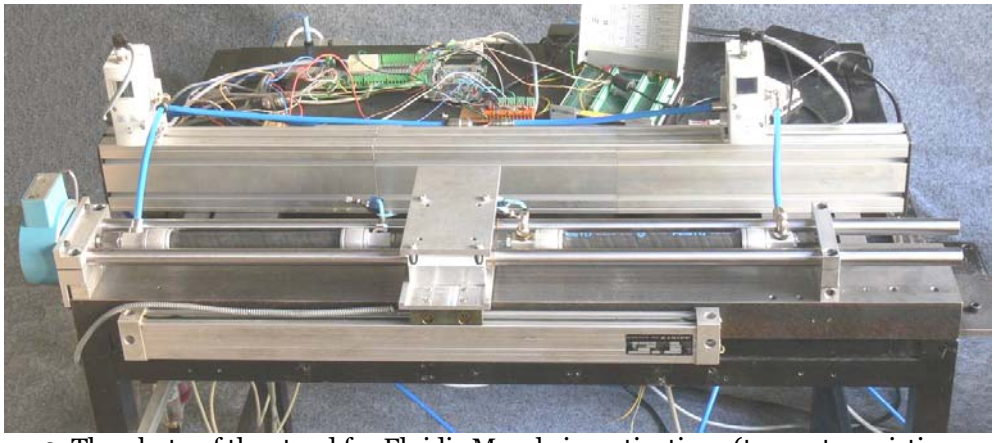


Figure 2. The photo of the stand for Fluidic Muscle investigations (two antagonistic muscle)

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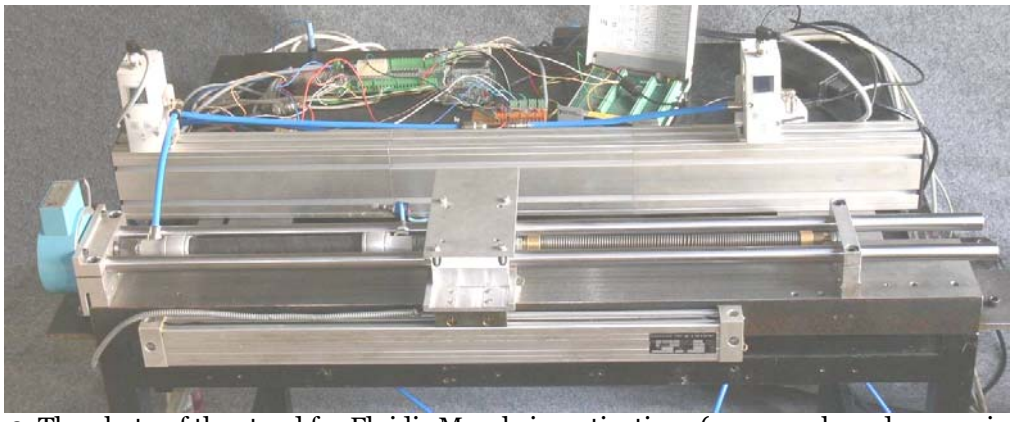


Figure 3. The photo of the stand for Fluidic Muscle investigations (one muscle and one spring pair)

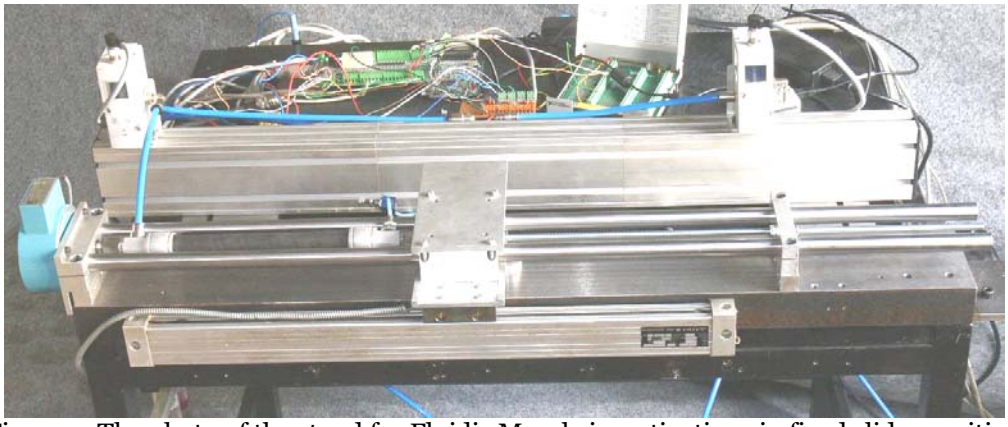


Figure 4. The photo of the stand for Fluidic Muscle investigations in fixed slider position

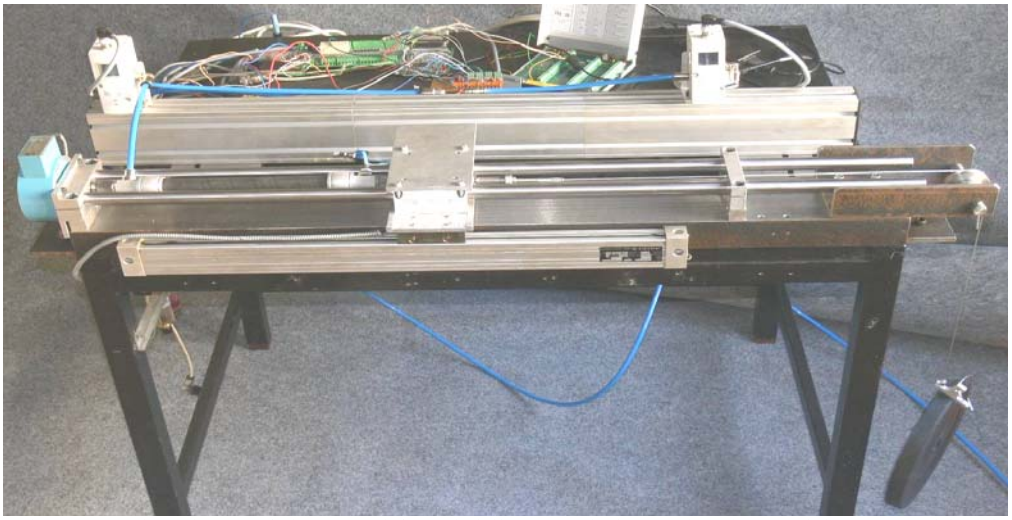


Figure 5. The photo of the stand for Fluidic Muscle investigations with external load

The fluidic muscle can be used as an actuator or a spring. If internal pressure is changed, the muscle can set an external load into motion like an actuator (Figure 6). If the external load is changed, the fluidic muscle reacts like a spring by changing its length. Contraction of the fluidic muscle is thus dependent upon internal pressure as well as external load (Fig. 7).

To see how the device operates, two basic experiments can be considered. In both cases a PAM of an arbitrary type is fixed at one end and has a mass hanging from the other. In the first experiment, shown in Figure 6, the mass $M$ is constant and the pressure difference across the membrane, i.e. its gauge pressure, is increased from an initial value of zero. At zero gauge pressure the volume enclosed by the membrane is minimal, $V$min, and its length maximal, $l$max. If the muscle is pressurized to some gauge pressure $p1$, it will start to bulge

and at the same time develop a pulling force. The mass will thus be lifted until the generated force equals $Mg$. The membrane's volume will then have grown to $V1$ and its length contracted to $l1$. Increasing the pressure further to $p2$ will continue this process. From this experiment two basic actuator behavior rules can be deduced: a PAM shortens by increasing its enclosed volume, and it will contract against a constant load if the pneumatic pressure is increased.

The other rules can be derived from the second experiment, shown in Figure 7. The gauge pressure is now kept at a constant value $p$, while the mass is diminished. In this case the muscle will inflate and shorten. If the load is completely removed, as depicted by Figure 7 (c), the swelling goes to its full extent, at which point the volume will reach its maximum value, $V$max, the length its minimal value, $l$min, and the pulling force will drop to zero. The PAM cannot contract beyond this point, it will operate as a bellows at shorter lengths, generating a pushing instead of pulling force. This means that a PAM will shorten at a constant pressure if its load is decreased and its contraction has an upper limit at which it develops no force and its enclosed volume is maximal. Concluding from both experiments a fifth rule can be added: for each pair of pressure and load a PAM has an equilibrium length.

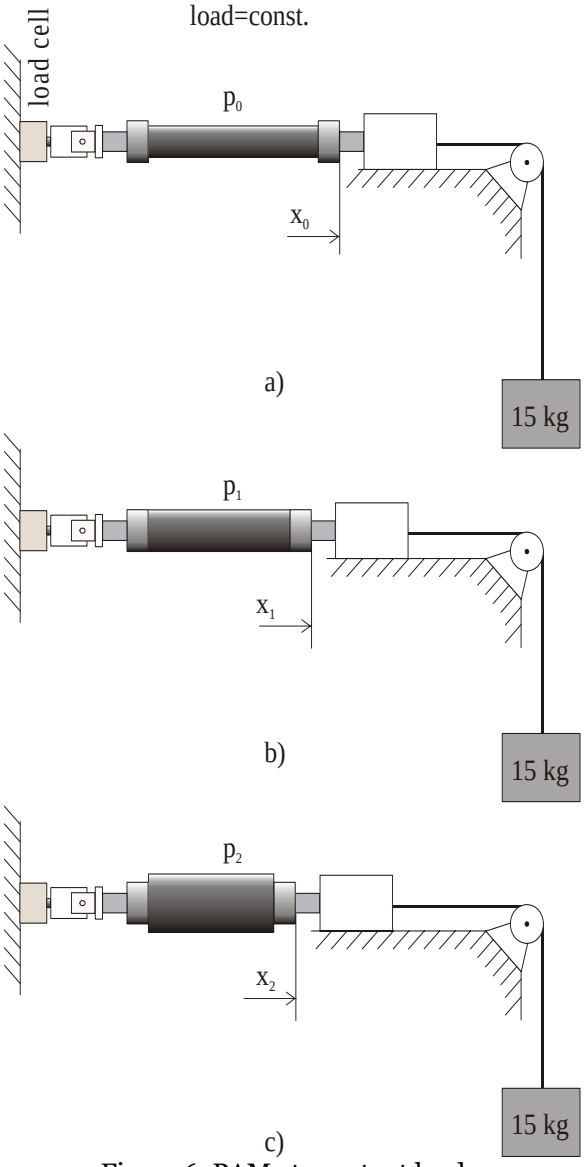



Figure 6. PAM at constant load

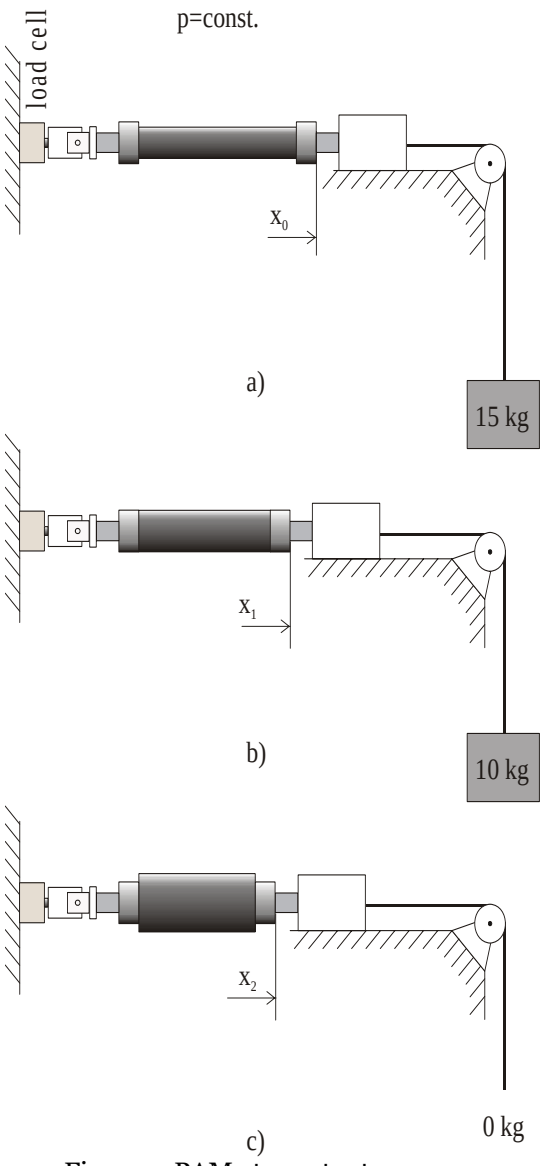



Figure 7. PAM at constant pressure

This behavior is in absolute contrast to that of a pneumatic cylinder: a cylinder develops a force which depends only on the pressure and the piston surface area so that at a constant pressure, it will be constant regardless of the displacement.

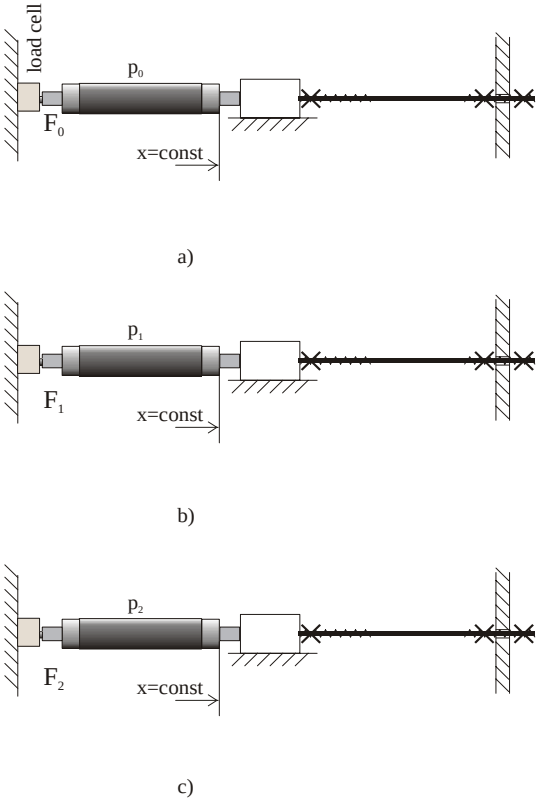



Figure 8. PAM at fixed position

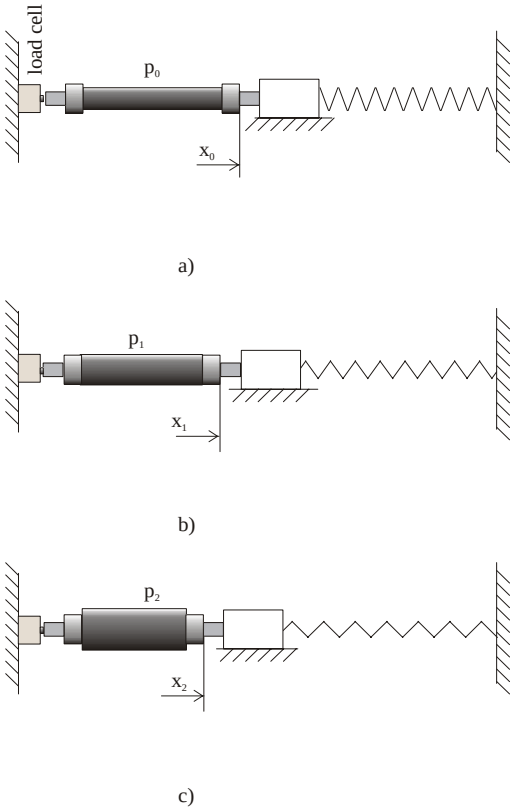



Figure 9. PAM with bias spring

## 3. RESULTS AND DISCUSSION

A pneumatic artificial muscle (PAM) is essentially a volume, enclosed by a reinforced membrane, that expands radially and contracts axially when inflated with pressurized air. Thereby, the muscle generates a unidirectional pulling force along the longitudinal axis. When neglecting the membrane's material deformation and the low inertial muscle properties, the generated force is expressed as:

$$F = -p\frac{dV}{dl} \tag{1}$$

with $p$ the gauge pressure inside the muscle, d$V$ the enclosed muscle volume changes and d$l$ the actuator length changes. The volume of the actuator increases with decreasing length until a maximum volume is reached. At maximum contraction these forces become zero; at low contraction these forces can be very high. Depending on the geometry and type of membrane, the specific force characteristic alters. Several concepts of PAM have been developed over time.

This work is the first fundamental step of a wider project aimed at studying the PAMs. With the help of this test-bed we can carried out several static and dynamic investigations (Figure 8-9).

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# EXAMINATION OF THE EFFECT OF MICROWAVE HEATING ON THE BIODEGRADABLE AND SOLUBLE FRACTION OF ORGANIC MATTER OF SLUDGE

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**Abstract**

Because of the high industrial wastewater output the quantity of sludge has been increased. The efficiency of biological sludge handling process was limited by the non-soluble and non-degradable component. Among sludge handling processes the thermal treatments are known as more utilizable methods because of pathogen destruction and digestion effect. In the case of microwave treatment the biodegradability is increased. In our work the effect of microwave irradiation on biodegradability and anaerobic digestionability of dairy originated sewage sludge was investigated. our results showed that microwave pretreatment is appropriate to enhance solubility of organic compounds thus the biodegradability and biogas product increased.

**Keywords:**

sludge, microwave pre-treatment, solubility, biodegradability, biogas

## 1. INTRODUCTION

The drinking water supply has been turned into the most urgent problem for assuring healthy human being in the world. A large scale development was experienced in the drinking water and waste water management technology and hereby the cleaning efficiency could be in a large measure improved, but simultaneously the quantity and the environmental risk of emitted sewage sludge increased. Generally, the solid phase of waste water is named sewage sludge.

Depending on the processed raw material the sludge may be rich in carbohydrates, lipids or proteins. In most cases the sludge handling system has been become the bottleneck of capacity of waste water treatment plants. The most common alternatives of sewage sludge handling are landfill, cropland application, incineration and in the last resort conditioned dumping as hazardous waste.

Waste management has become an acute problem in many countries. Management options require extensive waste characterization since many of them may contain compounds deleterious for the ecosystem, such as heavy metals, organic micropollutants and other persistent and less biodegradable compound. Beside the general characterization and testing of waste sludge the digestion and biodegradability testing give more utilizable information for planning of composting and biogas producing. The main structure of municipal and food industrial sewage sludge consists of extracellular polymeric substance (polysaccharides, proteins, lipids, nucleic acids), multivalent cations, other organic and inorganic matter and microbial cells which compose a special flock structure [1]. This agglomerated complex flock structure is resistance to a direct anaerobic degradation since cell walls and polymeric conformation present physical and chemical barriers for microbial and enzymatic degradation.

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Extracellular polymeric substance are present in varying quantities in sewage sludge, occurring as highly hydrated capsule surrounding the cell wall and loose in solution as slimy polymers and it is able to retain a large volume of water within the sludge matrix by electrostatic interactions and hydrogen bounds. The non-biodegradable polymeric structure does not only originate from cell autolysis and sludge bacterial cell but also originates from the compounds of raw wastewater. So besides the cationic content of dosed chemical and organic content, the efficiency and specific removal capacity of applied waste water treatment technology (chemical, biological or combined) have effect on biodegradability of sludge [2].

There are many possibilities to improve the digestibility and aerobical biodegradability of sludge. Mechanical, thermal, ultrasound, chemical, thermo-chemical and enzymatic pre-treatment methods can enhance the extent and the rate of biological degradation [3, 4]. It is verified the thermal pretreatments improve pathogen destruction and dewaterability process of sludge, too [5].

Microwave heating is used as a popular alternative to conventional heating mainly due to considerable reaction time reducing effect. The microwave equipment generally uses 2450 MHz frequency with a 12,24 cm operating wavelength. The microwave magnetron with 900 MHz operating frequency is used for industrial scale heating and drying of solid and low water content matter on the ground of larger penetration ability. Applications of microwave-assisted techniques in many fields of analytical methods, such as sample drying, moisture measurements and extraction processes are used [6].

The microwave irradiation has thermal and athermal effect. The thermal effect can be attributed heat generation in the matter due to rotation of dipole molecules or ionic conduction. Ionic conduction is the electrophoretic migration of ions when an electromagnetic field is applied. Dipole rotation means realignment of dipoles with the applied fields, for example at 2450 MHz the dipoles align and randomized $4{,}9\times10^{9}$ times per second and this forced molecular motion results heat. In many applications these two mechanisms have been applied simultaneously.

Due to high water content the sewage sludge can absorb microwave energy efficiency. Although the quantum energy of microwave radiation is too low ($1{,}05\times10^{-5}$ eV) to break the chemical bounds but some structures can be altered by the energies carried by microwaves. For example the athermal effect of microwave radiation is caused by polarized parts of macromolecules, it results breakage of hydrogen bound. The intensive microwave heat generation and the different dielectric properties of compounds of cell wall lead to a rapid disruption of extracellular polymer network and residue cells of sludge [7, 8]. However the cell liquor and extracellular organic matter within polymeric network can release into the soluble phase, hereby increase the ratio of accessible and biodegradable component [9, 10].

## 2. MATERIALS AND METHODS

The sewage sludge was originated from a industrial waste water treatment plant of a local dairy works (Sole-Mizo Ltd., Szeged, Hungary). In the case of dairy industrial sewage sludge a phyico-chemical waste water technology was applied and the final water content of sludge was 58,2 w/w%.

The microwave pre-treatments were performed in a self-developed monomode microwave treating and measuring unit, at 2,45 GHz frequency, at 50 to 700 W microwave power. The microwave irradiation time was 10 to 40 minutes. The applied specific microwave power level was 1, 2 and 5 W/g, which was adjusted by the ratio of magnetron power and the quantity of treated sludge. The sludge samples were placed invariably in 2 cm layer because of penetration depth of microwave radiation. Poly-tetrafluor-ethylene (PTFE) vessels were used on account of efficient microwave penetration and absorption. Cover was applied to prevent the evaporation during the irradiation. The surface temperature of sludge an Infracam (FLIR InfraCAM-SD, Sweden) was determined after microwave irradiation

As comparing method convective heat-treatments were performed. The convective heat-treatment was performed in automatic temperature controlled laboratory heater equipment (Medline CM 307, UK) at 95 °C.

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The value of biodegradability (BD) is commonly characterized by the BOD/COD ratio. COD is the chemical oxygen demand; the quantity of oxygen required oxidation by chemical oxidant. The soluble COD (sCOD) indicate the water soluble part of COD. BOD is the biochemical oxygen demand, the quantity of oxygen consumed by aerobic microorganisms due to carbonaceous oxidation at a standard temperature (20°C).

COD was measured according to the dichromate standard method in COD test tubes with an ET 108 digester and a Lovibond PC Checkit photometer. Before sCOD determination the samples were centrifuged for 20 minutes at 6000 RCF. The separation of water soluble phase a 0,45 μm pore size disc filter (Millipore) was used. The biochemical oxygen demand measurements were carried out in a respirometric BOD meter (BOD Oxidirect, Lovibond, Germany), at 20°C. To ensure the consistency of the results BOD microbe capsules (Cole Parmer, USA) were used for measurements. Biodegradability during 5 days ($BD_5$%) was characterized by the (1) expression:

$$BD_5\% = \frac{BOD_5}{COD} \times 100\% \quad (1)$$

The anaerobic degradability batch mesophilic biochemical methane potential (BMP) tests are used with applying of acclimated inoculums of methanogenic bacteria at mesophilic temperature range (25-45 °C). By our measurements the cumulative biogas production tests were performed in batch mode under mesophilic conditions, at 40°C for 30 day, in a temperature controlled anaerobic digester with Oxitop Control type pressure mode measuring system (WTW Gmbh, Germany). The digesters were inoculated with an acclimated anaerobic sludge from a biogas reactor of municipal wastewater treatment plant (Hódmezővásárhely, Hungary) in order to eliminate the possible lag-phase of biological degradation process. After inoculation nitrogen gas was flowed through the reactor to prevent exposure to air.

## 3. RESULTS AND DISCUSSION

The surface temperature of samples was measured by infracam, and the average temperature and standard deviation were represented in the following table.

Table 1: The surface temperature of microwave irradiated sludge after treatments

| MW Power level | Surface temperature [°C] | | | |
|---|---|---|---|---|
| | 10 min. | 20 min. | 30 min. | 40 min. |
| 1 W/g | 75,7 ± 2,9 | 83,5 ± 1,8 | 89,2 ± 1,6 | 90,2 ± 1,3 |
| 2 W/g | 79,3 ± 2,2 | 86,7 ± 1,4 | 89,6 ± 1,1 | 91,7 ± 0,7 |
| 5 W/g | 83,6 ± 0,8 | 89,1 ± 0,9 | 90,8 ± 0,3 | 92,8 ± 0,4 |

In the first series of our experiments the effect of microwave irradiation on biodegradability of sewage sludge was investigated at different specific microwave power level. Besides the specific power level the effect of irradiation time was studied too. It was found that without pre-treatment the dairy industrial sludge was less biodegradable because the biodegradability of untreated dairy sludge was 8%.

The biodegradability of dairy sewage sludge was 8% and however it was find that without pre-treatment the sludge was in a large measur resistant to aerobical biological degradation. The structure of dairy sludge, formed by interaction of extracellular polymeric substance and applied chemicals, caused less accesible property for biological decomposation.

Microwave irradiation at low power level (1 W/g) had slightly effect on biodegradability, but the higher microwave power level and enhanced irradiataion time seemed to be more efficiently. By higher applied power level (5-10 W/g) a saturation value of biodegradability was observed. The ratio of biodegradable component of dairy originated sludge was enhanced from 8 % to 40 % after 30 minutes microwave irradiation at 5 and 10 W/g (Fig. 1).

The following measurements the effect of microwave irradiation on solubility of organic matter content of dairy originated sewage sludge were examined. The water-solubilization of organic component was characterized by the ratio of soluble COD (sCOD) and total COD.

It was found that the microwave pre-treatment could increase the quantity of water-soluble part of organic matter. Similar to biodegradability in the case of solubility of organic matter content saturation values were observed at 5 and 10 W/g specific microwave treatment level, but the differences in values of solubilisation were more considerable (from 10% to 50%) than values of biodegradability (Fig. 2). But the efficiency of increased microwave power level was slighter than the difference by biodegradability. Enhancing of biodegradability may be linked to solubilization of organic matter which was indicated by the increased sCOD/COD ratio.

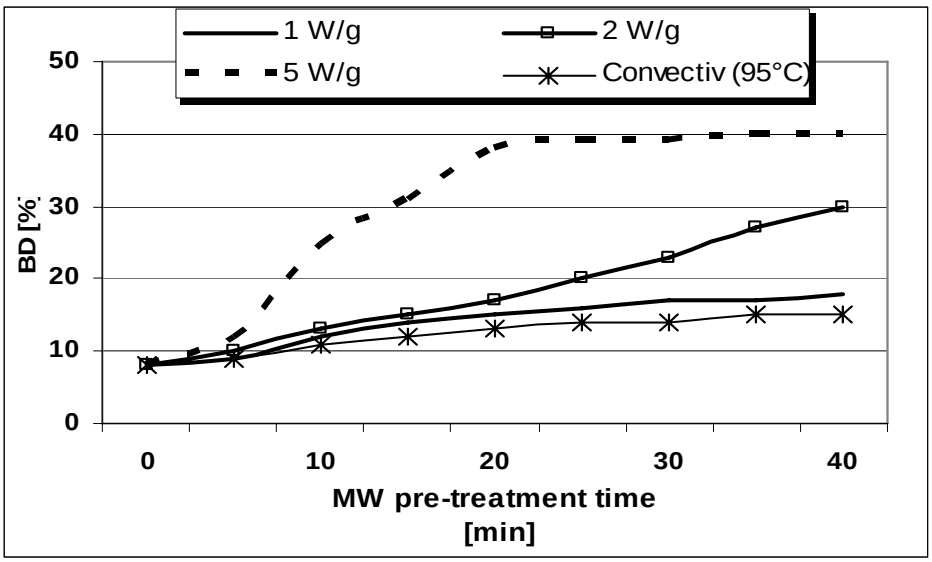



Fig. 1. Biodegradability (BD%) of dairy sewage sludge
after microwave and convective pre-treatments

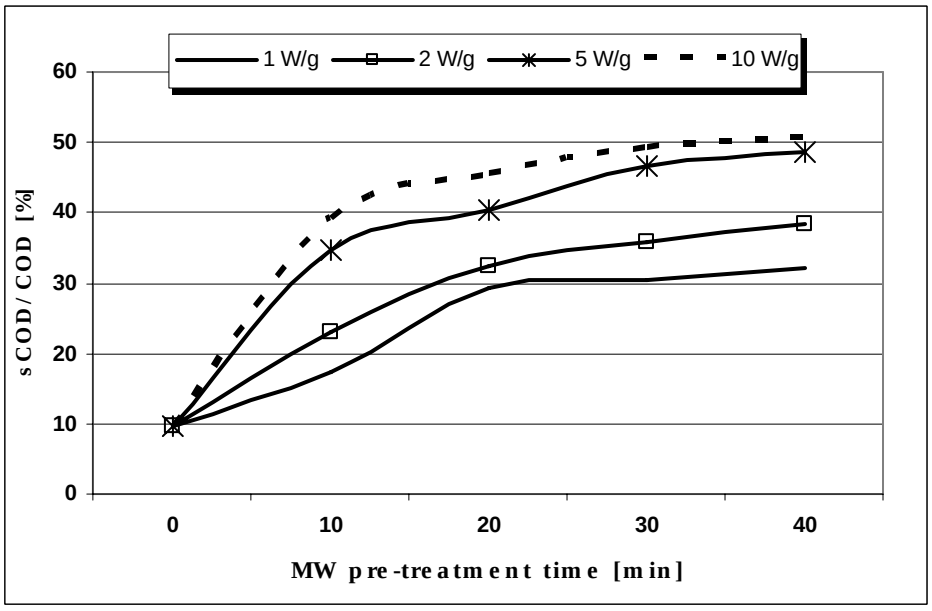



Fig. 2. The effect of microwave pre-treatments on solubilization (sCOD/COD ratio)
of organic matter content of sludge

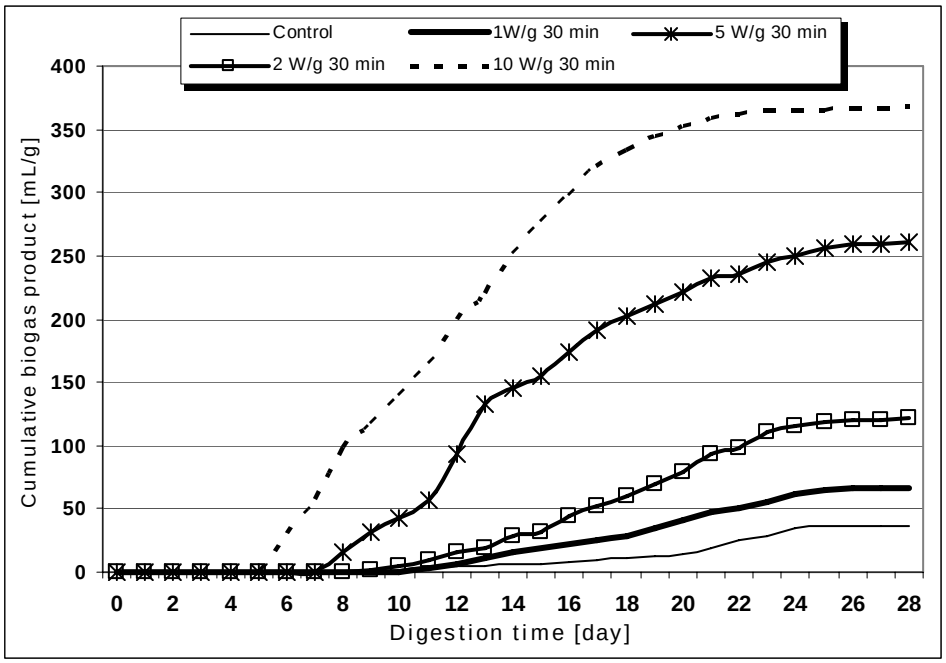



Fig. 3. Cumulative biogas product of microwave pre-treated sludge

Besides the change of biodegradability and solubilization the effect of microwave irradiation on anaerobic digestion was investigated also. The digestionability was characterized by cumultive biogas production. Similar to aerobical biodegradation the microwave pre-treatment improved the efficiency of the anaerobical decomposation. The untreated control sample had a small (40 $cm^3/g$) biogas production, and after a pre-treatment at 2 W/g for 30 minutes enhanced the methane product up to 120 $cm^3/g$ and by 10 W/g microwave treatment the biogas product could reach the 350 $cm^3/g$ value. The applied microwave treatment could decreased the lag-phase period of anaerobic digestioning process. The higher specific microwave power caused higher increasing in biogas production and however higher decreasing could have measured in period of lag-phase. Increasing power level of microwave treatment from 5 to 10 W/g caused a great enhancing in biogas product but not in the solubilization or aerobic biodegradability (Fig. 2, 3).

## 4. CONCLUSION

Our results showed that the microwave irradiation is successfully adjustable and utilizable technique in sewage sludge handling. Applying of microwave pre-treatment the solubility of organic matter content increased and it enhance more efficiently the aerobical biodegradability and biogas yield than the convective heat pre-treatments.

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# THE EFFECT OF MICROPARTICLES FOR THE MEMBRANE RESISTANCE

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**Abstract**

The aim of this study was to examine the applicability of bakelite particles for the reduced of the cake layer. Formation of a cake layer on the membrane surface has a decreasing effect on the long-term behaviour of the system. A typical cake layer shows compaction, which causes decrease in the porosity of the cake layer. One alternative approach to reduce fouling is to enhance the local shearing near the membrane surface, thereby increasing mass transfer of accumulated compounds back into the feed bulk. Ways of increasing the local shear rate near the membrane surface is use of scouring particles.

**Keywords:**

microfiltration, microparticles, shearing

## 1. INTRODUCTION

Pressure-driven membrane separation processes (microfiltration, ultrafiltration, nanofiltration and reverse osmosis) are important and attractive alternative candidates to conventional wastewater treatments for purification of wastewater and surface water [1], because of their high removal efficiencies and also because it allows reuse of the treated water or some of the valuable waste constituents [2]. The pressure-driven membrane techniques present several advantages: the permeate purified usually has a great quality, the processes are easy to operate with moderate temperatures and low energy requirements in general, no chemicals are needed, and combination with other separation processes is easy due to modular construction. In these processes, the water passes through the membrane and contaminants are removed by various mechanisms mainly depending on the pore size. Generally, microfiltration membranes have pores ranging from 0.1 to 10 μm and operate at pressures below5 bar [3]. They are useful for the removal of suspended solids, emulsified components and microorganisms larger than the pore size. Crossflow microfiltration is widely used in concentrating, purifying or separating macromolecules, colloids and suspended particles from solution.

Among the numerous applications of cross-flow microfiltration in the food processing industry. However, industrial applications of this technology meet two main problems. Permeate flux in microfiltration processes decreases with time as the retained particles accumulate on the membrane [4].

Membrane fouling is a very complicated phenomenon mainly caused by adsorption of particles, pore shrinkage and blockage, deposition of particles on the membrane surface and concentration polarization [5], and it is the irreversible alteration in the membrane caused by specific physical and/or chemical interactions between the membrane and various components [6]

The build-up of the filter cake increases the cake-layer resistance to flow, thereby it reduces the filtration flux rate, decreases the longevity of the membrane modules and increases the cost of production and limits the further industrial application to membrane microfiltration technology. Hence, how to alleviate the thickness of filter cake on the membrane surface is still a focus and key technology in membrane field and many various techniques have been suggested, such as turbulence promoting inserts, rotating. [7]. One alternative approaches to reduce fouling are discussed here. The local shear increase near the

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membrane surface, thereby increasing mass transfer of accumulated compounds back into the feed bulk. Ways of increasing the local shear rate near the membrane surface is use of scouring particles (bakelite) [8].

## 2. MATERIALS AND METHODS

*Solution preparation*

40 g bakelit particles were added into the 20l chulk-dust solution to prepare suspensions. We were added 125-160 μm, 160-200 μm and a 200-400 μm size bakelite. The prepared suspension was well mixed and was pumped into the cross-flow system by using a circulation pump. The suspension concentrations are 0.2, wt%.

*Microfiltration experiments*

The cross-flow microfiltration (MF/K1) unit used is represented in Fig. 1. It featured a tubular ceramic membrane, with the following attributes: 19 channels with an internal diameter ($d$=2.5 mm), average pore size diameter (0.45 μm), and a total effective filtration area ($A$ = 0.125 m²). Temperature was controlled, using cold water circulating through a tubular heat exchanger (H). Operating temperature was adjusted to 25±2 ◦C. The cross-flow velocity was adjusted and measured by a rotameter (R). The filtration pressure was adjusted by the control valves (14,17) and was measured using the pressure indicators (PI/1, PI/2). TMPs were varied at 100, 150, 200, 250, 300 kPa to determine TMP-dependent changes in permeate recycle of cross-flow filtration. The crossflow velocities are 2, 4, 6, 8, 10, 12 in this study. The Reynolds number is about 1500–5500. The concentrated chalk-dust solutions were recycled back into the suspension tank.

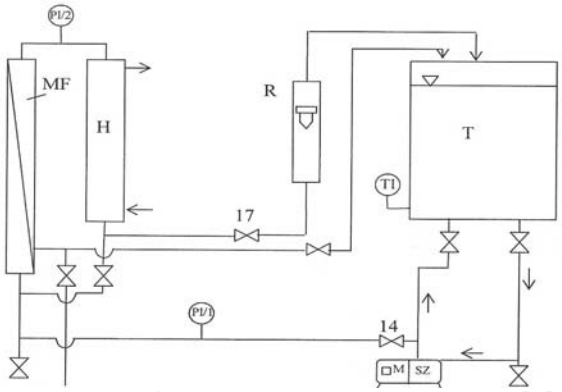


Figure 1. MF/K1 microfiltrtation equipment [9]

Before each experiment, the water flux was measured with destillated water at 20 ◦C. Membrane regeneration was achieved by washing in a 10gL⁻¹ NaOH solution and rinsing with distilled water under flux. A classic industrial cleaning procedure is carried out and followed by another determination of the clean membrane resistance:

$$J_W = \frac{\Delta p_{TM}}{\eta_W \cdot R_M} \quad (1)$$

where $J$ is the permeate flux rate (m s⁻¹) and $\Delta p_{TM}$ is the transmembrane pressure (Pa). The resistance ($R_M$) of the membrane was calculated from the flux using:

$$R_M = \frac{TMP}{\eta_W \cdot J_W} \quad (2)$$

where $\eta_W$ is the dynamic viscosity of water (Pa s). The membrane resistance at a TMP of 100 kPa was 1.16.±0.21×10¹¹ m⁻¹.

The total resistance ($R_T$) is calculated as:

$$R_T = R_M + R_{Cake} \quad (3)$$

where $R_M$ is the membrane resistance and $R_{Cake}$ the cake-layer resistance [10].

For the Re numbers, the following equation is used:

$$\mathrm{Re} = \frac{d_e \cdot v \cdot \rho}{\eta} \quad (4)$$

where $d_e$ is the equivalent pipe diameter, the v is the velocity, the ρ is the density and the η is the viscosity [11].

## 3. RESULTS AND DISCUSSION

The relation between flux and TMP was measured for the different particles used in chulk-dust solution. The results are presented in Fig. 2.

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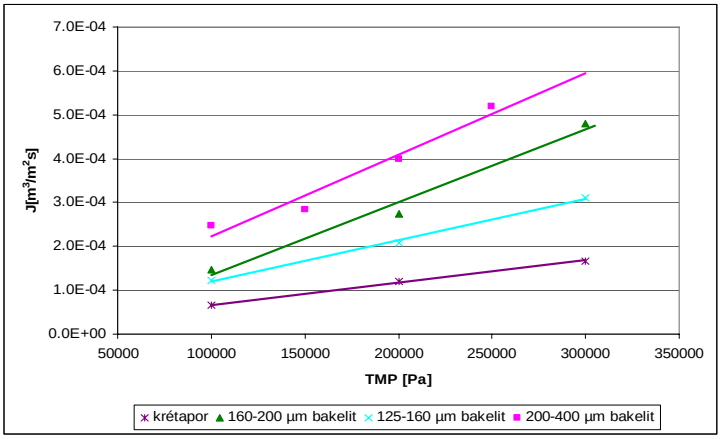



Figure 2. Flux change on the different TMP

There is a linear relationship between the flux and the transmembrane pressure difference at each case. The fluxes of the culk-dust solution are always lower than the bakelite solution because of the bakelite particles cause turbulence on the surface of the membrane. Due to the greater shearing on the membrane surface the cake layer resistance reduced and the molecules of the solvent can go easier though the membrane pores. I measured the lowest fluxes with the 125-160 µm size bakelite. The increasing of the diameter of particles caused increasing in the flux. I received the best fluxes with the 200-400 µm size bakelite, so here was the largest the shearing force.

We examined the hydrodynamic effect and we calculated the Re numbers. Increasing of Re numbers caused increasing of the permeate flux as well (Figure 3.).

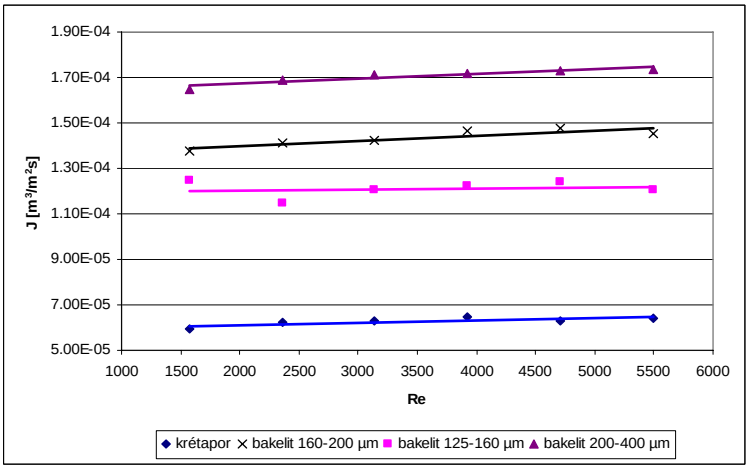



Figure 3. The measured fluxes vs. Re numbers

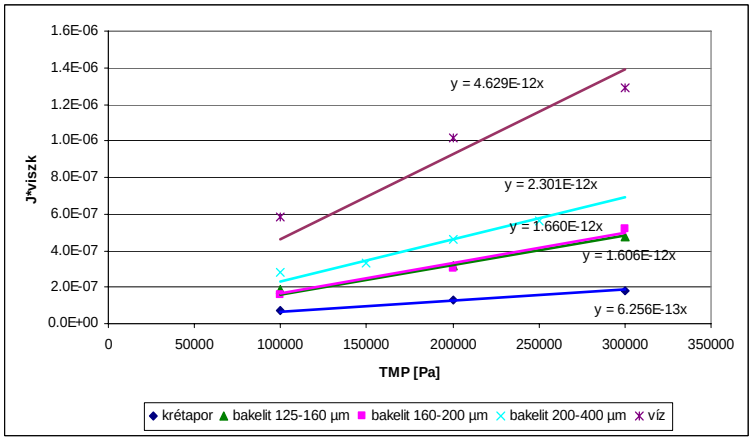



Figure 4. The total resistance ($R_T$) determination by fitted lines

The fluxes of the culk-dust solution are the lowest. The Re number values are into the laminar and transitional range, but the bakelite particles caused local turbulence on the surface of the membrane, that show the higher flux values. From the slopes of the lines according to Eqs. (5) the total resistance ($R_T$) at the end of the process can be calculated (Figure 4.).

$$J \cdot \eta = \frac{1}{R_T} \cdot \Delta p_{TM} \tag{5}$$

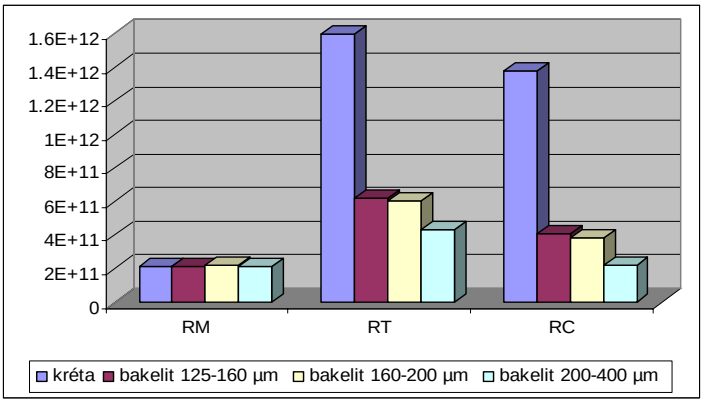



Figure 5. The comparison of resistance values

In the Figure 5 we can see, that the total resistance and the cake resistance are significant higher with the chulk-dust solution. The total resistance is the lowest with the 200-400 µm size bakelite, so these particles made the highest shearing force on the membrane surface, so decreased the thickness of the cake. The membrane resistance values are similar in all cases, because the membrane purification was efficient.

## 4. CONCLUSIONS

This work reports new results in the alternative approach to reduce of fouling. The use of bakelite can improve the performance of membrane processes. Introducing scouring particles seems very beneficial some microfiltration processes using conventional equipment. The bakelite enhances the local shear near the membrane surface. This approach has been successful in increasing fluxes of microfiltration. The larger particles induce much higher shear-induced diffusion and therefore dramatically improve mass transfer. The shear force is dependent on the square of the particle radius. Increasing size of bakelite was associated with an increasing flux. The total and the cake resistance were significant higher with the chulk-dust solution than with the bakelite. So the bakelite particles decreased the resistance of the filtration.

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# CALCULUS METHOD OF THE TECHNOLOGICAL LOADS TRANSMITTED TO THE EXTRACTING TOWERS WITH THE HOISTING INSTALLATIONS OF WINDING MACHINES WITH MULTICABLE DRIVING WHEELS ON

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**Abstract:**

In the paper there are presented certain aspects concerning the calculus of technological loads transmitted through the bearings of the extracting pulleys of the structure of the towers of the extracting installations in the case of functioning loads.

In the case of the extracting installations which have the extracting machine on the ground, having as a wrapping organ of the cables friction driving wheels, or a moving wheel the variation of the loads is determined not only by the kinematics of the installation (kinematics parameters), the dynamic (friction and inertia forces), but also by certain geometrical elements which define the position of the extracting machine towards the well geometrical elements that refer only to these type of installations. These geometrical elements are the incline angles of the extracting cable chords. These aspects were showed on the installation ,,Skip Shaft“ belonging to Mining Plant Lonea.

**Keywords:**

calculus method, technological loads, extracting tower

## 1. INTRODUCTION

In the case of the extracting installations which have the extracting machine on the ground, having as a wrapping organ of the cables double cylindrical wheels, or a moving wheel the variation of the loads is determined not only by the kinematics of the installation (kinematics parameters), ther dynamic (friction and inertia forces), but also by certain geometrical elements which define the position of the extracting machine towards the well geometrical elements that refer only to these type of installations.

These aspects were showed on the installation ,, Skip well “ Lonea Mining Plant (Fig.1). The installation taken into study has benn described as follows.

## 2. THE INSTALLATION TAKEN INTO STUDY

The extracting installation that operates on the new skip well from Lonea Mining Plant, is destined [7] for the extraction from the underground of minerals. The extraction is done from the horizons +169,40; +203,3 and 403,45 to the surface (the surface level is +704,5m; and the skip unloading level is +715,5m).

The installation (Fig.1) is ballanced and has an extracting machine type MK 5x2 (Fig.2) equipped with two motors type M2M-1000-213-4YXP/1986, of 1000 kW power and a nominal rpm of 54 rot/min (Fig.3).

The cables are wrapped around a moving wheel of ϕ 5000 mm (Fig.4).

The extracting cables with diameters of ϕ 46,5 mm and a mass (on a linear meter) of 8,049 kg/m are wrapped around the two extracting pulleys of ϕ 5000 mm with a mass (the pulley, the axel of the pulley and the bearing of the axel) of 12.108,83 kg (Fig.5), laying on the tower at a height of 51 m (pulley axel) The ballanced cables have a section of 135x20 mm and a mass (on a linear meter) of 9,062 kg. The extracting vessels are skips having a mass (own mass, plus D.L.C., plus D.E.C. and suplimentary mass) of 21600 kg and the effective load is 7000-8000 kg/skip. Another main component of the extracting installation is the metallic

tower (fig.6) with a height until the pulley axel of 51 m. The structure of the tower is composed of the extracting pulley platform sustained by the leading component and the one abutment set up as a frustum pyramid The extracting machine lies on the ground (at a height of 7,5 m to the 0 level of the well (well collar), sideways from the tower (well tower), at a distance (of the wheel axel), towards the vertical portion of the extracting cables which enter the well of 44m. The length of the cable chord (the distance between the tangent points of the cable to the deviating pulley from the tower and the wheel of the extracting machine, in the central position of the chord (perpendicular on the wheel axel)), is for the bottom branch Lci=52,78253595m, and Lcs=58,78482883m for the top branch. The incline angles of the cables chords are βi = 48º 43' 37" for the bottom branch and βs = 44º 37' 07", for the top branch [7].



Figure 1. Extracting installation

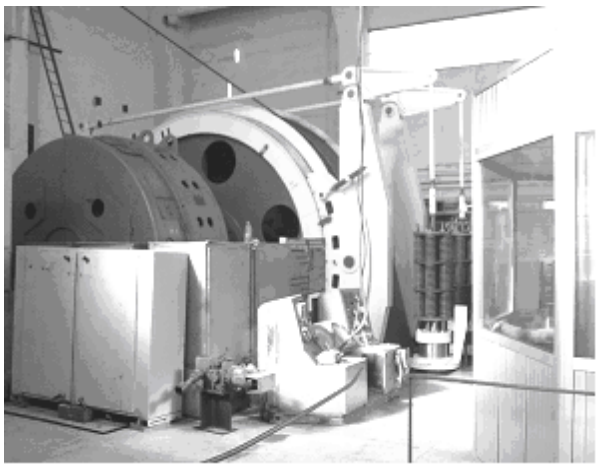


Figure 2. Extracting machine

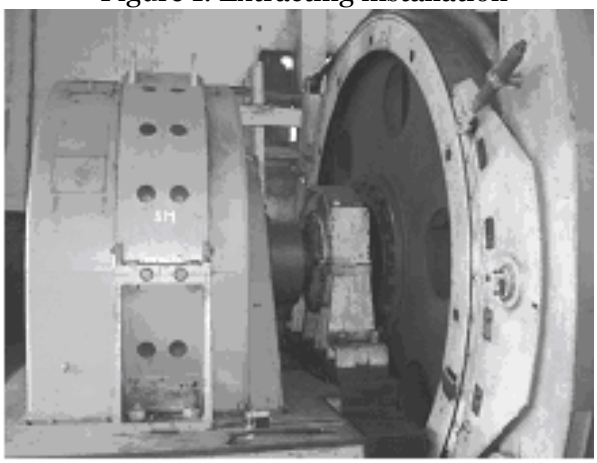


Figure 3. The motor

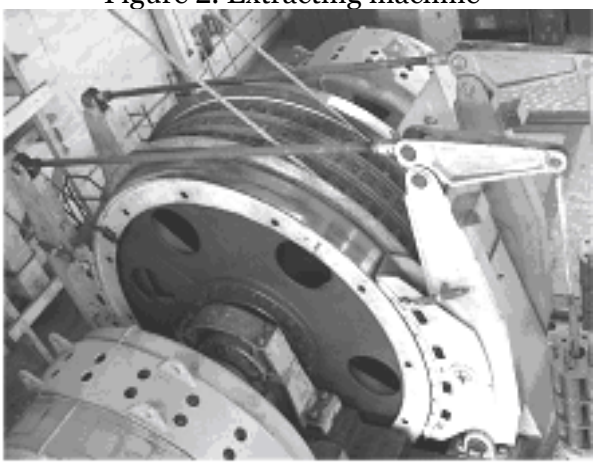


Figure 4. Wrapping organ

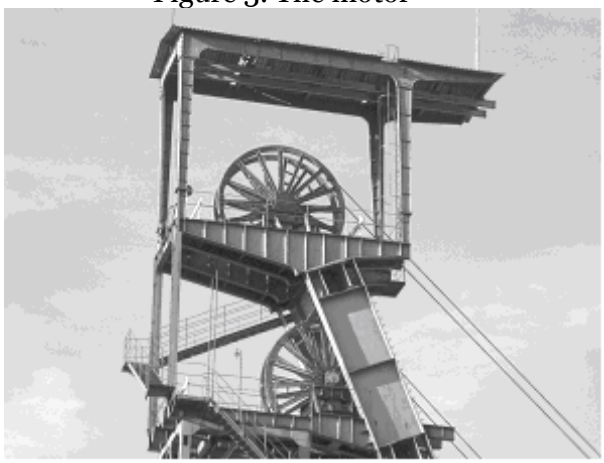


Figure 5. Extracting pulleys



Figure 6. Metallic tower

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## 3. LOADS TRANSMITED TO THE TOWER

For the determination of the loads (efforts) which act upon the installation taken into consideration it has been taken into study the case when one of the skips is descending (ascending) on one of the branches.

On the calculation of loads it has been considered the fact that their variation is determined not only by the kinematics of the installation (kinematical parameters) but also by certain geometrical elements which define the position of the extracting machine towards the well geometrical elements regarding only the installations where the extracting machine lies on the ground.([1],[3],[4],[5],[6]).

For this purpose it has been taken into analysis the case when the skip is descending on the top branch (case 1, the skip of the bottom branch is climbing and the top one is descending) and the case when the skip is descending on the bottom branch (case 2, the skip of the bottom branch is descending and the top one is climbing). The diagrams for the space, speed, and acceleration for the two cases taken into analysis are presented into Fig 7 case 1 and in Fig 8 case 2. The variations of acceleration and space have been used for the calculation of the loads applied to the tower. The determination of the loads acting upon the tower through the deviating pulleys has been done using the d'Alembert principle (the kinetics-static method [2]) taking into consideration the static forces (the weight of the extracting cable, the cage  the trolley the pulley and the load), the friction forces (multiple friction and aero-dynamic resistances which for installations with cages is approximated with a coefficient of k'=0,2 from the useful load [1]) and the dynamic forces (which intervene only in the acceleration and deceleration periods, Fig. 7 and Fig. 8).

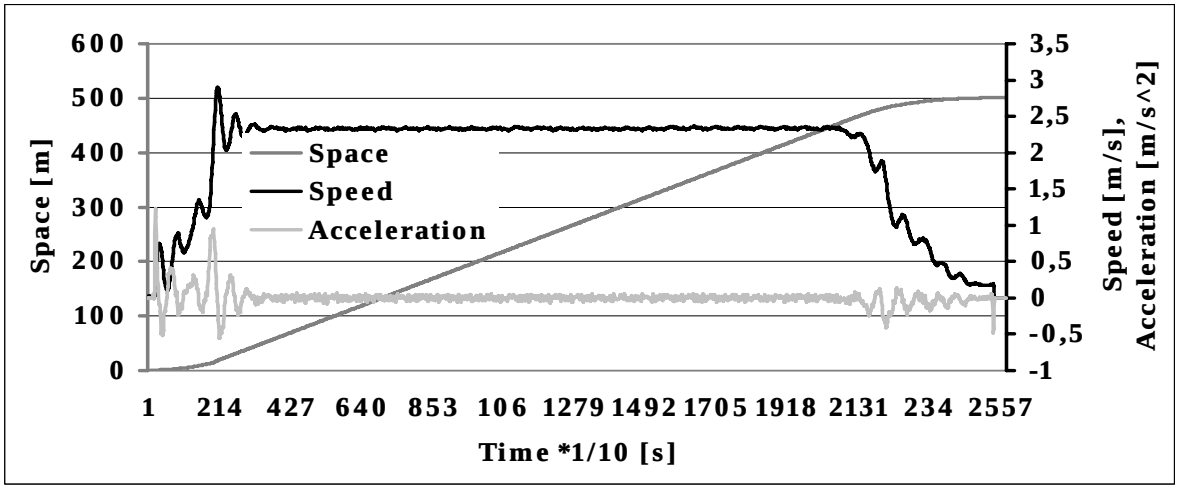



Figure 7. Speed acceleration and space for case 1

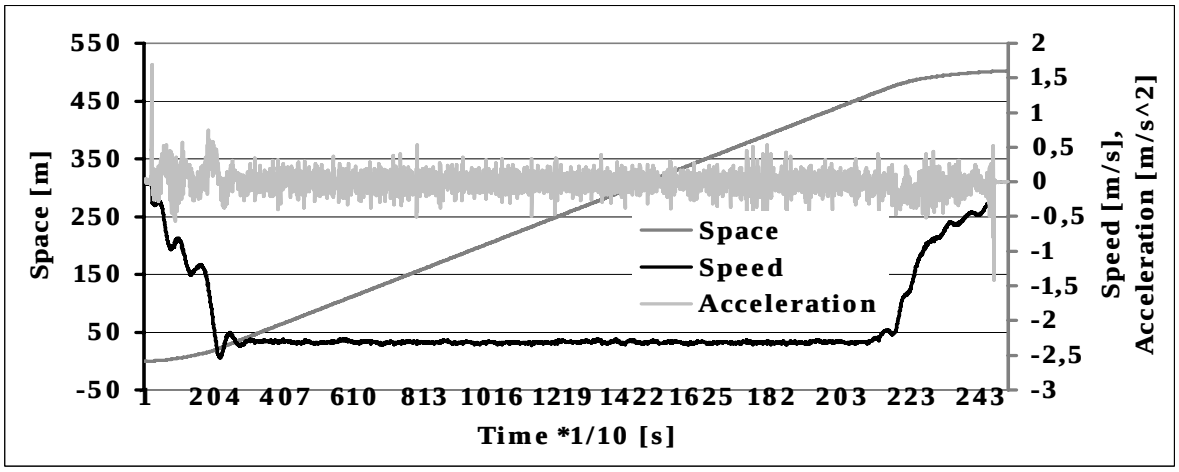



Figure 8. Speed acceleration and space for case 2

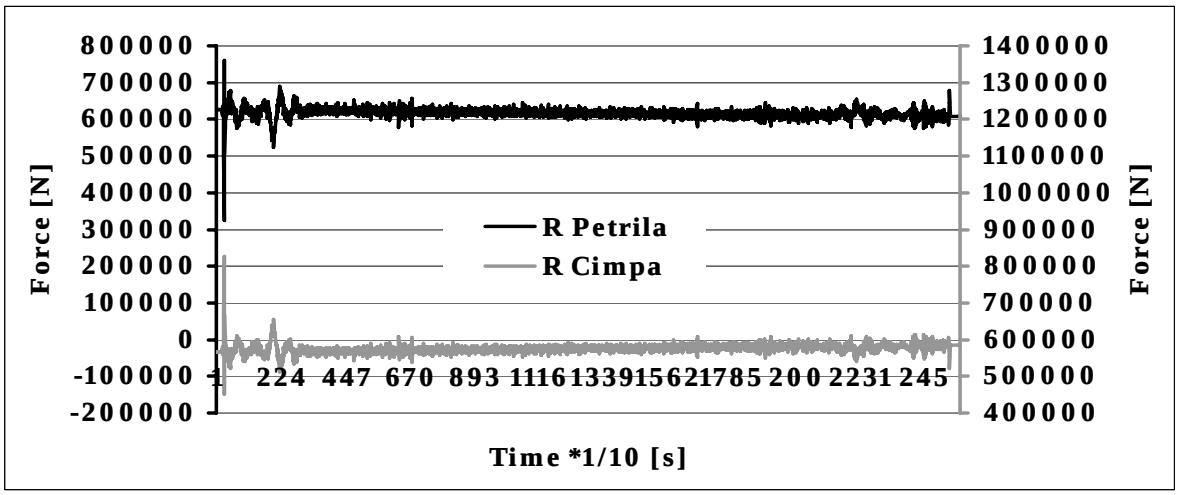



Figure 9. Reactions from the bearing of the top and bottom pulley when the top cage descends and the bottom one climbs, case 1

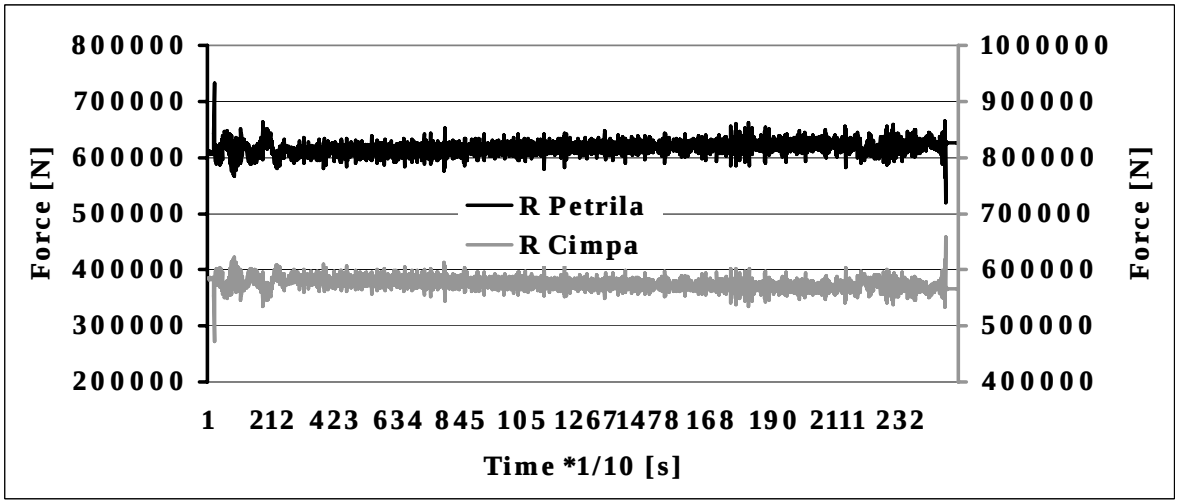



Figure 10. Reactions from the bearing of the top and bottom pulley when the top cage climbs and the bottom one descends, case 2

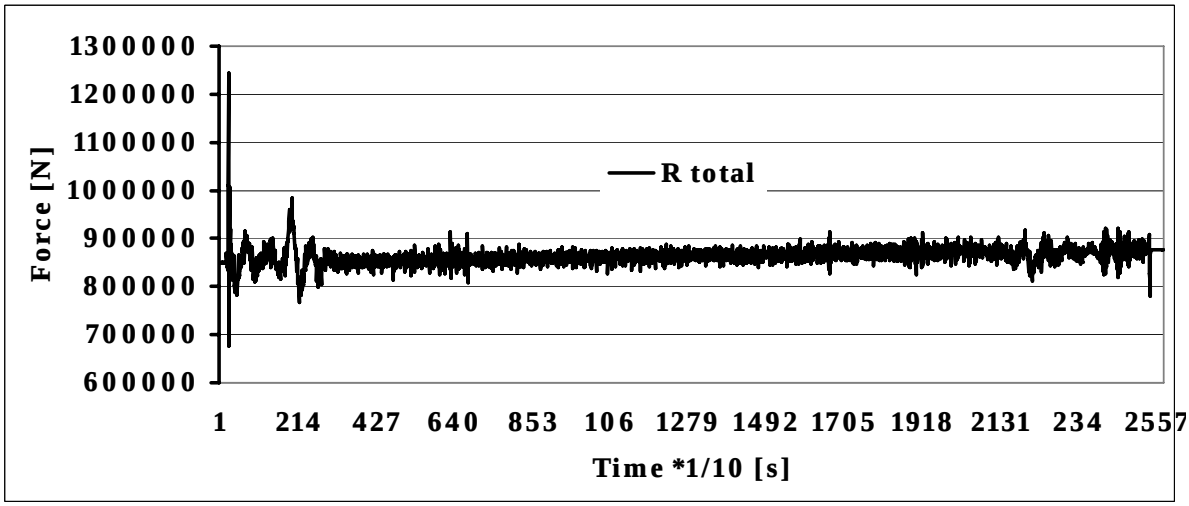



Figure 11. Total loads when the top cage descends and the bottom one climbs case 1

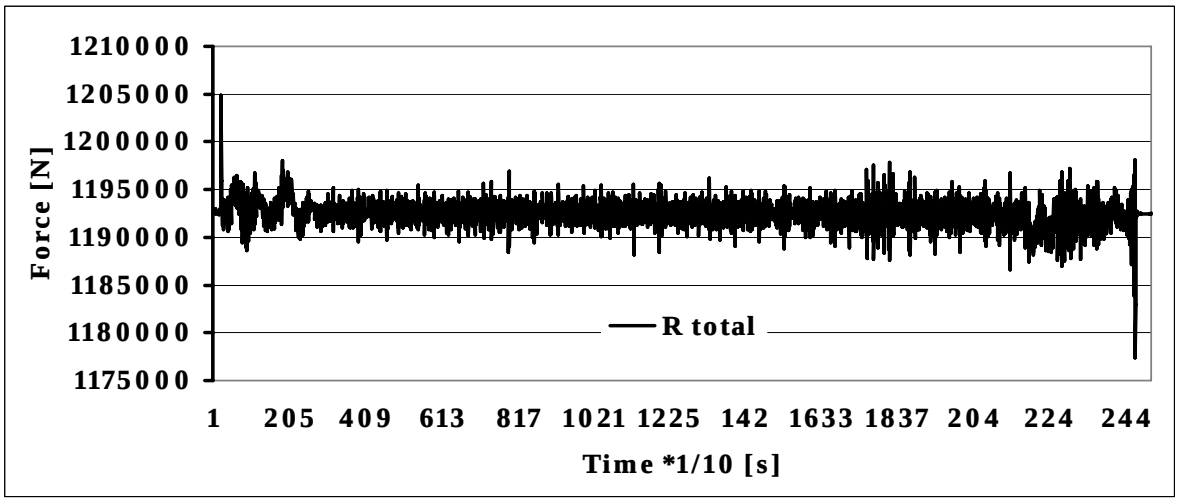



Fig. 12. Total loads when the top cage climbs and the bottom one descends case 2

The variation of the resultant forces from the bearings of the extracting pulleys for the two cases taken into consideration is presented in Fig 9, for case 1, for the top and bottom pulley and Fig 10, for case 2, also for the top and bottom pulley.

## 4. CONCLUSIONS

The calculation the structure of the mining extracting towers is done taking into consideration all the unfavorable combinations practically possible of the different loads called groups of loads.

Following the classification and grouping of the loads transmitted to the extracting mining towers in the paper there are presented certain aspects concerning the establishing of the exceptional short term loads due to the extracting cycle in the case of the appliance of the safety brake which are transmitted to the structure skip and the wrapping organ of the extracting machine is moving wheel.

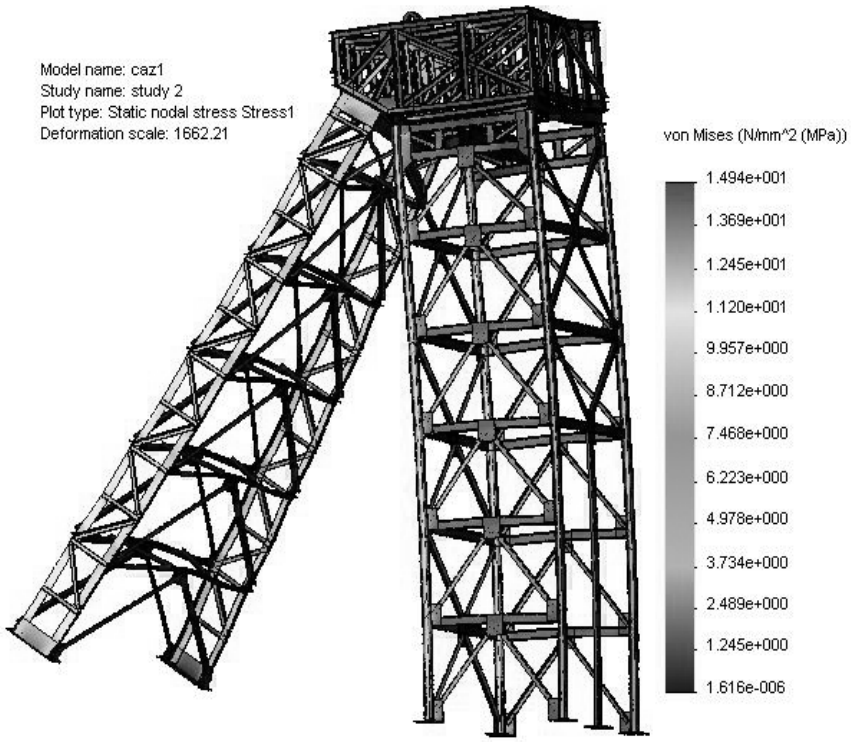



Figure 13. Stress on the tower

The loads transmitted to the tower through the bearings of the extracting pulleys from the tower due to the efforts from the extracting cables have been considered in the case when the emergency brake is applied due to an overcome of the max speed allowed when the skip are climbing and descending on one of the two extracting branches.

The variation of loads is due both for the cinematic parameters as well as for the geometric parameters of the extracting installation.

As noticed from the variation of the total loads which act upon the tower during an extracting cycle the maximum values are in case 1 of the cycle and in case 2 at the beginning of the cycle (Fig 11 and Fig 12).

The maximum values of the loads determined are further used to determine the values of mechanical stress and strain from the elements of the structure of the metallic tower of the installation in order to verify its resistance, like in Valea Arsului tower case, from Lonea Mining Plant. (Fig. 13).

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# ELEMENTS OF THE GEOMETRIC CALCULATION FOR STRAUGHT-TOOTHED CYLINDRICAL GEARS IN INCHES AND IN THE METRIC SYSTEM

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**Abstract**

The paper approaches the calculations of the basic geometrical elements of the cylindrical gear in inches and in metric system.
In the first part of the paper we present standardized reference racks in the main industrial states while in the second part we deal with the main gear equations that are used for diametral pitch inch gears and for metric gears.

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# MODIFIED DIAGRAM FOR STEAM-WATER INJECTOR MIXING CHAMBER

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**ABSTRACT**

The scope of this paper is a thermodynamic process in mixing chamber of supersonic steam-water injector. This injector is actually a simple heat pump due to the fact that it can substitute a pump and heat exchanger. Initial energy source of supersonic steam-water injector is usually a small amount of steam with low thermal properties which could not be used for more demanding utilities.

The aim of wider investigation is to build up a relatively high pressure of hot water at the outlet of mixing chamber during a "forced condensation" of steam which is in the cold water surrounding in mixing chamber. Forced condensation, which is described by modified Mollier diagram of wet steam, reveals clearer picture of this complex flow process.

The paper emphasizes Mach number ($M=v/c$) which, largely, represents flow process in mixing chamber. Sound velocity ($c$) is a physical property of fluid which is a function of different parameters ($T$, $\rho$, $\eta$, pipeline elasticity, solid impurities, gas bubbles). Intensity of sound velocity, in the case of steam-water injector, depends mostly on steam wetness. Experiments showed that flow process without shocks is possible and worthwhile because it provides the increase of efficiency rate and reliable operation. In addition, it can be concluded that the flow is without interruption and shocks due to small velocities of sound and fluid, which refers to outlet of mixing chamber where $M=1$. Momentum equation provides a possibility to determine location and intensity of average pressure ($p_{ave}$) in mixing chamber.

Accepted principles for description and analyses of thermodynamic processes in mixing chamber are based on process continuity, homogeneous flow field and thermodynamic and compressible flow laws.

Experimental investigation was done in Laboratory for Fluid Mechanics, at the Faculty of Technical Sciences in Novi Sad, Serbia.

**KEYWORDS**

Steam-water injector, mixing chamber, forced condensation, modified Mollier diagram, supersonic mixing chamber

## 1. INTRODUCTION

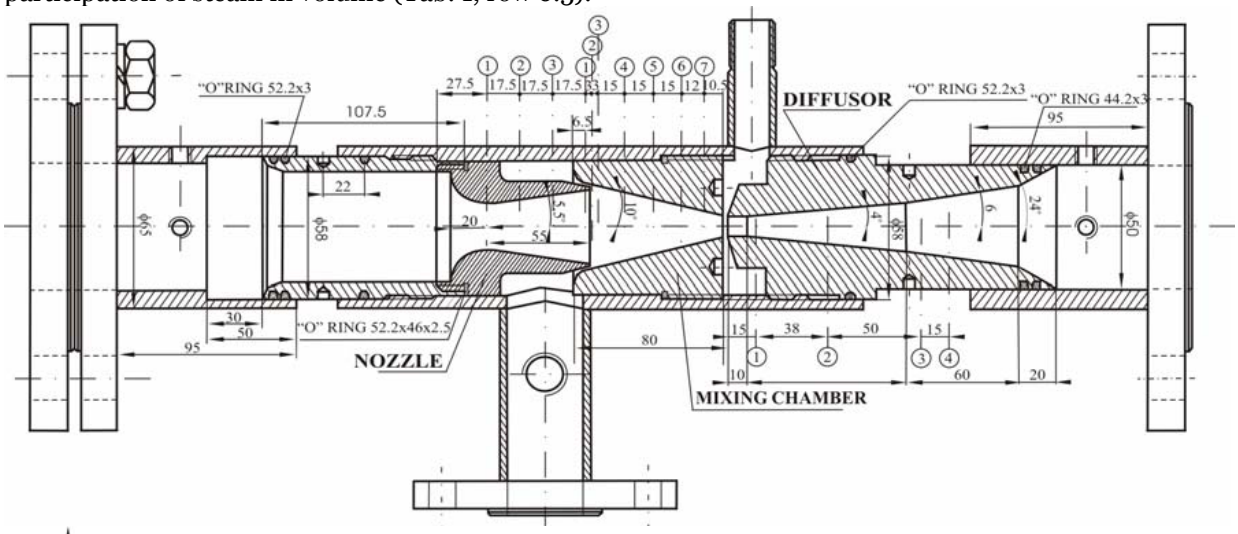
A possibility to gain pressure and rise temperature of mixture of cold water and steam was registered more than 120 years ago. Injector was instantaneously applied in feeding steam boiler with water. However, until today, reasonable and acceptable explanation of what really happens in mixing chamber has not appeared, although there have been numerous attempts. Many registered patents for different purposes of steam-water injector pointed out the usefulness of this device. Hence, striving to explain thermodynamic flow process through mixing chamber is fully justified. Detailed research of *Deich and Filipov* (1968) provided real basics for further investigations.

Steam and water parameters in experiments are: ratio steam-cold water is 1:5; $p_s$=2.5 bar; $t_s$=127.5 °C; $t_{cw}$=10-30 °C; $t_{hw}$=65-85 °C. In Fig. 1. is presented experimental steam-water injector. Pressure rise in mixture of steam and water, which is an intensive process of forced condensation, obey laws of compressible (supersonic) flow. Supersonic flow of steam at the outlet of Laval's nozzle, due to its dominating volume, transfers into the region of steam-water mixture. Locally formed shock waves, different in origin, are negligible when injector works properly. Conducted experimental research proved a possibility to maintain shock-less flow along injector. Relevant questions, which deserve precise answers, are:

- Which part of pressure rise in mixing chamber can or cannot be connected directly to enthalpy of initial steam?

- How to define sources and nature of losses in mixing chamber and determine efficiency rate of mixing chamber and total injector.

Mentioned shock-less transition of steam through Laval's nozzle and mixture through outlet throat of mixing chamber, can be explained with diagram of isentropic flow in supersonic regime (Fig. 2). This diagram is valid, to a certain extent, for homogenous mixture flow with considerable participation of steam in volume (Tab. 1, row 6.5).



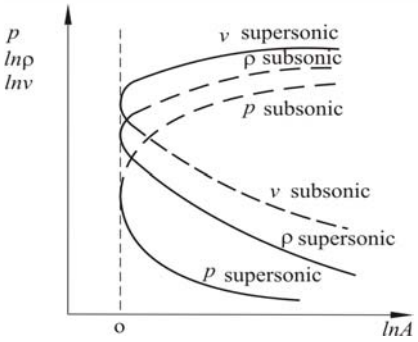




Fig. 1. Configuration of measuring locations and different possitions of Laval's nozzle and mixing chambers (Bukurov 2004)

Gradients of compressible properties of mixture (p, ρ) are specially large in very wet mixture at outlet section of mixing chamber, where transition from supersonic to subsonic flow takes place.

Fig. 2. Isentropic changes of flow parameters through supersonic-subsonic transition as function of nozzle geometry

## 2. MODIFIED ENERGY DIAGRAM

Modified diagram or diagram of forced condensation allows comparing three types of condensation processes:

- natural - free condensation of steam – without flow under $p$=const., $T$=const. (Mollier diagram)
- free condensation - flow without direct mixing of steam and water under $p \neq$const. and $T \neq$const. (Mollier diagram)
- forced condensation with direct mixing of steam and water ( $\text{grad}p_{forced} > \text{grad}p_{free}$ ).

Range of condensation in modified diagram corresponds to borders of mixing chamber where the whole condensation process takes place. Energy change, no matter if condensation is free or forced, is from 2500 kJ/kg to 0 kJ/kg (Fig. 3).

Graphical presentation of processes during forced condensation in mixing chamber, due to introduced cold water, provides better physical view than applicable analytic equations. Also, there are open possibilities to make conclusions about certain parts of processes as well as data which can help to organize experiments more efficiently.

Diagram $p$-$h$ is the most convenient way to present the results of investigation.

Forced condensation begins when water is introduced into steam region. It has four basic characteristics:

- Condensation process is faster and lasts shorter;
- Geometry of mixing chamber is changed (central angle of conical mixing chamber increases);
- Gradients of physical, flow and energy characteristics, which are functions of time and distance, are considerably larger;
- Temperature through condensation process is below steam temperature at the inlet of Laval's nozzle (127.5 °C, Fig.3).

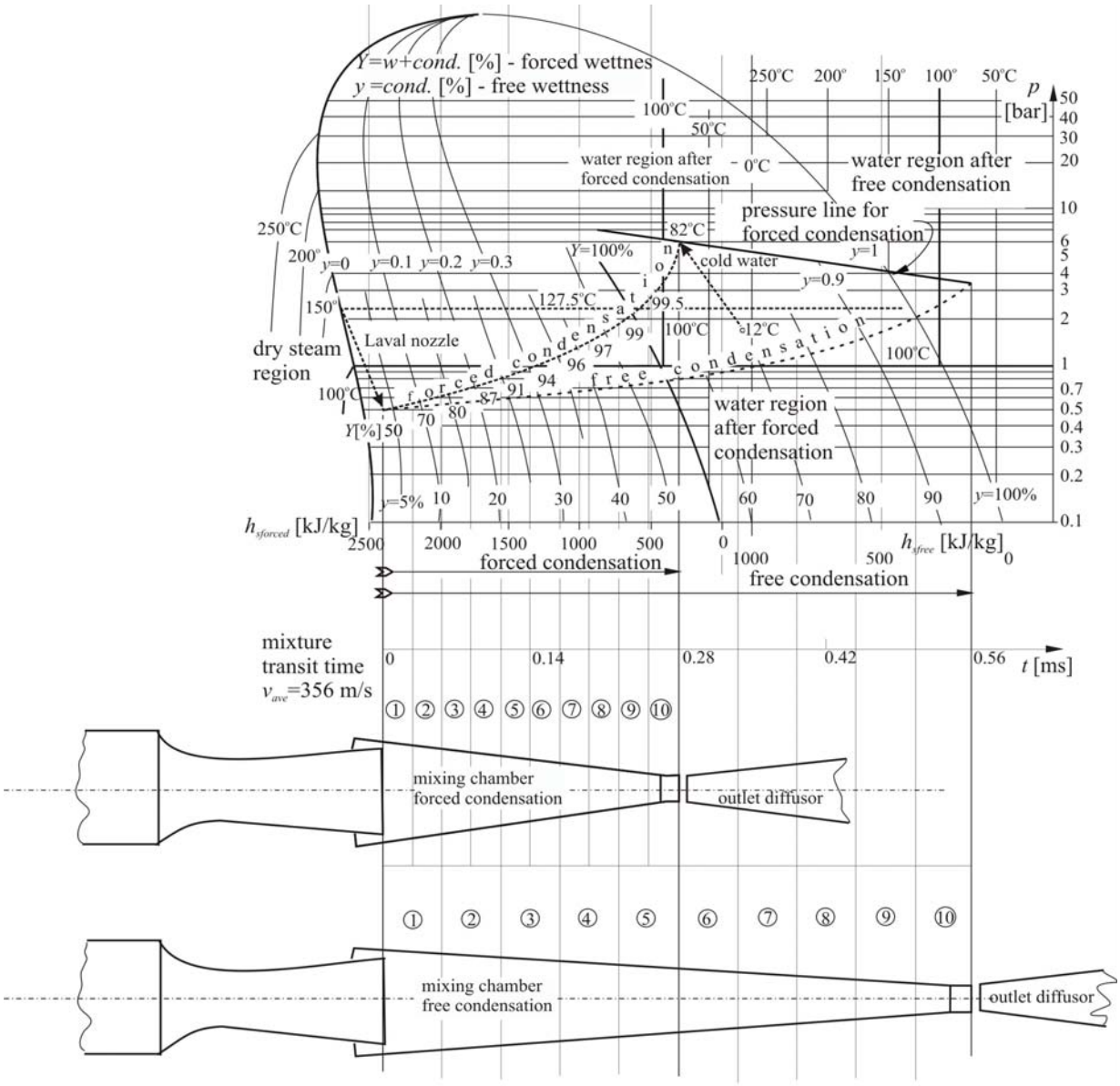



Fig. 3. Energy and geometry change in mixing chamber for forced and free condensation

## 3. LOCAL CONDENSATION PARAMETERS *X*, *Y*

Modified energy diagram is formed by drawing new lines (*X*, *Y*) in Mollier diagram (*x, y*) of wet steam. Steam quality *X* is a concentration of dry saturated steam (*x*=*X*). Wetness *Y* is water fraction which is involved during forced condensation. In Mollier diagram of wet steam, *x* and *y* represent mass fractions of dry saturated steam and water under standard (static) conditions. It is possible to reach such conditions during the flow (hypothetically) when every section of mixing chamber is instantaneously separated. Masses of steam and water are calculated for each section (1-10 in Fig.3). This type of concentration of steam and water is called local concentration, i.e. local dryness (steam quality) and wetness.

Although total amount of cold water is introduced at the entrance of mixing chamber, it is considered that cold water is mixing with wet steam along the whole mixing chamber. Mixing occurs in such manner that each 1/10 of inlet water is mixed with steam in every section and thus, mixture (*X*, *Y*) is produced. Unmixed part of water flows further. Hence, there are two different kinds of water: water for mixing (*wm*) and the rest of water (*wrest*).

Condensation of steam (*y*) is conducted continuously and homogenously along the whole mixing chamber. Definition of free condensation (*p*=const., *T*=const.) is valid for forced condensation too, although pressure and temperature rise. Volume of steam in mixing chamber corresponds to uniform condensation profile in the mixing nozzle according to *Beithou et al.* (2000).

Mass characteristics of steam and water, i.e. dryness $X$ and wetness $Y$ along the mixing chamber are determined according to velocities of steam ($v_s$) and water flow through chamber, which are presented in Table 1. Velocity diagram ($v_s$,$v_m$) is presented according to experimental results and flow laws.

Table 1. Characteristic values of mixture in sections of mixing chamber

Inlet properties of steam and water: $\dot{m}_s = 0.17\,\text{kg/s};\ \dot{m}_w = 0.85\,\text{kg/s}$. Assumption: steam condenses equally in each section of mixing chamber; cold water mixes with steam evenly in each section of mixing chamber; the rest of cold water, which does not mix, stays inert.

| No. of section $i$ | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Geometry of sections | | | | | | | | | | | |
| 1.1 | $d_{iave}$ [cm] | 3.28 | 3.04 | 2.8 | 2.56 | 2.32 | 2.08 | 1.84 | 1.6 | 1.36 | 1.12 |
| 1.2 | $A_i$ [cm²] | 8.44 | 7.25 | 6.15 | 5.14 | 4.22 | 3.4 | 2.66 | 2.01 | 1.45 | 0.98 |
| 1.3 | $V_i$ [cm³] | 8.44 | 7.25 | 6.15 | 5.14 | 4.22 | 3.4 | 2.66 | 2.01 | 1.45 | 0.98 |
| Characteristics of steam | | | | | | | | | | | |
| 2.1 | $v_s$ [m/s] | 710 | 680 | 650 | 600 | 530 | 450 | 350 | 250 | 150 | 50 |
| 2.2 | $\rho_s$ [kg/m³] | 0.338 | 0.395 | 0.45 | 0.507 | 0.646 | 1.0 | 1.40 | 1.7 | 2.16 | 3.0 |
| 2.3 | $\dot{m}_s$ [kg/s] | 0.161 | 0.144 | 0.127 | 0.110 | 0.093 | 0.08 | 0.059 | 0.04 | 0.02 | 0.008 |
| 2.4 | $Q_s$ [l/s] | 478 | 366 | 283 | 218 | 145 | 76.5 | 39.2 | 25 | 11.2 | 0.28 |
| 2.5 | $A_s$ [cm²] | 6.729 | 5.628 | 4.358 | 3.632 | 2.73 | 1.7 | 1.122 | 1.0 | 0.79 | 0.566 |
| Characteristics of condensate in the central part of each section (0.05, 0.15,...0.95) | | | | | | | | | | | |
| 3.1 | $\dot{m}_{con}$ [kg/s] | 0.0085 | 0.025 | 0.0425 | 0.0595 | 0.0765 | 0.093 | 0.11 | 0.127 | 0.144 | 0.15 |
| 3.2 | $Q_{con}$ [l/s] | 0.0085 | 0.025 | 0.0425 | 0.0595 | 0.0765 | 0.093 | 0.11 | 0.127 | 0.144 | 0.15 |
| 3.3 | $A_{con}$ [cm²] | 0.0001 | 0.0004 | 0.0006 | 0.001 | 0.0014 | 0.002 | 0.0031 | 0.005 | 0.009 | 0.03 |
| Characteristics of water for mixing $v_{wm}$=0.5$v_s$ | | | | | | | | | | | |
| 4.1 | $v_{wm}$ [m/s] | 355 | 340 | 325 | 300 | 265 | 225 | 175 | 125 | 75 | 25 |
| 4.2 | $Q_{wm}$ [l/s] | 0.085 | 0.17 | 0.255 | 0.34 | 0.425 | 0.51 | 0.595 | 0.68 | 0.765 | 0.85 |
| 4.3 | $A_{wm}$ [cm²] | 0.0024 | 0.005 | 0.0078 | 0.011 | 0.016 | 0.023 | 0.034 | 0.054 | 0.102 | 0.34 |
| Characteristics of rest of water | | | | | | | | | | | |
| 5.1 | $\dot{m}_{wrest}$ [kg/s] | 0.765 | 0.68 | 0.595 | 0.51 | 0.425 | 0.34 | 0.255 | 0.17 | 0.085 | 0 |
| 5.2 | $A_{wrest}$ [cm²] | 1.708 | 1.617 | 1.783 | 1.496 | 1.473 | 1.675 | 1.501 | 0.946 | 0.55 | 0.044 |
| 5.3 | $v_{wrest}$ [m/s] | 4.479 | 4.205 | 3.337 | 3.409 | 2.885 | 2.030 | 1.699 | 2.24 | 1.797 | 0 |
| Volumes of fluids | | | | | | | | | | | |
| 6.1 | $V_s$ [cm³] | 6.729 | 5.628 | 4.358 | 3.632 | 2.73 | 1.7 | 1.122 | 1.0 | 0.788 | 0.566 |
| 6.2 | $V_{wm+con}$ [cm³] | 0.0025 | 0.0054 | 0.0084 | 0.012 | 0.0174 | 0.025 | 0.0371 | 0.059 | 0.112 | 0.37 |
| 6.3 | $V_{s+wm+con}$ [cm³] | 6.7315 | 5.6334 | 4.3664 | 3.644 | 2.7474 | 1.725 | 1.159 | 1.059 | 0.9 | 0.936 |
| 6.4 | $V_{wrest}$ [cm³] | 1.708 | 1.617 | 1.783 | 1.496 | 1.473 | 1.675 | 1.501 | 0.946 | 0.55 | 0.044 |
| 6.5 | $V_s/V_{wm+con}$ [-] | 2691.6 | 1042.2 | 518.8 | 302.7 | 157 | 68 | 30.2 | 16.9 | 7 | 1.53 |
| 6.6 | $V_s/(V_{s+wm+con}+V_{wrest})$ [-] | 0.8 | 0.776 | 0.708 | 0.706 | 0.647 | 0.4 | 0.421 | 0.5 | 0.543 | 0.604 |
| Masses of fluids | | | | | | | | | | | |
| 7.1 | $m_s$ [g] | 0.0022 | 0.0022 | 0.0019 | 0.0018 | 0.0018 | 0.0017 | 0.0016 | 0.0017 | 0.0017 | 0.0003 |
| 7.2 | $m_{wm+con}$ [g] | 0.0025 | 0.0054 | 0.0084 | 0.012 | 0.0174 | 0.025 | 0.0371 | 0.059 | 0.1112 | 0.37 |
| 7.3 | $m_{wrest}$ [g] | 1.708 | 1.617 | 1.783 | 1.496 | 1.473 | 1.675 | 1.501 | 0.946 | 0.55 | 0.044 |
| 7.4 | $m_{wtotal}$ [g] | 1.71 | 1.622 | 1.791 | 1.508 | 1.49 | 1.7 | 1.538 | 1.005 | 0.662 | 0.414 |
| Mixture humidity during forced condensation $Y=(m_{wm+con})/(m_s+m_{wm+con})$ $X=m_s/(m_s+m_{wm+con})$ | | | | | | | | | | | |
| 8.1 | $Y$ [-] | 0.527 | 0.707 | 0.812 | 0.867 | 0.908 | 0.936 | 0.959 | 0.972 | 0.985 | 0.999 |
| 8.2 | $X$ [-] | 0.473 | 0.293 | 0.188 | 0.133 | 0.092 | 0.064 | 0.041 | 0.028 | 0.015 | 0.0007 |
| Exponent of polytrophic process (Deich, 1968) | | | | | | | | | | | |
| 9.1 | $\kappa$ [-] | 1.08 | 1.015 | 0.95 | 0.86 | 0.76 | 0.67 | 0.5 | 0.38 | 0.25 | 0.01 |

where are in Tab 1.

$$2.5\ A_s = \frac{\dot{m}_s}{\rho_s v_s};\ 3.1\ \dot{m}_{con} = \dot{m}_{sin} - \dot{m}_s = 0{,}17 - \dot{m}_s;\ 3.3\ A_{con} = \frac{(0.05....0.95)\dot{m}_s}{\rho_w v_{con}},\ v_{con} = v_s;$$

$$4.3\ A_{wm} = \frac{Q_{wm}}{v_{wm}},;\ 5.1\ A_{wrest} = A_d - (A_s + A_{con} + A_{wm});\ 5.1\ \dot{m}_{wrest} = \dot{m}_w - \dot{m}_{wm};$$

$$5.2\ A_{wrest} = A_i - (A_s + A_{con} + A_{wm});\ 5.3\ v_{wrest} = \frac{\dot{m}_{wrest}}{\rho_w A_{wrest}}$$

Mass flow rates of steam and water are determined with their entrance values ($(\dot{m}_s)_{in}$ =0.17 kg/s, $\dot{m}_{cw}$ =0.85 kg/s). It is assumed that mixing and condensation are consistent in each section of the chamber. Volume flow rates of steam are determined according to data given in steam table for density ($\rho$) as function of pressure and temperature. Density of steam through chamber is changeable from 0.338 to 3.0 kg/m$^3$.

Velocity of water through mixing chamber, as well as its volume in considered section ($i$=1,2,...10), are determined according to geometry of mixing chamber and volume of steam.

Characteristics of water-steam mixture in certain sections of mixing chamber are shown in Table 1. Steam is condensed (*con*) in each section of mixing chamber equally. Cold water (*cw*) is mixed with steam equally in each section of mixing chamber, too. The rest of cold water (*rest*) which is not mixed with steam jet does not participate in steam water mixture formation. Entrance and exit diameters of experimental chamber are 3.4 and 1 cm. Length of chamber is 10 cm, and each section is 1 cm long. Volume of chamber is 41.70 cm$^3$.

## 4. BASICS FOR ENERGY FLOW ANALYSES

### Borders of polytrophic flow

Relation between volume of steam ($V_s$) and volume with active water ($V_{con}$+$V_{wm}$) is authoritative for estimation to which length of mixing chamber laws of gas dynamics are valid. It could be seen that steam is still present even in the last section of the chamber.

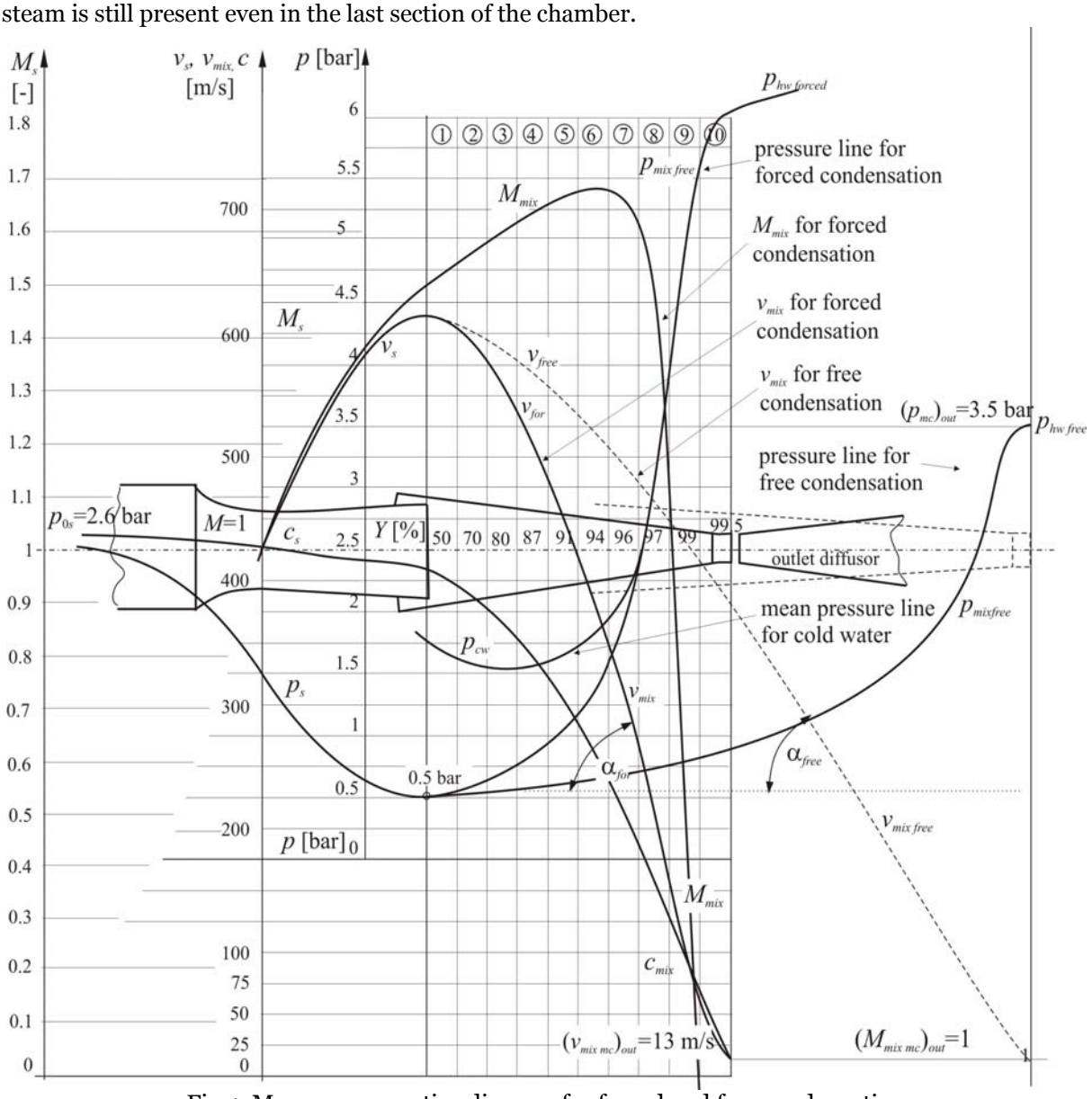



Fig 4. M, v, p comparative diagram for forced and free condensation

High wetness of steam water mixture through the whole mixing chamber causes low sound velocities and high Mach numbers, which confirms the behavior of compressible flow together with the given polytrophic exponents $\kappa$ (*Deich and Filipov* 1968).

The basic task is to determine a volume of steam and water along the mixing chamber. Steam carries total energy and thus, steam flow laws can be estimated according to thermodynamic relations with certain corrections. The flow is conducted in certain volume, so relation $V_s/V_w$ determines the area of mixing chamber in which these relations are valid. It is considered that this border is within 2/3 of mixing chamber length which is agreeable with *Narabayashi et al.* (2000).

**Basic relations**

Basics for analyses of complex energy flow process through mixing chamber are given in:

- diagram of isentropic changes of flow parameters through supersonic-subsonic transition (Fig 2.)
- change of sound velocity ($c$) and polytropic exponent ($\kappa$) depending on relevant factors of influence (*Deich and Filipov* 1968)
- basic equations (Eq. 1 to 3) for the flow of compressible flow

$$\frac{v^2}{2}+\frac{c^2}{\kappa-1}=const. \tag{1}$$

$$\frac{p_t}{p}=1+\frac{\kappa}{2}M^2+\frac{\kappa}{8}M^4+... \tag{2}$$

$$\frac{T_t}{T}=1+\frac{\kappa-1}{2}M^2 \tag{3}$$

- energy equation (Eq. 4)

$$\left[\left(h_s+\frac{v_s^2}{2}+\frac{p_s}{\rho_s}\right)\dot{m}_s\right]_{mc}^{in}+\left[\left(h_{cw}+\frac{v_{cw}^2}{2}+\frac{p_{cw}}{\rho_{cw}}\right)\dot{m}_{cw}\right]_{mc}^{in}=\left[\left(h_m+\frac{v_m^2}{2}+\frac{p_m}{\rho_m}\right)\dot{m}_{hw}\right]_{mc}^{out}+h_l\dot{m}_{hw}. \tag{4}$$

**Momentum equation**

Momentum equation, as it is known, is without any practical limitation in application on any flow process. It is applied on control volume which represents mixing chamber and takes into account only changes on borders of control volume. Its simplicity and reliability leads to accurate information which, in this case, gives magnitude of average pressure in mixing chamber.

Control volume (Fig. 5) represents two inlet sections (steam and cold water) and one outlet – throat of mixing chamber. It is well known that this law governs only those parameters which prevail on borders of control volume. Inner changes are negligible. This simple relation determines average pressure in mixing chamber. According to *Bukurov* (2004), it is possible to determine more accurate pressure distribution in mixing chamber with known average pressure $p_{ave}$.

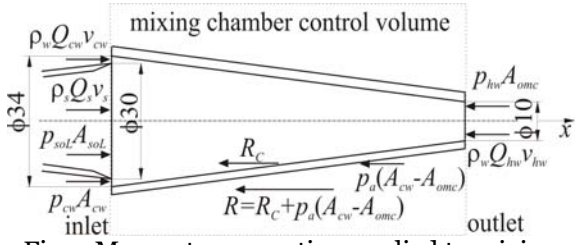


Fig. 5 Momentum equation applied to mixing chamber

If average pressure in mixing chamber increases, pressure at the throat of mixing chamber also increases.

The influence of surrounding to insulated mixing chamber is realized with forces which are presented in Fig. 5. Momentum equation is given as

$$F_{ps} + F_{pcw} - F_{phw} - F_a + F_{cw} + F_s - F_{hw} - R_c = 0 \tag{5}$$

From here, the pure reaction of connection is

$$R_c = F_{ps} + F_{pcw} - F_{phw} - F_a + F_{cw} + F_s - F_{hw} \tag{6}$$

On the other hand, pure reaction $R_c$ can be presented with average pressure in mixing chamber acting on orthogonal projection of mixing chamber:

$$R_c = p_{mave}\left(\left(A_{mc}\right)_{in}-\left(A_{mc}\right)_{out}\right) \tag{7}$$

where is $p_{mave}$ – is average manometric pressure in mixing chamber. Combination of eq. (6) and (7) leads to average manometric pressure

$$p_{mave}=\frac{F_{ps}+F_{pcw}+F_{cw}+F_s-(F_{phw}+F_a+F_{hw})}{\left(A_{mc}\right)_{in}-\left(A_{mc}\right)_{out}} \tag{8}$$

Forces that act on mixing chamber are ($v_{cw}$=4.1 m/s; $v_{hw}$=13 m/s):

$$F_{ps} = p_{soL} A_{soL} = 50000 \times 0.03^2 \times p / 4 = 35.34 \text{ N} \quad (9)$$

$$F_{pcw} = p_{cw} A_{cw} = 180000 \times \left(0.034^2 - 0.03^2\right) p / 4 = 36.19 \text{ N} \quad (10)$$

$$F_{phw} = p_{hw} (A_{mc})_{out} = 600000 \times 0.01^2 p / 4 = 47.12 \text{ N} \quad (11)$$

$$F_s = r_s Q_s v_s = \dot{m}_s v_s = 0.17 \times 611 = 103.87 \text{ N} \quad (12)$$

$$F_{cw} = r_w Q_{cw} v_{cw} = \dot{m}_{cw} v_{cw} = 0.85 \times 4.1 = 3.48 \text{ N} \quad (13)$$

$$F_{hw} = r_w Q_{hw} v_{hw} = \dot{m}_{hw} v_{hw} = 1.02 \times 13 = 13.26 \text{ N} \quad (14)$$

$$F_a = p_a \left((A_{mc})_{in} - (A_{mc})_{out}\right) = 101325 \cdot (0.034^2 - 0.01^2) \cdot \frac{\pi}{4} = 84.04 \text{ N}. \quad (15)$$

All pressures in equations above are absolute.

By substituting eq. (9)-(15) into eq. (8), $p_{mave}$ is determined:

$$p_{mave} = \frac{35.34 + 36.19 + 3.48 + 103.87 - (47.12 + 84.04 + 13.26)}{\frac{\left(0.034^2 - 0.01^2\right)\pi}{4}} = 41670 \text{ Pa}. \quad (16)$$

Average pressure $p_{mave}$ rises if known terms in numerator of eq. (8) are greater. Forces acting at the outlet of mixing chamber are considered as given. Average pressure depends to the greatest extent on $F_s$, since relations of forces are following: $F_s/F_{ps}$=3, $F_s/F_{pcw}$=3, $F_s/F_{cw}$=35. These values are known from experimental investigations. If it is possible to provide higher pressure of cold water at the entrance of mixing chamber, without extra energy, efficiency rate of mixing chamber increases proportionally. But, if cold water is on atmospheric pressure, or even lower, vacuum at the entrance of mixing chamber will suck in cold water what is a valuable technical advantage (pupm for cold water is not necessary); and efficiency rate decreases compared to previous case. Force $F_{cw}$ is neglectable. Force $F_s$ is three times greater than force $F_{ps}$, and from energy point of view, it is more favourable to achieve higher steam velocity at the outlet of Laval nozzle, which requires decrease of pressure $p_s$ at the outlet of Laval nozzle. The limit to which it is possible to decrease outlet steam pressure from Laval nozzle $p_{sL}$ depends on possibility to maintain isentropic steam expansion without schocks. Higher steam pressure at inlet of Laval nozzle provides higher values of $F_{ps}$ and $F_s$, what should be used if steam of such quality is at disposal.

For experimentaly gained inlet and outlet values $D_{oL}$=30 mm, $(D_{mc})_{in}$ =34 mm, $(D_{mc})_{out}$ =10 mm, $\dot{m}_s = 0.17$ kg/s, $\dot{m}_m = 1.02$ kg/s, $p_{cw}$=1.8 bar, $p_{os}$=2.6 bar, $p_{hw}$=6 bar, $v_{cw}$=4,1 m/s, $v_{hw}$=13 m/s, average absolute pressure in mixing chamber is 1.42 bar.

## 5. CONCLUSION

Inaccessible and deficient data on what happens in mixing chamber during the flow of supersonic mixture of cold water and steam is one of the reasons for conducting a careful investigation on this complex process of forced condensation. Unstable flow conditions through injector over a longer period of time hinders accurate measuring and its reviewing. Determining relatively accurate pressure change through mixing chamber would lead to more precise analyses of established procedures and conditions in mixing chamber.

Since the general laws are non-existent, analyses of complex energy transformation through injector device demand puzzle like collection of data and filling in reliable details.

Reliable details presented in this paper are:

- Mach number strongly represents the process. Sound velocity $c$ entirely depends on mixture wetness, and thus, analytic relations of compressible flow can be applied. Dynamic relation of compressible flow consists of inertial and elastic forces ($v^2$, $\kappa M^2$) and can be applied to flow process in mixing chamber, taking into account change of $\kappa$.
- Modified diagram of forced condensation locates energy and flow changes in corresponding cross sections in mixing chamber. Diagram connects energy surrounding (superheated steam and cold water) with flow process, which can be directed into desired course. Diagram of forced condensation indicates that in order to get higher pressures of warm water, shorter condensation process with higher wetness seems to be more appropriate.
- Determining magnitude of average mixture pressure in mixing chamber ($p_{ave}$) enables to get a more accurate pressure distribution in mixing chamber and geometry of mixing chamber, according to the inlet parameters. Application of momentum equation provides a clear inside of forces acting in mixing chamber. The influence of some of these forces to pressure change in the

chamber is obvious and thus, there is no need for further investigation. Considerably high deceleration of mixture velocity in front of the mixing chamber throat, during forced condensation, in comparison with free condensation (tg$\alpha$ in Fig. 3), is a measure of outlet pressure increase. Outlet pressure multiplied by cross section area is acting inertial force.

Further investigation predicts:

- Determining velocity distribution in mixing chamber by using LDA of new generation and its comparison with the research of *Dumaz et. al.* (2005).
- Investigating central water nozzle and annular steam nozzle and its comparison with the research of *Deberne et. al.* (1999). That investigation could deal with determination of friction losses on the wall with annular introduction of steam in mixing chamber.

**NOMENCLATURE**

| | | |
|---|---|---|
| $A$ | [cm²] | cross section area |
| $h$ | [J/kg] | enthalpy |
| $\dot{m}$ | [kg/s] | mass flow rate |
| $p$ | [Pa] | pressure |
| $Q$ | [m³/s] | flow rate |
| $q$ | [J/kg] | heat energy |
| $T$ | [K] | temperature |
| $t$ | [°C] | temperature |
| $V$ | [m³] | volume |
| $v$ | [m/s] | velocity |
| $X$ | [%] | dryness during forced condensation |
| $x$ | [%] | dryness during free condensation |
| $Y$ | [%] | wetness during forced condensation |
| $y$ | [%] | wetness during free condensation |
| $\rho$ | [kg/m³] | density |

**Subscripts**

| | |
|---|---|
| 0 | total |
| *a* | atmosferic |
| *ave* | average |
| *con* | condensed |
| *cw* | cold water |
| *d* | diffuser |
| *hw* | hot water |
| i | section number ($i$=1,2,...10) |
| *in* | inlet |
| *L* | Laval's nozzle |
| *l* | losses |
| *m* | manometric |
| *mc* | mixing chamber |
| *mix* | mixture |
| *out* | outlet |
| *s* | steam |
| *w* | water |
| *wm* | water for mixing |
| *wrest* | the rest of water |

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# ANALYSIS OF THE MOST COMMON FAILURES OF GEARS IN UNIVERSAL GEAR REDUCERS

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**Abstract:**

Universal gear reducers are important mechanisms of every machine and production line and they are often used in all branches of mechanical engineering. Regular work and quality of many machines depend on reliability and quality of gear reducers. Thus, the gears, as the most important elements of every gear reducer, have to be properly calculated, dimensioned and designed. However, beside all this precautions, gear failures can happened due to occurring of overloads, manufacturing and material failures of gears and other different unpredicted influences. Failures can occur suddenly or as a gradually teeth wearing off. This paper will give a review of the most common failures of gears in gear reducers and also some measures for their prevention.

**Key words:**

gear reducers, gears, breakdowns, gear failures

## 1. INTRODUCTION

Mechanical power transmission units are among the oldest mechanisms that mankind invented and they are certainly the most often used mechanisms in mechanical engineering and machine industry today.

Today, mechanical power transmission devices are produced in large series of millions specimens as special units (for example in the frame of automotive industry, railway machine industry, constructing machines industry, etc.), and as universal units (for all fields of mechanical engineering, usually with electric motor mounted, so called motor gear units or driving units). Application of mechanical power transmission units is certainly wide today, and it can be concluded that there is no industry branch that does not need any type of gear unit. Universal gear units are usually applied in mines, thermo and hydro plants, food industry, constructing materials industry, municipal service companies, etc.).

By their proper operating, mechanical gear units, as an important component of driving system, have significant influence on reliability of overall system. However, breakdowns of gear units can also happen, and thus they could be the cause of unplanned production interrupts. Although all conditions for proper operating are ensured by their construction, their sudden breakdowns yet occur. The reason for that can be failure of one or several elements, which causes irregular operating, or momentary break of gear unit operating.

Because of its function, to transfer mechanical energy from motor to some working machine, breakdown of mechanical gear unit refers to momentary breakdown of overall system, interrupt of its operating and production stop, which can cause large economic losses for users of gear units.

## 2. BREAKDOWNS OF GEAR REDUCERS AND THEIR CAUSES

In order to provide reliable and quality operating of gear units and systems that contain gear units, during whole projected operating life, it is necessary to analyze in detail all

characteristics of proper operating of gear unit, their operating characteristics with different failures, as well as reasons for occurring of accidental and breakdown situations.

This paper analyses different causes and failures of gears inside of motor gear reducer. Reducing possibility of failures occurrence is also considered by the authors of this paper, using particular example of gear reducer made by Sever-Subotica with axis height 90 mm. Possibility of failures reducing is analyzed prevailing due to constructional malfunctions which are the most usual technical causes of gear units breakdowns. As a result of this analysis, modified design solution is recommended, so it can carry projected loading without breakdowns.

The most of breakdowns of gear reducers do not happen immediately, but gradually, because some period of time is necessary to pass, so that all conditions requisited for breakdown occurrence are created. Failures of gear reducer components usually occur due to design defects, material defects, manufacturing defects and exploitation defects. Failure occurrence, i.e. occurrence of reduced operating capability, can be manifested by different intensity. Increasing failure intensity, in one moment reducer will turn to the breakdown state. Gear reducer breakdowns can be considered from different points of view, so that they can be classified according to several criteria (Fig. 1) [1].

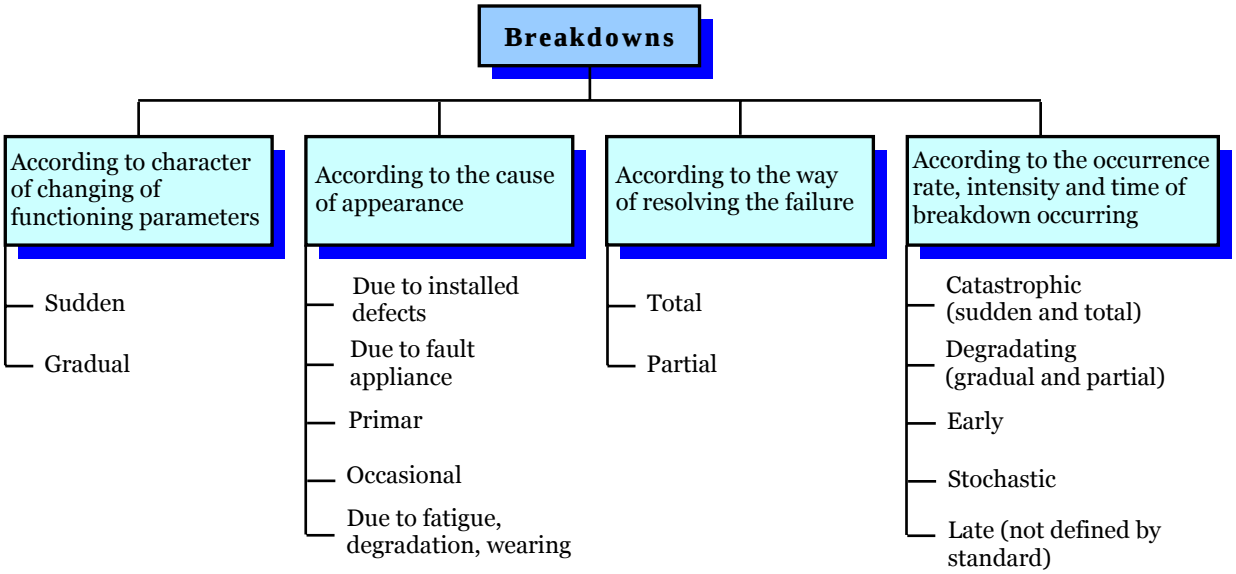



Figure 1. Schematic review of breakdown classification of gear reducer [1]

According to changing of functioning parameters of gear reducers, breakdowns can be sudden or gradual (late). Causes of sudden breakdowns have stochastic, unsteady character and they can not be predicted (for example connection breaking, fractures, processes of concentric wearing, etc.). Gradual breakdowns can be predicted by its intensity and direction (surfaces wearing processes, material degradation, corrosion processes, weakening of connections between reducer components, etc.).

According to cause, breakdowns can occur due to installed defects, due to fault appliance, due to fatigue, degradation or material wearing, and also can be primar and occasional.

According to breakdowns resolving, there are total and partial breakdowns. Total breakdowns result with totally loss of operating capability of reducer and they are resolved by replacing part that has broken down. These breakdowns are usually breakings and fractures, and this kind of breakdown can cause breakdown of other reducer components. Partial breakdowns occur as a result of disturbance in operating process, when only partial operating capability of reducer is lost. This kind of breakdowns can be failures of sealers and washers, oil leaking, higher vibration due to fault mounting or improper installation, and they are resolving by certain maintenance procedures.

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According to speed, intensity and time of occurring, breakdowns can be catastrophic, degradating, early, stochactic and late. Catastrophic breakdowns are, in the same time, sudden and total, and their characteristic is large economic and material damage. Degradating breakdowns are gradual and partial in the same time. Early breakdowns of reducer occur in the period of running in. Stochastic breakdowns occur during regular exploitation, and late breakdowns intensively occur after period of projected operating life.

Breakdowns of gear reducers can happen due to technical defects, organizational faults and unsatisfactory competence and personnel training. Nevertheless, gear reducers usually fail due to technical malfunctions, where especially belong design, technological and exploitation causes (Fig. 2). 12% breakdowns, of overall breakdowns amount, are caused by mistakes and defects made during the process of constructing and design [1]. This paper deals with possibility of intensity reducing this kind of design failures to minimum.

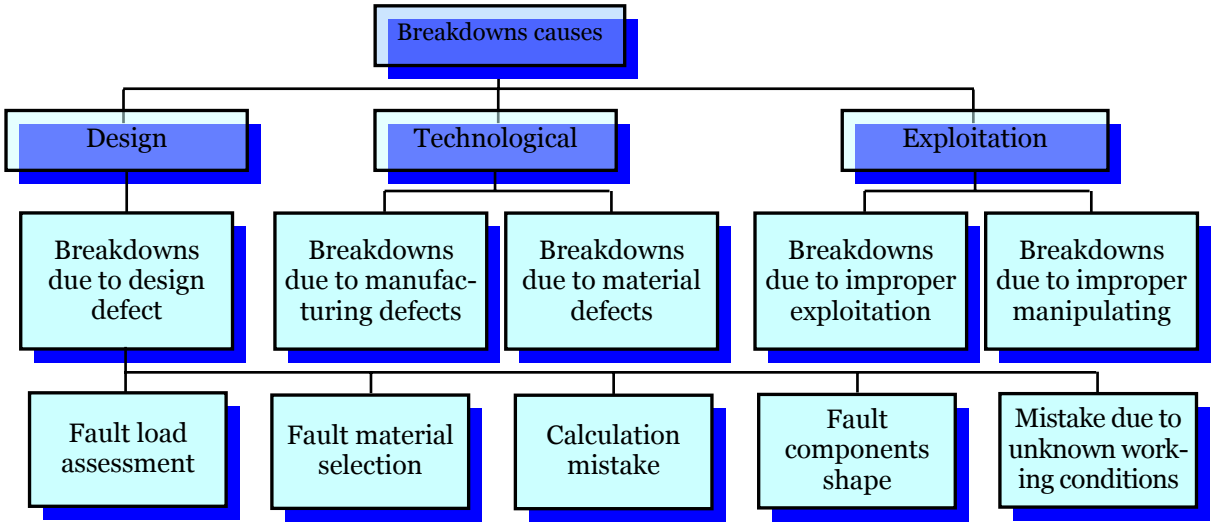



Figure 2. Causes of breakdowns occurrence

Considering breakdowns during exploitation and their causes, three characteristic periods can be noticed. In the beginning of exploitation, early breakdowns occur as a result of latent design and technological malfunctions. In further reducer exploitation, stochastic breakdowns can occur due to overloadings. After long period of exploitation, amplified (late) breakdowns occur as a result of fatigue, corrosion and aging. Causes of breakdowns for all these three domains are different, so that measures for their reducing (increasing reducer reliability) are different for all of these three time range. Frequency of all these breakdowns is directly proportional to undertaken activities for resolving design and technological causes of breakdowns during period of reducer development. Therefore, it is important to detect and remove as much causes as possible in this period, especially those latent defects and causes which could cause later, during exploitation, premature breakdowns and reducing projected operating life of gear reducer.

## 3. GEAR FAILURES

60% of gear reducer breakdowns happen due to gear failures [2], which means that quality and reliability of gears are very important for proper operating of reducer. When transfer load from pinion to gear wheel, teeth flanks relatively move between each other by sliding and rolling. Thus, depending on torque value, teeth flanks are exposed to smaller or bigger contact pressures with sliding at the same time, and tooth dedendum is exposed to flexion, too. In these conditions, depending on torque and operating regime, different failures of gears can occur, i.e. breakdowns can be manifested in different ways. Failures that occur on gear teeth, are various and can be, according to ISO 10825, classified as: surface disturbances, scuffing, permanent deformations, surface fatigue phenomena, fissures and cracks and tooth breakage (Fig. 3).

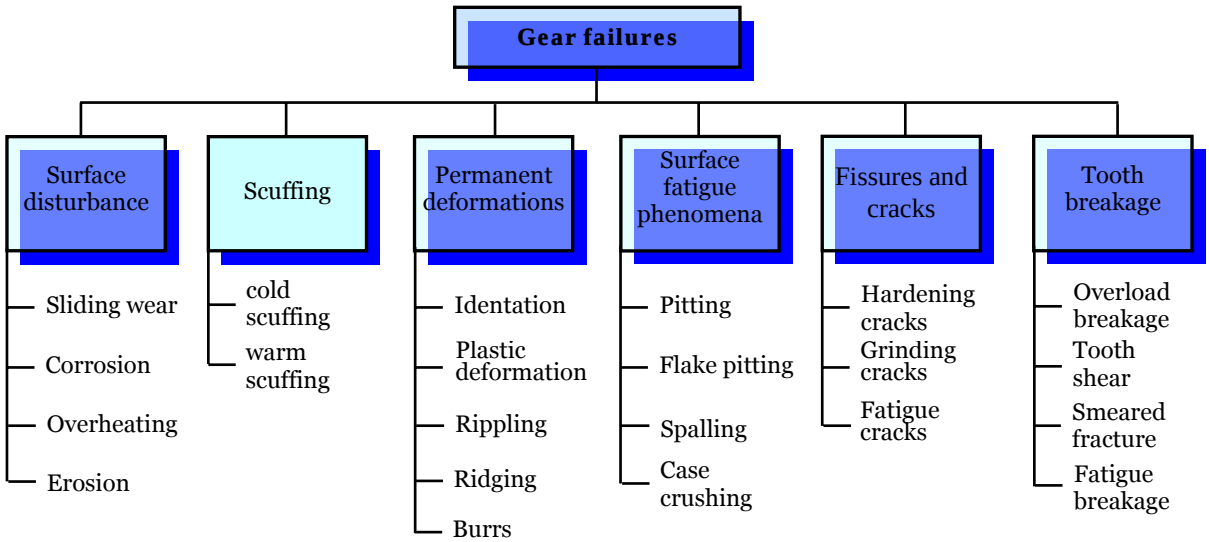
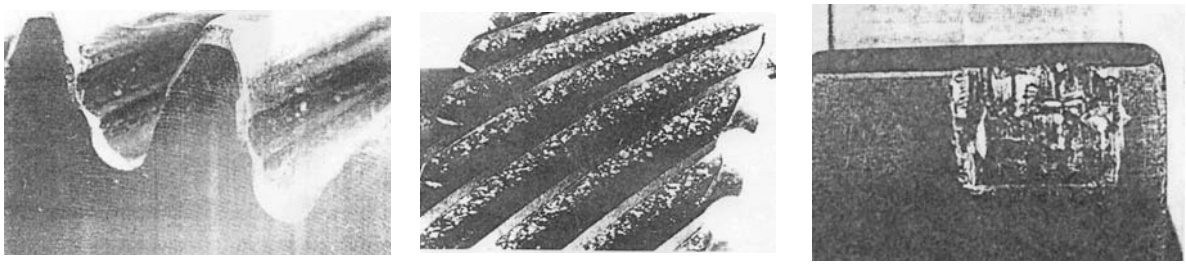


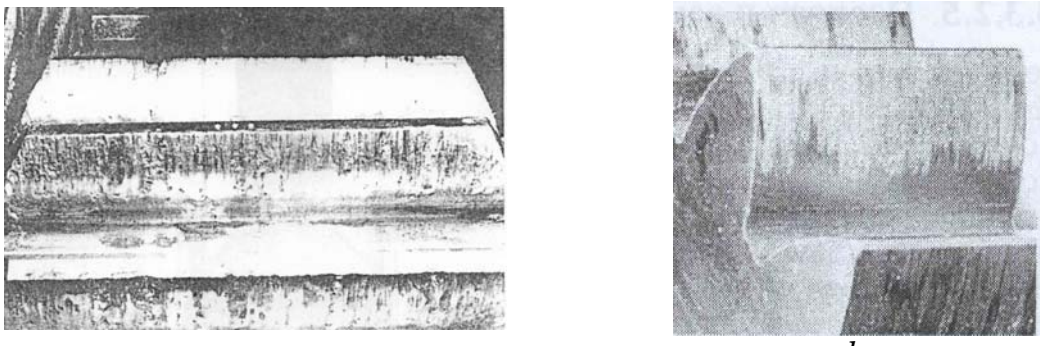

Figure 3. Classification of gear failures according to ISO 10825 [5]

Indications of surface disturbances comprise failures of gear teeth, such as: sliding wear (Fig. 4-a), corrosion (Fig. 4-b), overheating (Fig. 4-c), as well as some types of erosion, but they are not result of fatigue process.



*a* *b* *c*

Figure 4. Types of surface failures of gear teeth
(a- sliding wear; b - corrosion; c - overheating)



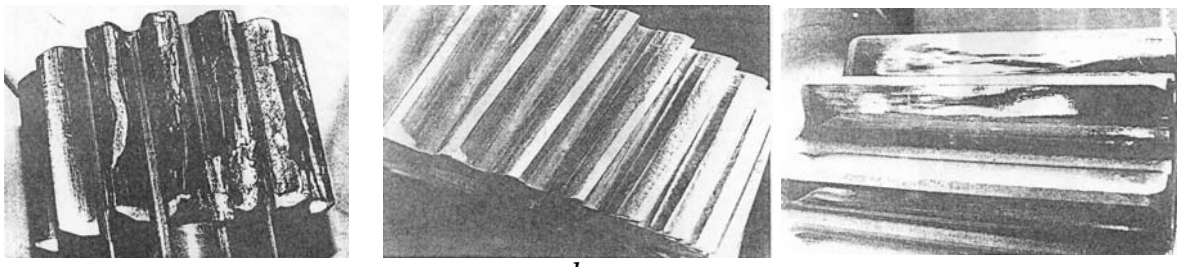
*a* *b*

Figure 5. Scuffing of gear teeth
(a- cold scuffing; b - warm scuffing)

Scuffing of gear teeth (Fig. 5) occurs due to great pressure loads and high sliding velocities. It represents drastic kind of teeth failure. Scuffing occurs suuddenly, when lubricant film between the tooth flanks is disrupted. This can lead to localized welding of the tooth flanks with transfer of material.

Permanent deformations of gear teeth are failures of tooth profile. They occur due to great torques, when material of gear or heat treatment of gear are not properly matched with working conditions, or some filthiness or foreign bodies are present in lubricant. This kind of failure usually comprises: identation (Fig. 6-a), plastic deformations (Fig. 6-b) and rippling (Fig. 6-c).

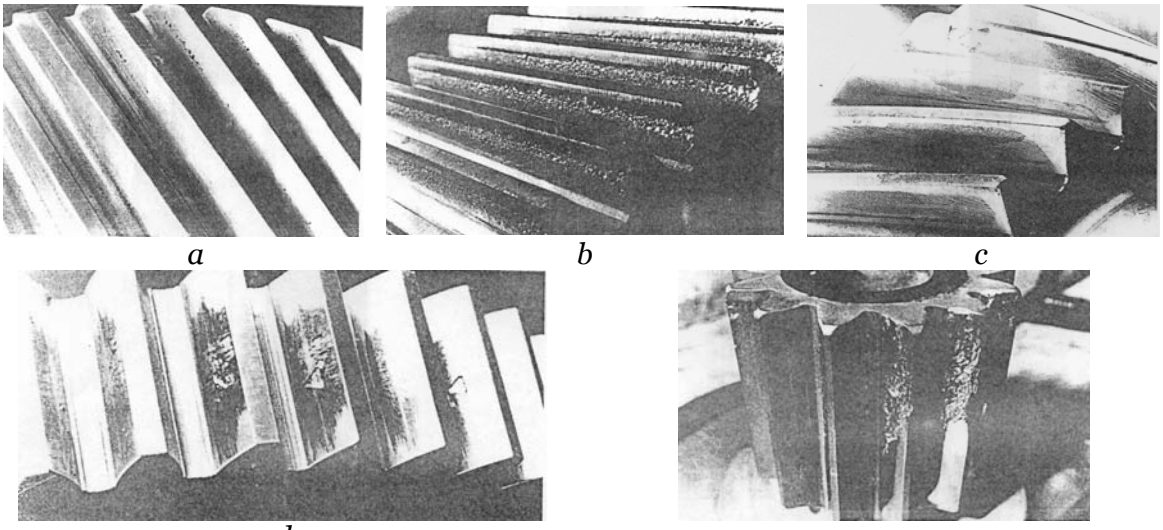
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*a* *b* *c*

Figure 6. Permanent deformations of gear teeth
(a- identation; b - plastic deformations; c - rippling)

Surface fatigue phenomena occur because of material damage due to surface and subsurface stresses produced by the repeated application of forces. It is characterized by removal of metal and the formation of cavities. Pitting is one of the most usual fatigue surface failures. It occurs in the presence of rolling or mixed rolling and sliding contacts. Particles break out of affected areas leaving surfaces pock-marked with scattered holes. There are several kinds of pitting: initial pitting (Fig. 7-a), progressive pitting (Fig. 7-b), micropitting (Fig. 7-c), flake pitting (Fig. 7-d) and progressive macropitting, called spalling (Fig. 7-e).

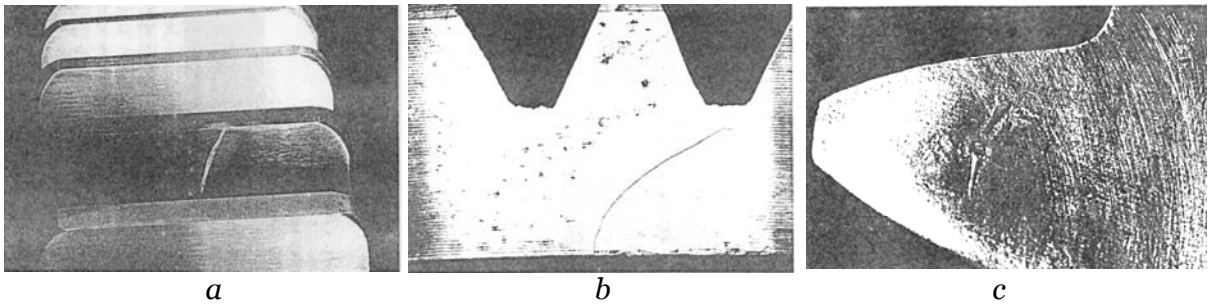


*a* *b* *c*

*d* *e*

Figure 7. Surface fatigue failures of gear teeth
(a- initial pitting ; b - progressive pitting; c - micropitting; d - flake pitting; e - spalling)

Fissures and cracks of gear (Fig. 8) can occur even before gear start to transfer torque, i.e. in its manufacturing phase. They usually occur as a result of defects, filthiness and gas inclusions in material that gear is made of, and also as a result of improper heat treatment, high internal stresses and defects during grinding operation.

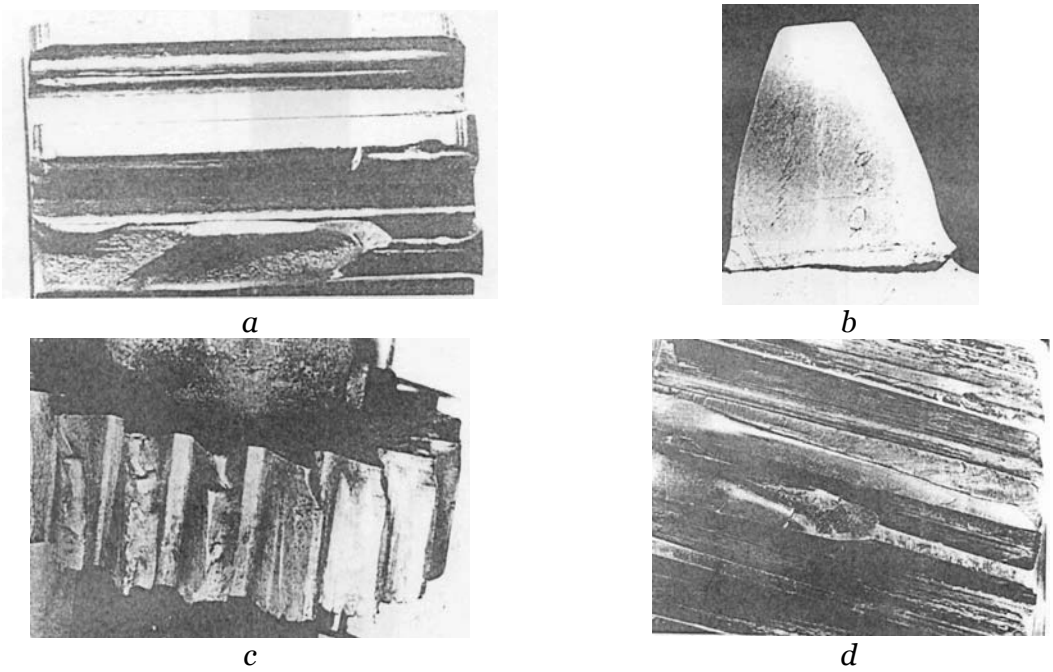


*a* *b* *c*

Figure 8. Fissures and cracks of gear teeth
(a- crack caused by a forging defects; b – crack in the rim of a wheel due to inadequate rim thickness; c – fatigue crack which has appeared in the tooth root fillet below the loaded flank)

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Tooth breakage usually occurs at the tooth dedendum, where the stresses are higher, especially on flexion tooth flank. It also may occur on the other place when it is a result of pitting process, fault heat treatment or other failures on flanks. These failures are classified as: overload breakage (Fig. 9-a), tooth shear (Fig. 9-b), breakage after plastic deformation, so called smeared fracture (Fig. 9-c) and fatigue breakage (Fig. 9-d). When overload breakage happens, several teeth are damaged, and if it is fatigue breakage, usually one tooth is damaged.



*a* *b* *c* *d*

Figure 9. Surface fatigue failures of gear teeth
(a- overload breakage; b - tooth shear; c - smeared fracture; d - fatigue breakage)

## 4. PROBLEM DESCRIPTION

After testings of new series of gear reducers of axis height 90 mm, it is identified that early failures of some components occur and that reducer rapidly degrades. These early breakdowns of reducer are caused due to constructional faults and design defects. Problem occurs because gear reducer is not adapted to projected load capacity, so that projected output torque can not be achieved, for such defined sets of gears and current reducer construction. Projected output torque value is defined according to new series of reducers of leading manufacturers of gear units. However, because of constructional faults and design defects, Sever's gear reducers are not capable to fulfill established demands. Values of gear ratii are satisfied, but still output torque is not, so that Sever's gear reducers can not be competitive on the market.

Testings are carried out on two stages and three stages gear reducers according to standard program and testing methodology of gear units that is used in Sever factory. After testing with particular torque value, gear reducer is disassembled and every component is being examined and analyzed. If total breakdown of some component occurs, or some failures are noticed, testings are being repeated with smaller torque. The biggest output torque, for which breakdowns and failures do not occur, is adopted as nominal permitted output torque for particular gear ratio.

According to defined testing methodology, testings are carried out for reducer with the smallest overall gear ratio, and at the same time the biggest gear ratio on output gear stage. For this two stages gear reducer, it is gear set with speed ratio 9.73, and for three stages variant, it is gear set with speed ratio 96. After testings of both variants of reducer, besides some failures of shaft and bearing, following failures of gears are also noticed:

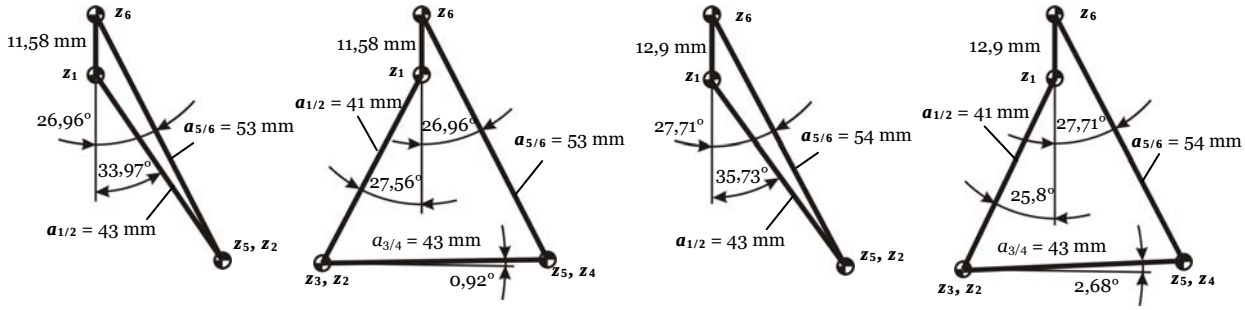
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% failure of output gear pair, i.e. occurring pitting and uneven loading trace on tooth flanks;
% uneven loading trace also on the first gear pair, as well as pitting occurrence on pinion of the first pair, due to excessive deformation of input shaft.

## 5. RESULTS AND CONCLUSION

On the basis of calculated results, following modifications of present reducer design are recommended:
% modifying of axis distance of output gear stage $a_{5/6}$ from 53 mm to 54 mm;
% increasing the diameter of fifth gear shaft under the gear $z_5$, raising the pinion teeth number for one, from $z_5 = 11$ to $z_5 = 12$, by maintaining approximately same partial speed ratii of output gear pair;
% increasing overhanged diameter of fifth gear shaft, from 15, and 12 mm to 17 mm;
% choosing stronger cylindrical bearing, instead of NU202 it is chosen NU203.

After increasing axis distance of output gear stage $a_{5/6}$ from 53 mm to 54 mm, position of shaft axes in reducer has been changed and the axis of input shaft comes down from 11.58 mm to 12.9 mm, relating to output shaft (Fig. 10).




*a* *b* *c* *d*

Figure 10. Position of gear axes for present design solution of gear reducer with axis height 90 mm (a - present two stages, b - present three stages) and for proposed design solution (c - proposed two stages, d - proposed three stages)

Increasing axis distance of output gear stage $a_{5/6}$ for only 1 mm enables raising teeth number of fifth gear for one, as well as teeth number of sixth gear, so that approximately same partial speed ratii will be maintained. Also, increasing teeth number of fifth gear influenced increasing rigidity and reducing shaft deformations under the gear. This simply increasing of teeth number was possible for partial speed ratii 2.94 (teeth number $z_5 = 17$ and $z_6 = 50$ has been increased to $z_5 = 18$ and $z_6 = 53$), 4.08 (teeth number $z_5 = 13$ and $z_6 = 53$ has been increased to $z_5 = 14$ and $z_6 = 57$) and for 4.91 (teeth number $z_5 = 11$ and $z_6 = 54$ has been increased to $z_5 = 12$ and $z_6 = 59$). Thus, loading capability of gear pair $z_5 / z_6$ enabled carrying projected output torque. However, for speed ratio 6.27 (teeth number $z_5 = 11$ and $z_6 = 69$ has been increased to $z_5 = 12$ and $z_6 = 75$), due to insufficient axis distance, loading capability was not satisfied. Because of that, teeth number of sixth gear is reduced to $z_6 = 73$, so that projected output torque could be satisfied, but with negligible reducing of speed ratio, i.e. from 6.25 to 6.08 (Fig. 11).

It is demonstrated that it is possible to reduce breakdown intensity and to prevent failures of gears and thus increase loading capability of two stages and three stages gear reducers by applying certain design modification and avoiding constructing faults.

This paper gives a review of different types of gear failures which can occur due to various kinds of malfunctions and unproper working condition. Gear failures usually occur due to design faults, wrong assembling and mounting, poor maintenance and uncareful manipulating.

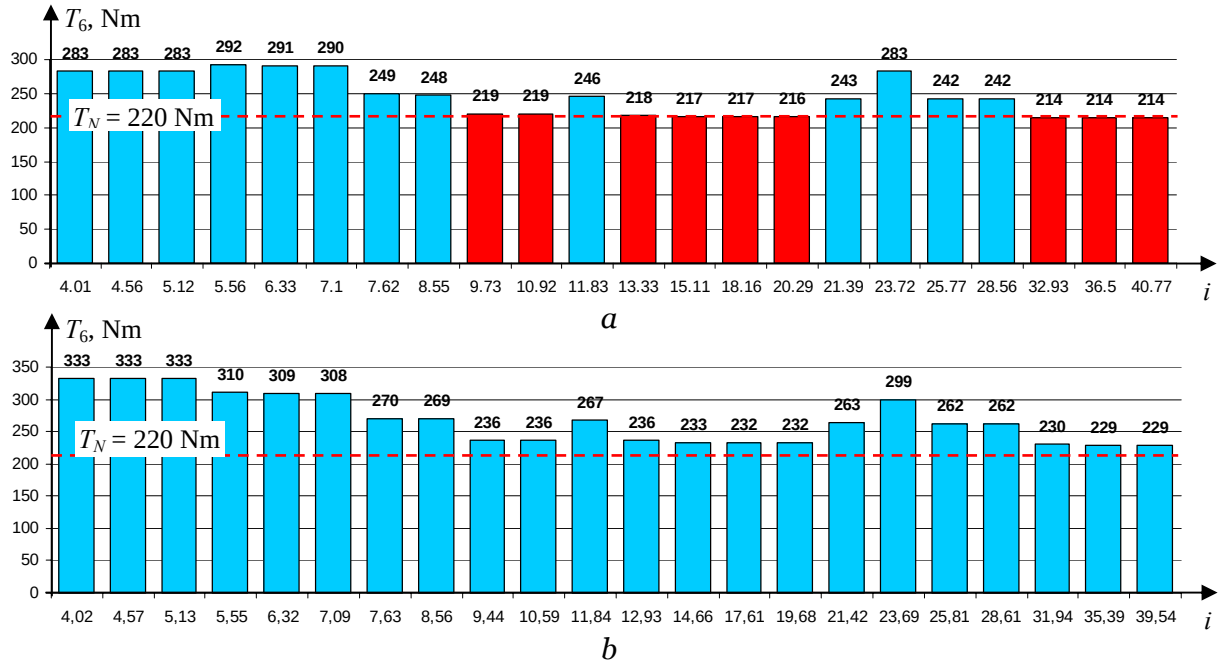



Figure 11. Permissive output torques of present (a) and proposed (b) design solution of two stages gear reducer with axis height 90 mm depending on endurance of teeth flanks of output gear pair $z_5/z_6$

After recommended design modifications, significant increasing of loading capacity of gear reducer is obtained. After carried out modifications, projected parameters of gear reducer are achieved, so that analyzed construction of Sever's reducer can be competitive with other leading manufacturers of gear units. Proposed modifications should be implemented to all other dimensions of gear reducers' family, which will enable successful access of these reducers to world market.

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# GENERAL CONCEPTS OF MAINTENANCE

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**Abstract:**
Maintenance involves preventive (planned) and unplanned actions carried out to retain a system at or restore it to an acceptable operating condition. Optimal maintenance policies aim to provide optimum system reliability and safety performance at the lowest possible maintenance costs. Proper maintenance techniques have been emphasized in recent years due to the fact that the safety and reliability requirements of system, increased complexity and costs of material and labor are increasing.

**Keywords:**
maintenance, reliability, Preventive maintenance (PM),
Corrective Maintenance (CM), Imperfect maintenance

## 1. INTRODUCTION

Maintenance has evolved from simple model that deals with machinery breakdowns, to time-based preventive maintenance, to today's condition-based maintenance. It is of great importance to avoid the failure of a system during its actual operation especially, when such failure is dangerous or costly. Time-based and condition-based maintenance are two major approaches for maintenance. In contrast, condition based maintenance can be more profitable in order to avoid failure occurrence at the lowest cost and to improve the availability and reliability of the maintained system.

The choices of the inspection schedule and preventive maintenance thresholds obviously have a great influence on the economic performance of the maintenance policy. The inspection dates and the preventive maintenance are main decision variables considered in many researches.

## 2. MAINTENANCE CLASSIFICATION

Maintenance can be classified by two major categories: corrective and preventive. Corrective Maintenance (CM) is the maintenance that is performed when the system fails. Corrective maintenance means all actions performed as the result of failure, to restore an item to a specified condition.

Preventive maintenance (PM) is the maintenance that happens when the system is operating and it means all actions performed in an attempt to retain an item in specified condition by providing systematic inspections, detection, and prevention on failures. Maintenance can also be classified according to the degree to which the operating condition of an item is restored by maintenance in the following way [1]:

1. Perfect repair: perfect maintenance is maintenance actions which restore a system operating condition to as „good as new”. That is, perfect maintenance and a system has the same lifetime distribution and failure rate function as a new one. Generally, replacement of a failed system by a new one is a perfect repair.
2. Minimal repair: minimal maintenance actions which restore a system to the same failure rate as it had when it failed. Minimal repair was first studied by Barlow [2]. The system operating state after the minimal repair is literally called „as bad as old”.
3. Imperfect repair or imperfect maintenance: maintenance actions which do not make a system not „as good as new” but younger. Usually, it is assumed that imperfect

4. maintenance restores the system operating state to somewhere between „as good as new" and „as bad as old". Clearly, imperfect repair (maintenance) is a general repair (maintenance) which can include two extreme cases: minimal and perfect repairs (maintenance). Engine tune-up is an example of imperfect maintenance.
5. Worse repair or worse maintenance: maintenance actions which un-deliberately make the system failure rate or actual age increase but the system dose not breakdown. Thus, upon worse repairs a system operating condition became worse than that just prior to its failure.
6. Worst repair or worst maintenance: maintenance actions which un-deliberately make the system fail or break down.

According to the above suggested classification, we can say that a PM can be a minimal, perfect, imperfect, worst or worse one. Similarly, a CM could be a minimal, perfect, imperfect, worst or worse CM. We will refer to imperfect CM and PM as imperfect maintenance later. The type and degree of maintenance used in practice depends on types of systems, their costs as well as reliability and safety requirements.

In the related literature, most studies assume that the system after CM or PM is „as good as new" (perfect maintenance) or „as bad as old" (minimal maintenance). In practice, the perfect maintenance assumption may be acceptable for system with one component which is structurally simple. On the other hand, the minimal repair assumption seems reasonable for failure behavior of systems when one of its components, non-dominating component, is replaced by a new one. However, many maintenance activities may not result in these two extreme situations but in a complicated intermediate one. Therefore, perfect maintenance and minimal maintenance are not practical in many actual instances and realistic imperfect maintenance should be modeled.

Recently, imperfect CM and PM have received more attention in reliability and maintenance literature. In fact, we can say that imperfect maintenance study indicates a significant breakthrough in maintenance and reliability and maintenance theory. In [3] the author mentioned that imperfectness of maintenance is related to the skill of the maintenance personnel, the quality of the maintenance procedure, and the maintainability of the system [3]. Obviously, maintenance expenditure and reliability requirement also have important effects on imperfectness of maintenance. Barlow and Proschan presented some possible causes for imperfect, worse or worst maintenance due to the maintenance performer [4]:

- Repairing the wrong part.
- Only partially repairing the faulty part.
- Repairing (partially or completely) the faulty part.
- Incorrectly assessing the condition of the inspected units.
- Performing the maintenance action not when called for but at customer convenience.
- Nakagawa mentions three reasons causing worse or worst maintenance [5]:
- Hidden faults and failure which are not detected during maintenance.
- Human errors such as wrong adjustments and further damage done during maintenance.
- Replacement with faulty parts.

According to Barlow and Proschan [4], maintenance policies based on planned inspections are „periodic inspection" and „inspection interval dependent on age". By periodic inspections, a failed unit is identified or it is determined whether the unit is functioning or not. With aging of the unit, the inspection interval may be shorter. These inspection methods are subject to imperfect maintenance caused by randomness in the actual time of inspection, in spite of the schedule, imperfect inspection and cost structure. Therefore, realistic and valid maintenance models must incorporate with random features of the inspection policy. So far only a small portion of literature concerning to the stochastic behavior of the repairable systems and maintenance is involved in imperfect maintenance.

## 3. MULTI COMPONENT SYSTEM'S MAINTENANCE

Currently, the interest for multi component maintenance models is increasing. In the beginning vast majority of the maintenance models were concerned about a single piece of

equipment operating in a fixed environment, considered as an intrinsic barrier for allocations. Maintenance action of a multi component system differs from that one for a single-unit system; because these depend on some factors. One of the dependencies is economic dependence. Another one is failure dependence, or correlated failures. Economy dependency is a common term in most continuous operating systems. For this type of systems, the cost of system unavailability (one-time shut-down) may be much higher than component maintenance costs. Therefore, there is often great potential cost saving by implementing an opportunistic maintenance policy.

Obviously, the joint maintenance of two or more subsystems tends to spend less money and less time (economy dependency), and the failures of different subsystems in multicomponent system may not be independent (failure dependency). Thus, each subsystem may not be considered as a single-unit system, and to apply the existing optimum maintenance models of a single-unit system to each of such subsystems may not be practical.

Imperfect maintenance exists also in a repairable multi-component system. If one of its subsystems fails, it can be repaired by replacing some of its parts. Clearly, reliability measures of the repaired subsystems are improved after repair but it might not be as good as new (imperfect CM), and consequently the entire system will no longer function as well as a new one.

Realistic imperfect maintenance associated with individual subsystems and accordingly systems have to be modeled. According to [6], systems used in the production of goods and delivery of services constitute the vast majority of most industry's capital. These systems are subject to deterioration with usage and age. System deterioration is often in higher production costs and lower product quality, to keep production costs down while maintaining good quality. PM is often performed on such systems. It is obvious that these kinds of system are often composed by many subsystems whose maintenance is often imperfect or sometimes even worse. It is necessary to point out that considering the entire system as a single unit by a minimal repair model may not be suitable for large-scale systems. Such maintenance modeling is also too rough for complex systems due to the economy and failure dependencies. In practice, some subsystems are inspected and tested separately and their reliability performances are also evaluated individually.

Lifetime distributions of all new subsystems are known through reliability tests and statistical results before they will be used for such systems. As a result, we can evaluate whole system reliability measure and system maintenance cost based on failure information, maintenance costs, and maintenance degree of all subsystems. Therefore, we may say that a realistic method is to treat a system the same as one with many subsystems which are subjects to imperfect maintenance. We are, also able to model imperfect maintenance of the system through imperfect maintenance modeling of all subsystems and at the same time economical model and failure dependency of the system in order to obtain global optimum maintenance policies for the system.

## 4. CONCLUSIONS

The usual criteria of optimization of maintenance policies are based on maintenance cost measures, same as expected maintenance costs per unit of time and total discounted costs. Hence the optimal maintenance policies are the ones that minimize or maximize a given cost criterion

Reliability is the branch of quality assurance that deals specifically with the ability function upon demand. During the last decades many works have been devoted to the binary-state reliability analysis, where it is assumed that a system may experience only two possible states: one working state and one failure state.

However, in many real world situations a system or a component could experience more than two levels of performance varying from perfect functionality to complete failure; these systems are called multi-state systems. The evaluation of maintenance, testing, and repair policies becomes more and more complex for multi-state systems that contain combinations of revealed and unrevealed failure [7].

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# A STUDY OF THE BOCKER'S OBSERVER IMPLEMENTATION TO ESTIMATE THE INDUCED POWER WITHIN A CAST-IRON CONVEYANCE AND DOSAGE ELECTROMAGNETIC PUMP

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**Abstract:**
In this paper the structural elements and applications of the electromagnetic pumps for melted cast iron conveyance and dosage within the metallurgical engineering are presented. The mathematical model in steady-state operation of the electromagnetic pump is deduced within Chapter 2. Based on this model, the physical parameters of the melted metal may be estimated. The vector-matrix representation of the dynamic set of equations of the pump is then used, in Chapter 3 to obtain the Bocker's observer. This observer allows to reconstruct the flux-linkages of the magnetic field. Based on these results an estimate of the induced power is sibsequently obtained. At the end of the paper, an implementation of this approach on a given electromagnetic pump is presented

**Keywords:**
electrothermy, electromagnetic pump, state observers

## 1. INTRODUCTION

The implementation of the Electro-thermal processes within foundries and forge departments is an important element to improve the products quality and to optimize the energy costs. A modern approach for the conveyance and dosage of melted metals, cast-iron, aluminum, copper and so is the useage of the electromagnetic pumps, Figure 1. The electromagnetic pumps may be used [1] to extract the melted metal directly from the basis of the induction furnace with a not mobile structure and to cast and dose the melted metals from the mobile melting pot. The electromagnetic pumps may be easily inserted into complex plants for continuous casting.

The advantages of the electromagnetic conveyance of melted metals are: (1) the control by electrical means of the liquid's flow-rate if the pump is supplied from controlled three-phased frequency converters, (2) costs reduction due to the elimination of purging the channel with tempered metal scraps, (3) the increase of the metal's pureness because the non-metallic elements aren't drawn by the electromagnetic forces, (4) the melting furnace and the melting pot may be at the same level thus their structure is much simpler, and (5) an improve of the working conditions within the casting departments.

The main disadvantage of the electromagnetic pump is the channel maintenance especially to the channel's basis where the material is highly solicited.



Figure 1. An electromagnetic pump for casting melted cast-iron

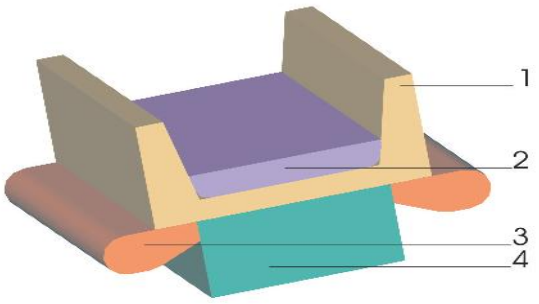



Figure 2. A Simplified cross-section through an electromagnetic pump, single-sided stator.

Table 1
The main features of the electromagnetic pumps

| Denomi-nation | Units | Lighte metals | Heavy metals | Cast-iron |
|---|---|---|---|---|
| Tempe-rature | $^{o}$C | 650 – 750 | 900 – 1200 | 1450 |
| Flow rate | kg/s | 0,1 – 10 | 0,3 – 30 | 1,3 – 100 |
| Level | mm | 50 – 540 | 80 – 540 | 80 – 930 |
| Length | mm | 1080 - 2600 | 1800 - 2600 | 1800 - 4200 |

The induction electromagnetic pump is an induction motor with a two-sided or single-sided stator. The main parts of an induction electromagnetic pump with single-sided stator are, Figure 2. The magnetic circuitry 4 with the three-phased winding 3 are placed below the ascending channel 1, build with refractory cement concrete. The melted metal 2 flows through the channel due to the electromagnetic forces. The main technical characteristics of some widely used electromagnetic pumps are presented in Table 1.

## 2. THE MATHEMATICAL MODEL OF THE SINGLE-SIDED-STATOR ELECTROMAGNETIC PUMP

The stator winding of the induction electromagnetic pump supplied from a three-phased electric network produces a progressive electromagnetic field, Figure 3. The first harmonic of the resulting electromagnetic field above the single-sided stator is given by the following expression:

$$B_{\delta}(x,t) = B_{\delta m} \cdot sin\left(\omega_1 \cdot t - \frac{\pi}{\tau} \cdot x\right) \tag{1}$$

where: $B_{\delta m}$ - the magnitude of the magnetic induction, $\omega_1 = 2 \cdot \pi \cdot f_1$ - the angular frequency and the frequency of the voltages at the stator windings, $\tau$ - the stator's winding polar step.

The motion speed of the first harmonic of the progressive wave, $v_1$ is:

$$v_1 = \frac{\Delta x}{\Delta t} = 2 \cdot \tau \cdot f_1 \tag{2}$$

The progressive magnetic field induces into the melted metal electric electrical currents due to the electromagnetic induction phenomenon. From the interaction between the resulting magnetic field and the induced currents, electromagnetic force results. This force acts on the melted metal. The electromagnetic force over a unit volume of melted metal may be computed with the relation:

$$\overline{f} = \overline{J} \times \overline{B} \tag{3}$$

where: $\overline{J}$ - the per-unit induced currents and $\overline{B}$ – the induction of the resulting magnetic field into the melted metal.

The expressions of the physical variables of the progressive field and the electromagnetic force, respectively may be deduced through the Maxwell's equations into the space above the inductor –l the air gap of the electromagnetic pump such as for the classical electric machines. In addition, for the induction electro-magnetic pumps the following phenomena have to be taken into account: the transversal edge effect, and the longitudinal edge effect (static and dynamic).

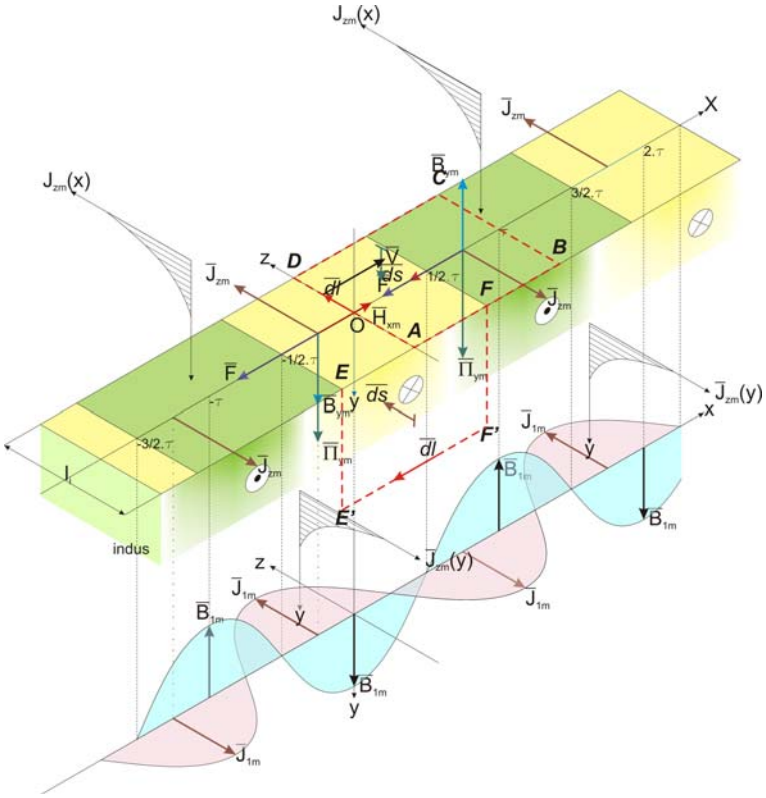



Figure 3. The distribution of the progressive field's first harmonic within the air gap of the electromagentic pump.

The transversal edge effect consists in the modification of currents distribution through the transversal cross-section of the massive induced because the currents paths freely encircle the magnetic field.

The electro-magnetic force results less than the classical machines provided with windings on both armatures. The decrease of the electromagnetic force depends on the ratio between the polar step and the geometrical dimensions of the induced cross-section within the field, Figure 4.

The transversal edge is taken into account in the electrical equivalent diagram through an additional coefficient that increases the value of the equivalent induced resistance.

The static longitudinal edge effect is because the stator windings aren't balanced – linear stator. The phenomenon consists in a non-symmetrical currents sequence in the stator's windings.

If the magnitudes of the phase voltages are known through measurements and the electric and magnetic parameters are estimated through computations, than the direct- and inverse phase sequence of the stator currents may be determined with the following set of equations:

$$\begin{cases} \left(3\cdot \underline{Z}_d + j\cdot 4\cdot X_0\right)\cdot \underline{I}_d + \left(3\cdot \underline{Z}_i + j\cdot 4\cdot X_0\right)\cdot \underline{I}_i = \underline{U}_{AB} - \underline{U}_{CA} \\ \underline{Z}_d \cdot \underline{I}_d - \underline{Z}_i \cdot \underline{I}_i = \dfrac{j}{\sqrt{3}}\cdot \underline{U}_{BC} \end{cases} \qquad (4)$$

A practical approximation is: $\underline{Z}_d = \underline{Z}_i = \underline{Z}_1$. In the relations (4) the significance of the terms is: $\underline{Z}_d, \underline{Z}_i, \underline{Z}_1$ - - the stator direct- and inverse-phase sequence impedances respectively, $\underline{I}_d, \underline{I}_i$ - the symmetrical components of the stator phase currents, $X_0$ - reactanța totală de dezechilibru şi $\underline{U}_{AB}, \underline{U}_{BC}, \underline{U}_{CA}$ the unbalanced total reactance and - the stator phase voltages.

The dynamic longitudinal edge effect consists in the modification of currents distribution along the longitudinal direction.

This is due to the induced motion with respect to the progressive magnetic field.

If the induced reaction is weak then the static longitudinal edge effect on the non-symmetrical system of currents will be preponderant.

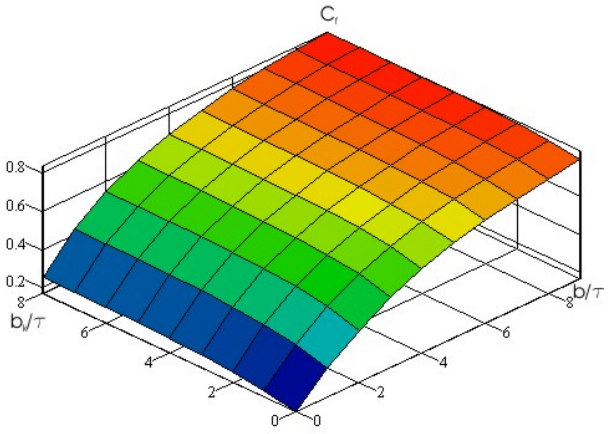



Figure 4. The dependencies of the induced resistance's coefficient.

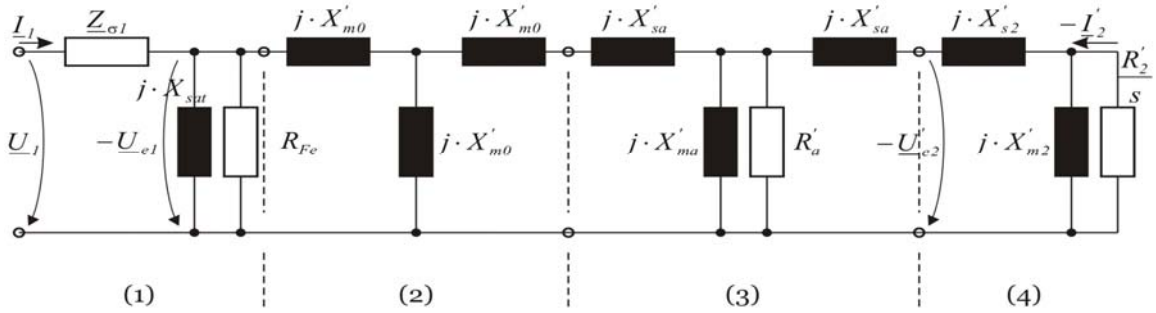



Figure 5. The equivalent electrical diagram of the electromagnetic pump, single-sided stator: (1) – stator, (2) – air, (3) – channel, (4) – melted liquid (induced).

The electrical equivalent diagram on a phase of the induction electromagnetic pump may be deduced by integrate the Maxwell's equations into the space above the single-sided stator.

To perform this operation, the vector magnetic potential, $\underline{\Psi}$ has to be used with the boundary conditions on the surfaces between the layers within the pump's air gap:

$$\frac{d^2\underline{\Psi}}{dz^2} - \underline{\beta}^2 \cdot \underline{\Psi} = 0, \quad \underline{\beta} = \sqrt{\left(\frac{\pi}{\tau}\right)^2 + j \cdot \frac{s \cdot \omega_1 \cdot \mu_0}{k_r \cdot \rho}} \tag{5}$$

where: s – the slip, $\mu_0$ - the vacuum magnetic permeability, $\rho$ - the melted metal resistivity, $k_r$ - the resistance's coefficient due to the transversal edge effect.

An equivalent electric diagram is obtained through cascade connection of equivalent elements corresponding to the air gap layers, Figure 5.

For the on-line computations i.e. adaptive control, the simplified electrical equivalent diagram, Figure 6, is to be used; the significance of the components in Figure 6 is as follows: $\underline{Z}_{\sigma 1}$ - the leakage inductance with respect to the induced, $X_m$ - the linkage inductance, $R_{Fe}, R'_a$ - the equivalent resistances corresponding to the cast-iron and channel losses respectively $R'_2$ - the equivalent resistance of the induced and $s$ - the slip. The simplified diagram is only valid for larger polar step inductors at low frequencies.

If the pump is supplied from frequency converters, the constant stator flux operation is to be used. In this operation the converter provides a voltage direct phase-sequence with variable magnitude and variable frequency such as $U_1 / f_1 = const.$

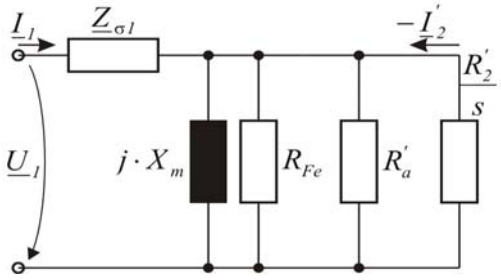



Figure 6. The simplified equivalent electrical diagram of the electromagnetic pump.

In this case the reference coordinate system is referred to the stator.

To obtain an estimate of the induced power into the melted metal the induced currents components and the magnetic flux-linkages components into the induced are to be computed.

The reference coordinate system is the stator and the inputs are the voltages and the currents through the stator winding.

## 3. IMPLEMENTATION OF BOCKER OBSERVER FOR DETERMINATION OF THE TRANSFERRED POWER TO THE MELTED METAL

The Bocker's observer provides an estimate of the magnetic flux linkages components, [3]. The voltages equations and the flux-linkages equations of the two-phased equivalent system represented in a coordinate system related to the stator are given by the following expressions, [4]:

$$
\begin{aligned}
u_{d1} &= R_1 \cdot i_{d1} + \frac{d\Psi_{d1}}{dt} \\
u_{q1} &= R_1 \cdot i_{q1} + \frac{d\Psi_{q1}}{dt} \\
0 &= R_2^{'} \cdot i_{d2}^{'} + \frac{d\Psi_{d2}^{'}}{dt} + \frac{\pi}{\tau} \cdot v \cdot \Psi_{q2}^{'} \\
0 &= R_2^{'} \cdot i_{q2}^{'} + \frac{d\Psi_{q2}^{'}}{dt} - \frac{\pi}{\tau} \cdot v \cdot \Psi_{d2}^{'}
\end{aligned}
\qquad (6 - 9)
$$

$$
\begin{aligned}
\Psi_{d1} &= L_1 \cdot i_{d1} + L_h \cdot i_{d2}^{'} \\
\Psi_{q1} &= L_1 \cdot i_{q1} + L_h \cdot i_{q2}^{'} \\
\Psi_{d2}^{'} &= L_2^{'} \cdot i_{d2}^{'} + L_h \cdot i_{d1} \\
\Psi_{q2}^{'} &= L_2^{'} \cdot i_{q2}^{'} + L_h \cdot i_{q1}
\end{aligned}
\qquad (10 - 13)
$$

From the (10 - 13) set of equations the currents are expressed. Afterwards the results are introduced into the relations (6 - 9). The following set of equations is then obtained:

$$
\begin{aligned}
\frac{d\Psi_{d1}}{dt} &= -R_1 \cdot \frac{1}{\sigma \cdot L_1} \cdot \Psi_{d1} + R_1 \cdot \frac{1-\sigma}{\sigma \cdot L_h} \cdot \Psi_{d2}^{'} + u_{d1} \\
\frac{d\Psi_{q1}}{dt} &= -R_1 \cdot \frac{1}{\sigma \cdot L_1} \cdot \Psi_{q1} + R_1 \cdot \frac{1-\sigma}{\sigma \cdot L_h} \cdot \Psi_{q2}^{'} + u_{q1} \\
\frac{d\Psi_{d2}^{'}}{dt} &= R_2^{'} \cdot \frac{1-\sigma}{\sigma \cdot L_h} \cdot \Psi_{d1} - R_2^{'} \cdot \frac{1}{\sigma \cdot L_2^{'}} \cdot \Psi_{d2}^{'} - \frac{\pi}{\tau} \cdot v \cdot \Psi_{q2}^{'} \\
\frac{d\Psi_{q2}^{'}}{dt} &= R_2^{'} \cdot \frac{1-\sigma}{\sigma \cdot L_h} \cdot \Psi_{q1} - R_2^{'} \cdot \frac{1}{\sigma \cdot L_2^{'}} \cdot \Psi_{q2}^{'} + \frac{\pi}{\tau} \cdot v \cdot \Psi_{d2}^{'}
\end{aligned}
\qquad (14 - 17)
$$

Subsequently the given set of equations is rewritten in the matrix form as follows:

$$
\begin{cases}
\dfrac{d\hat{X}}{dt} = A \cdot \hat{X} + B \cdot U \\
\hat{Y} = C \cdot \hat{X}
\end{cases}
\qquad (18 - 19)
$$

where:

$$
A = \begin{bmatrix}
-\dfrac{R_1}{\sigma \cdot L_1} & 0 & \dfrac{R_1 \cdot L_h}{\sigma \cdot L_1 \cdot L_2^{'}} & 0 \\
0 & -\dfrac{R_1}{\sigma \cdot L_1} & 0 & \dfrac{R_1 \cdot M}{\sigma \cdot L_1 \cdot L_2^{'}} \\
\dfrac{R_1 \cdot L_h}{\sigma \cdot L_1 \cdot L_2^{'}} & 0 & -\dfrac{R_2^{'}}{\sigma \cdot L_2^{'}} & -\dfrac{\pi}{\tau} \cdot v \\
0 & \dfrac{R_1 \cdot L_h}{\sigma \cdot L_1 \cdot L_2^{'}} & +\dfrac{\pi}{\tau} \cdot v & -\dfrac{R_2^{'}}{\sigma \cdot L_2^{'}}
\end{bmatrix}, \quad B = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix},
$$

$$
C = \begin{bmatrix}
\dfrac{1}{\sigma \cdot L_1} & 0 & -\dfrac{1-\sigma}{\sigma \cdot L_h} & 0 \\
0 & \dfrac{1}{\sigma \cdot L_1} & 0 & -\dfrac{1-\sigma}{\sigma \cdot L_h}
\end{bmatrix}
$$

and the vectors: $\hat{X} = \begin{bmatrix} \Psi_{d1} \\ \Psi_{q1} \\ \Psi_{d2}^{'} \\ \Psi_{q2}^{'} \end{bmatrix}$, $U = \begin{bmatrix} u_{d1} \\ u_{q1} \end{bmatrix}$, $Y = \begin{bmatrix} i_{d1} \\ i_{q1} \end{bmatrix}$.

This set of equations is also called the Bocker's observer.

The maximum of the induced reaction is achieved when the melted metal doesn't move, i.e. the induced speed is at zero with respect to the stator, $v = 0$. This approximation may also be used in normal operation of the pump because the speed of the melted metal is usually much smaller than the synchronous speed of the pump. For example, for a given unit the synchronous speed is $v_1 = 19{,}8\ m/s$, while at rated (or nominal) operation the speed of the melted metal results $v_N = 0{,}8\ m/s$.

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The system of differential equations (18 - 19) is to be transformed into a system of difference equations with the sampling period $T_e$ and follows the following recursive equations:

$$\begin{bmatrix}\Psi_{d1}(k+1)\\ \Psi_{q1}(k+1)\\ \Psi'_{d2}(k+1)\\ \Psi'_{q2}(k+1)\end{bmatrix}=\begin{bmatrix}1-T_e\cdot\frac{R_1}{\sigma\cdot L_1} & 0 & T_e\cdot\frac{R_1\cdot L_h}{\sigma\cdot L_1\cdot L'_2} & 0\\ 0 & 1-T_e\cdot\frac{R_1}{\sigma\cdot L_1} & 0 & T_e\cdot\frac{R_1\cdot M}{\sigma\cdot L_1\cdot L'_2}\\ T_e\cdot\frac{R'_2\cdot L_h}{\sigma\cdot L_1\cdot L'_2} & 0 & 1-T_e\cdot\frac{R'_2}{\sigma\cdot L'_2} & 0\\ 0 & T_e\cdot\frac{R'_2\cdot L_h}{\sigma\cdot L_1\cdot L'_2} & 0 & 1-T_e\cdot\frac{R'_2}{\sigma\cdot L'_2}\end{bmatrix}\cdot\begin{bmatrix}\Psi_{d1}(k)\\ \Psi_{q1}(k)\\ \Psi'_{d2}(k)\\ \Psi'_{q2}(k)\end{bmatrix}+$$

$$+T_e\cdot\begin{bmatrix}1 & 0\\ 0 & 1\\ 0 & 0\\ 0 & 0\end{bmatrix}\cdot\begin{bmatrix}u_{d1}(k)\\ u_{q1}(k)\end{bmatrix} \quad (20)$$

$$\begin{bmatrix}i_{d1}(k)\\ i_{q1}(k)\end{bmatrix}=\begin{bmatrix}\frac{1}{\sigma\cdot L_1} & 0 & -\frac{1-\sigma}{\sigma\cdot L_h} & 0\\ 0 & \frac{1}{\sigma\cdot L_1} & 0 & -\frac{1-\sigma}{\sigma\cdot L_h}\end{bmatrix}\cdot\begin{bmatrix}\Psi_{1d}(k)\\ \Psi_{1q}(k)\\ \Psi'_{2d}(k)\\ \Psi'_{2q}(k)\end{bmatrix} \quad (21)$$

The structure of the flux reconstructor is represented in Figure 7.

By means of the flux reconstructor, and the system of equations (10 - 13) the induced currents components are determined.

The power transferred to the liquid metal may be determined from the balance of power as follows:

$$P_{2tot}=[i]^T\cdot[u]-[i]^T\cdot[R]\cdot[i],\ \text{în care: } [i]=\begin{bmatrix}i_{d1}\\ i_{q1}\\ i'_{d2}\\ i'_{q2}\end{bmatrix},\ [u]=\begin{bmatrix}u_{d1}\\ u_{q1}\\ u'_{d2}\\ u'_{q2}\end{bmatrix},\ [R]=\begin{bmatrix}R_1 & 0 & 0 & 0\\ 0 & R_1 & 0 & 0\\ 0 & 0 & R'_2 & 0\\ 0 & 0 & 0 & R'_2\end{bmatrix} \quad (22)$$

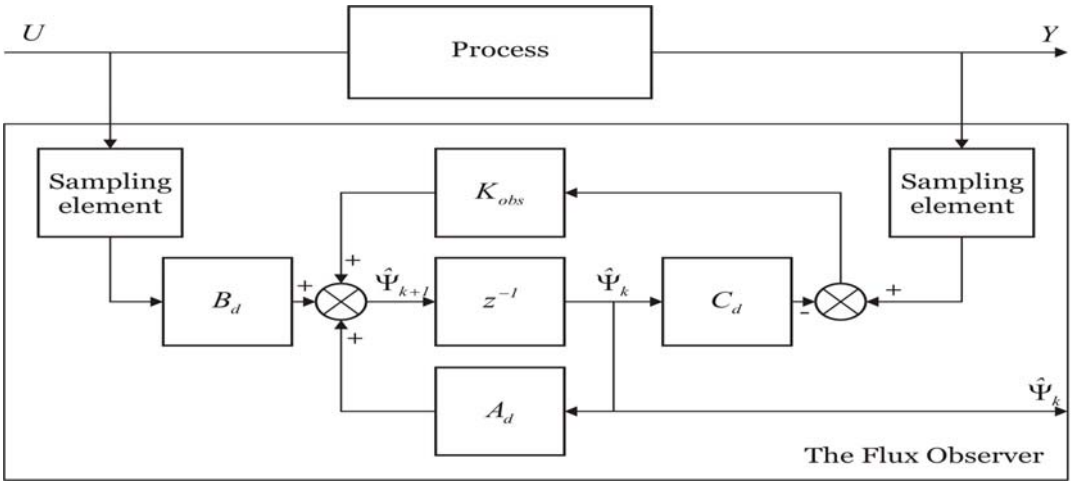



Figure 7. The flux observer.

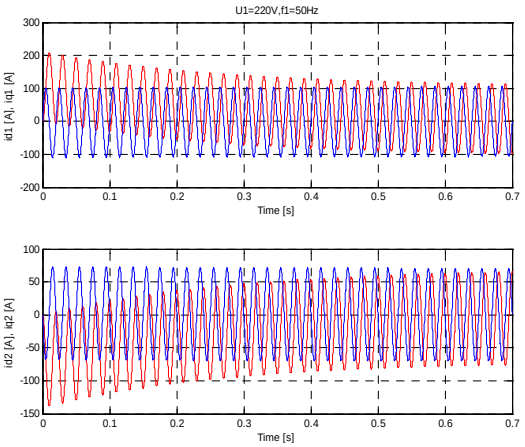



Figure 8. The currents components at start-up and in steady-state operation. Above: stator, below induced.

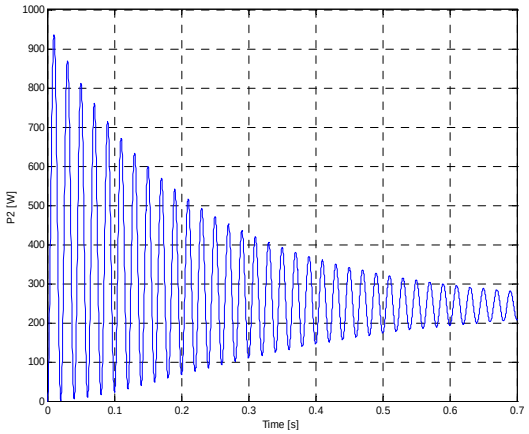



Figure 9. The transferred power to the induced at start-up and in steady-state operation- rated frequency.

The previous considerations have been implemented for a given induction electromagnetic pump designed with the procedure presented in [1]. The technical features of the pump are presented in Table 2.

Table 2. The technical features of the experimental induction electromagnetic pump.

| No. | Denomination | Symbole | Units | Value |
|---|---|---|---|---|
| 1 | The rated supply voltage | $U_{1N}$ | $V$ | 220 |
| 2 | The rated frequency | $f_{1N}$ | $Hz$ | 50 |
| 3 | The rated flow rate | $Q_{mN}$ | $kg/s$ | 22 |
| 4 | No. of units | - | - | 2 |
| 5. | Total power of a unit | $P_t$ | $W$ | 9500 |
| 6. | The induced | - | - | cast-iron |
| 7. | The pump's slope | s | o | 10 |

The estimated values of the electric parameters of the pump are presented in Table 3. The computations have been performed according to the study [1]. To the practical implementation of the flux observer a software application has been conceived into the MatLab environment. The results are presented in Figures 8 and 9.

The currents components at start-up and in steady-state operation are presented in Figure 8.

Table 3. The estimated values of the electrical parameters of the experimental pump

| No. | Denomination | Symbol | Units | Value |
|---|---|---|---|---|
| 1 | The phase resistance of the inductor | $R_1$ | Ω | 0.042361 |
| 2 | The total inductance of the stator winding | $L_1$ | $H$ | 0.0038067 |
| 3 | The equivalent resistance of the melted metal referred to the number of stator turns | $R_2^{'}$ | Ω | 5.9419e-006 |
| 4 | The linkage inductance | $L_m$ | $H$ | 0.0028573 |
| 5. | The inductancies coefficient | σ | - | 0.75061 |

As seen from the computations, the induced reaction is rather weak in comparison with the classical induction machine. In Figure 9 the estimate of the induced transferred power is presented. At start-up, i.e. when the melted metal doesn't moves, the transferred power has a maximum while at normal operation the power decreases three times.

## 4. CONCLUSIONS

Within this paper an analisys of state observers implementation to estimate the transferred power to the melted metal into an electromagnetic pump is presented. This estimation is possible if a model of the system is available. The proposed method allows the magnetic flux components reconstruction. The computations performed into the MatLab environment are compatible to the experiments and design data of the pump under study. The further researches could enhance pe usage of the observer to the melted metal flow rate estimation.

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# ADAPTIVE GENETIC FUZZY SYSTEMS IN INDUSTRY: CURRENT FRAMEWORK AND NEW TRENDS

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**Abstract**:
Adaptive genetic fuzzy systems are ability to solve different kinds of problems in various application domains. There is an increasing interest to mix fuzzy systems with learning and adaptation capabilities. Adaptive genetic fuzzy systems are very hybridizing the approximate reasoning method of fuzzy systems with the adaptive and evolutionary algorithms. Learning/optimization methods drawn from both fuzzy theory and genetic algorithms are used to find the optimal strategy.
This paper provide an account of genetic fuzzy systems, with special attention to adaptive genetic fuzzy rule-based systems. After a brief introduction to models and applications of genetic fuzzy systems, critical evaluation is elaborated. The resulting expert system is an open system that uses frames, rules, fuzzy implication and connection matrices to produce a form of machine learning. Authors open questions for the future investigation of new trends in genetic fuzzy systems.

**Keywords**:
Fuzzy, Expert System, Genetic Algorithm

## 1. INTRODUCTION

Fuzzy systems successfully purposed to problems in classification [1.], modeling [2.] control [3.], in industry applications. The key for success was the ability of fuzzy systems to incorporate human expert knowledge.

One of the most approaches have been the hybridization attempts made in the framework of soft computing, were different techniques, such as neural and evolutionary, provide fuzzy systems with learning capabilities, as shown in Figure. 1. Neuro-fuzzy systems are one of the most successful and visible directions of that effort [4.,5.,6.]. A different approach to hybridization leads to genetic fuzzy systems (GFSs) [7.].

A GFS is basically a fuzzy system augmented by a learning process based on a genetic algorithm (GA). GAs are search algorithms, based on natural genetics, that provide robust search capabilities in complex spaces, and thereby offer a valid approach to problems requiring efficient and effective search processes [8.].

Genetic learning processes cover different levels of complexity according to the structural changes produced by the algorithm [9.], from the simplest case of parameter optimization to the highest level of complexity of learning the rule set of a rule based system. Parameter optimization has been the approach utilized to adapt a wide range of different fuzzy systems, as in genetic fuzzy clustering or genetic neuro-fuzzy systems.

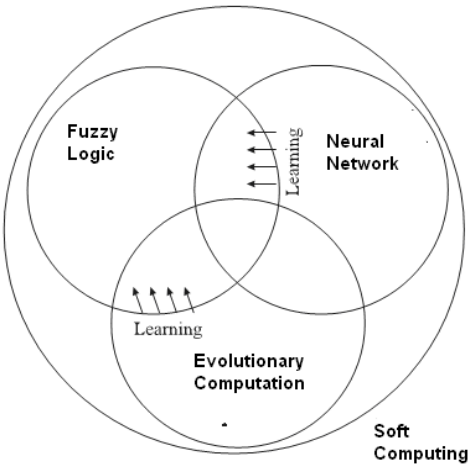



Figure 1 soft computing and learning in fuzzy system

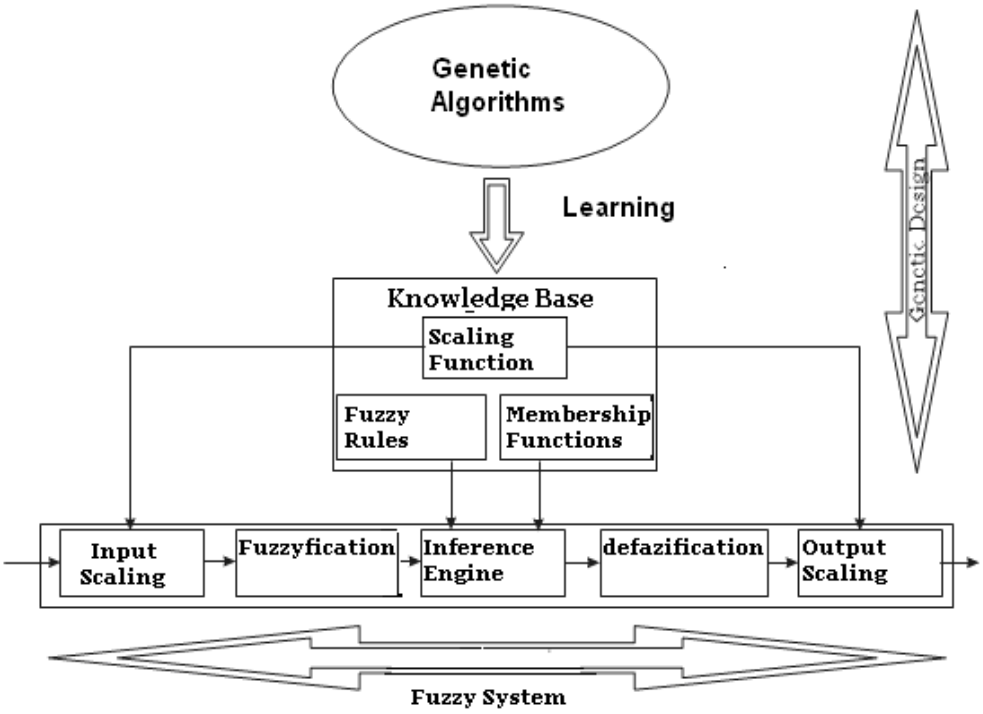



Figure. 2. Genetic design and fuzzy processing

Analysis of the literature shows that the most prominent types of GFSs are genetic fuzzy rule-based systems (GFRBSs) [10.], whose genetic process learns or tunes different components of a fuzzy rule-based system (FRBS). Figure. 2 shows this conception of a system where genetic design and fuzzy processing are the two fundamental constituents. Inside GFRBSs it is possible to distinguish between either parameter optimization or rule generation processes, that is, adaptation and learning.

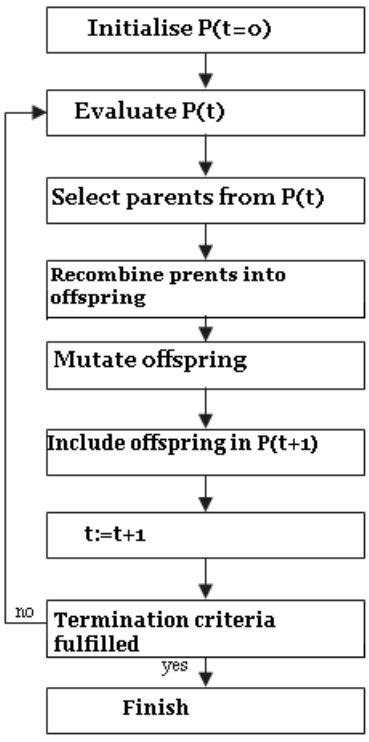



Figure. 3. Principal structure of a genetic algorithm

## 2. GENETIC ALGORITHMS

GAs are general purpose search algorithms which use principles inspired by natural genetics to evolve solutions to problems [8.]. The basic idea is to maintain population of chromosomes (representing candidate solutions to the concrete problem being solved) that evolves over time through a process of competition and controlled variation.

A GA starts with a population of randomly generated chromosomes, and advances towards better chromosomes by applying genetic operators modeled on the genetic processes occurring in nature. The population undergoes evolution in a form of natural selection.

During successive iterations, called generations, chromosomes in the population are rated for their adaptation as solutions, and on the basis of these evaluations, a new population of chromosomes is formed using a selection mechanism and specific genetic operators such as crossover and mutation. An evaluation or fitness function must be devised for each problem to be solved.

Given a particular chromosome, a possible solution, the fitness function returns a single numerical value, which is supposed to be proportional to the utility or adaptation of the solution represented by that chromosome.

Although there are many possible variants of the basic GA, the fundamental underlying mechanism consists of three operations: evaluation of individual fitness, formation of a gene pool (intermediate population) through selection mechanism, and recombination through crossover and mutation operators. Figure 3 illustrate this operation mode. The specific characteristics of the evaluation method are quite dependent on the application.

As previously stated, genetic learning processes cover different levels of complexity, from parameter optimization to learning the rule set of a rule based system. Genetic learning processes designed for parameter optimization usually fit to the description given in previous paragraphs, but when considering the task of learning rules in a rule based system, a wider range of possibilities is open.

## 3. GENETIC FUZZY RULE-BASED SYSTEM

The mean point is to employ an evolutionary learning process to automate the design of the knowledge base, which can be considered as an optimization or search problem.

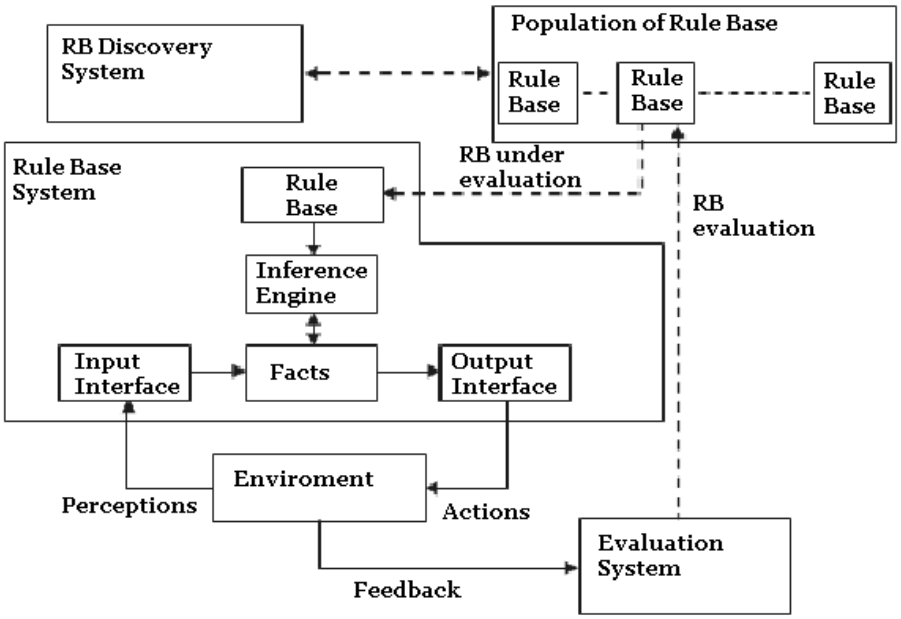



Figure. 4. Learning with the Pittsburgh approach

From the viewpoint of optimization, the task of finding an appropriate knowledge base (KB) for a particular problem, is equivalent to parameterize the fuzzy KB (rules and membership functions), and to and those parameter values that are optimal with respect to the design criteria. The KB parameters constitute the optimization space, which is transformed into a suitable genetic representation on which the search process operates.

The first step in designing a GFRBS is to decide which parts of the KB are subject to optimization by the GA. The KB of an FRBS does not constitute a homogeneous structure but is rather the union of qualitatively different components. KB of a descriptive Mamdani-type FRBS is comprised of two components:

- a data base (DB), containing the definitions of the scaling functions of the variables and the membership functions of the fuzzy sets associated with the linguistic labels, and
- a rule base (RB), constituted by the collection of fuzzy rules.

The decision on which part of the KB to adapt depends on two conflicting objectives: dimensionality and efficiency of the search.

A search space of a smaller dimension results in a faster and simpler learning process, but the obtainable solutions might be suboptimal. A larger, complete search space

that comprises the entire KB and has a finer dimensionality is therefore more likely to contain optimal solutions, but the search process itself might become prohibitively inefficient and slow.

First of all, it is important to distinguish between tuning (alternatively, adaptation) and learning problems:

- Tuning is concerned with optimization of an existing FRBS, whereas learning constitutes an automated design method for fuzzy rule sets that starts from scratch.
- Learning processes perform a more elaborated search in the space of possible RBs or whole KBs and do not depend on a predefined set of rules.

Summing up, the classical genetic learning procedures to evolve FRBSs are:

- Genetic tuning of the DB,
- Genetic learning of the RB,
- Genetic learning of the KB.

Although the review is by no means exhaustive, this section reviewed the most important approaches found in the literature.

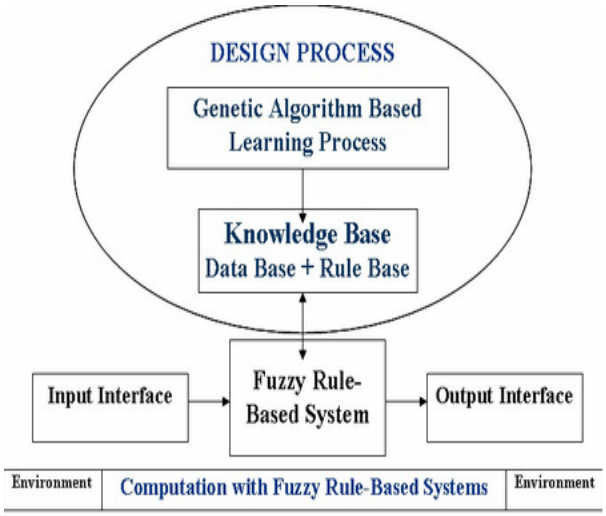



Figure 5. Genetic fuzzy systems

## 4. APPLICATIONS OF GENETIC FUZZY SYSTEMS

Authors provides a computational framework to address design, analysis and modeling problems in the context of uncertain and imprecise information. Its constituents fuzzy logic, neural networks, probabilistic computing and evolutionary algorithms are considered as complementary and synergistic partners rather than competing methodologies.

Neuro-fuzzy systems [5.] are by far the most prominent and visible representative of hybrid systems in terms of number of applications.

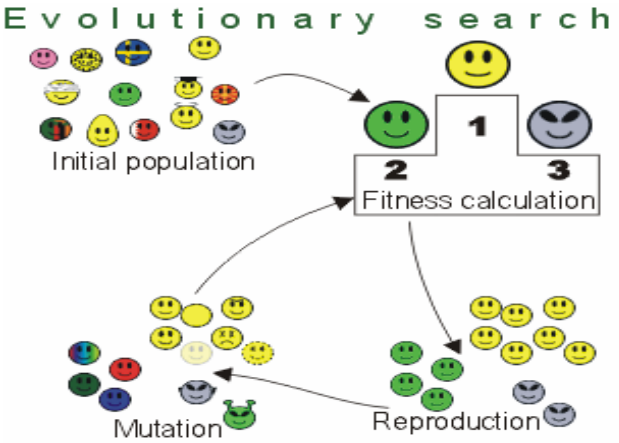



Figure 6. Evolutionary search

Compared to neuro- fuzzy systems, GFS applications until today remained less visible, in particular in an industrial setting.

In a second phase, the GA tunes the membership functions causing a local adaptation. Adaptation of membership functions for a controller with properly tuned scaling factors only results in a marginal improvement.

The role of the evolutionary algorithm is to adapt the number of rules and to fine tune the membership functions to improve the performance of fuzzy systems for estimation and control.

In [11.], Mizutani propose a hybrid neuro-genetic–fuzzy system for computerized colour prediction, a challenging problem in paint production.

Their architecture for colour paint manufacturing intelligence cannot be characterized as conventional GFSs in which the evolutionary algorithm optimizes the fuzzy knowledge base. Instead, colour expert knowledge is expressed by fuzzy rules.

Bonissone et al. apply evolutionary techniques to tune a fuzzy decision system [12.]. The fuzzy system automatically classifies the risk of an insurance application, which in turn determines the premium to be paid by the applicant.

In [14] Latinovic presents an approach to modeling genetic fuzzy real-time expert diagnostic system for PLC controlled manufacturing system in Tobacco Industry in Banjaluka. These approaches to modeling inspired by biological evolution are called evolutionary computation. It contains the design and engineering knowledge about the manufacturing system to be diagnosed.

The list of applications above indicates that GFSs can contribute to solve industrial and commercial problems. The major driving force behind this development is the need for low-cost solutions that utilize intelligent tools for information processing, design and optimization. GFSs can reduce the cost and time required to design, autonomously operate and maintain systems with a high degree of machine intelligence for control, prediction, modeling and decision making.

## 5. NEWTRENDS IN GENETIC FUZZY RULE-BASED SYSTEMS

In addition to the classical systems, here new directions to apply genetic (evolutionary) techniques to FRBSs are explored:

1. Genetic selection of fuzzy rule sets
2. Genetic feature selection
4. Learning knowledge bases via genetic derivation of data bases
5. Maintaining interpretability via multi-objective genetic processes
6. Genetic-based learning approaches considering different model structures
7. Genetic-based learning approaches with sophisticated genetic algorithms
8. Genetic-based machine learning approaches
9. Genetic fuzzy neural networks
10. Genetic fuzzy clustering algorithms

Until recently, there was no systematic procedure to design and develop fuzzy systems. A common approach was defining fuzzy systems based on expert knowledge and testing them to verify if the design is satisfactory. However, when expert knowledge is lacking or when considerable amount of data must be processed and analyzed, purely knowledge-based design approaches become limited.

Machine learning approaches have shown to be useful in these cases. For instance, neural networks can learn from data, but the linguistic representation of fuzzy rules and their transparency may be lost [13.].

GA-based approaches have been developed to learn:

a) membership functions with fixed fuzzy rules ,
b) fuzzy rules with fixed membership functions ,
c) fuzzy rules and membership functions using (a) and (b) in alternate steps ,
d) membership functions and RB simultaneously ,
e) Rules and RB structure and parameters (granularity, rule antecedent aggregation operator, rule semantics, rule base aggregation operator, defuzzification, membership function shape and parameters) simultaneously.

## 6. CONCLUSIONS

The last decade has seen a large interest in technologies that have as their motivation some aspect of human function. Some of these, like artificial intelligence, can be seen to be rooted in the psychological domain. Others, like neural networks, genetic algorithms, and evolutionary programming, are inspired by reconsiderations of biological processes.

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Common to all these so-called "intelligent technologies" is a need to represent knowledge in a manner that is both faithful to the human style of processing information as well as a form amenable to computer manipulation

This paper provided an account of the current status of GFSs after many years of considerable research and development effort. In addition to a brief overview of the field to address the classical models and applications, new trends have been identified. A critical evaluation of the contribution that GFSs bring to knowledge acquisition and fuzzy rule base design was conducted, and challenges for further developments in the field were outlined. From authors point of view we need to build hybrid intelligent systems that go beyond simple combinations.

Development of GFSs that offer acceptable trade-of between interpretability and accuracy is also a major requirement for efficient and transparent knowledge extraction. Discovery of more sophisticated and new evolutionary learning models of GFSs and its application to new areas and problems still remain as key questions for the future development trends of GFSs.

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# POSSIBILITY OF APPLYING HYDRODYNAMIC COUPLERS FOR DRIVING BELT CONVEYORS

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**Abstract**:
The analysis of the possibility of applying hydrodynamic couplers between the drive electromotor and the gear reducer was carried out in the biggest Serbian mine in order to improve and modernize the operation of belt conveyors. This paper contains the basic parameters of these couplers manufactured by Voith, as well as the critical comment on their eventual application.

**Keywords**:
hydrodynamic coupler, conveyor

## 1. INTRODUCTION

The hydrodynamic coupler consists of the two working circuits: the pump circuit (P) - the entrance, connected to the drive engine shaft and the turbine circuit (T) - the exit, which is connected to the working machine shaft. Both circuits are placed in the common housing filled with oil.

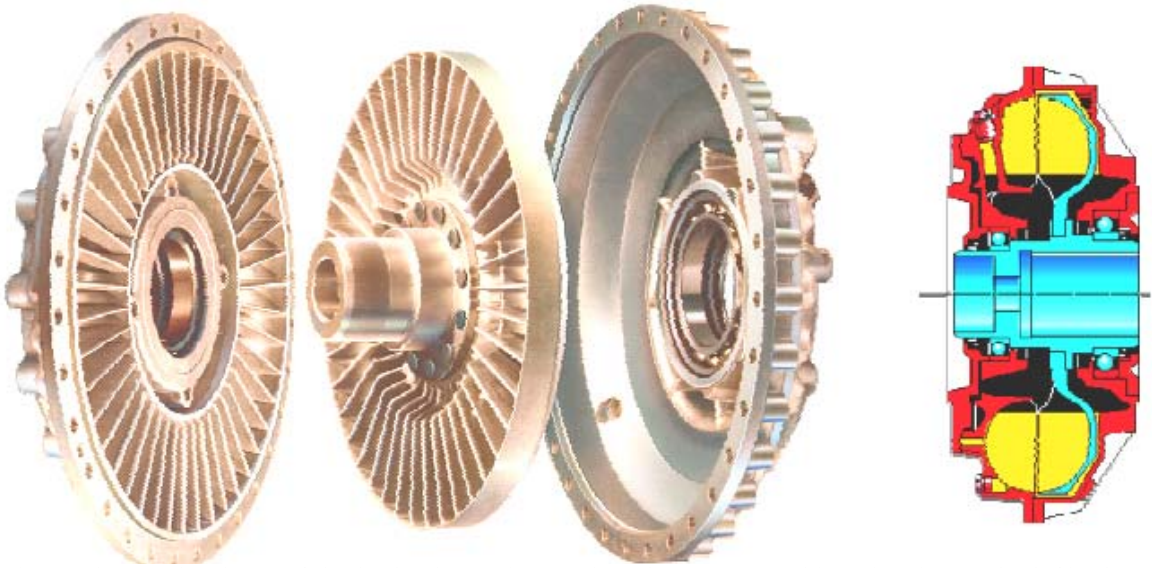


Fig. 1. The mechanisms of the hydrodynamic coupler: the pump working circuit (on the left), the turbine working circuit (in the middle) and the outer covering (on the right); the cross-section of the coupler

The rotation of the pump circuit speeds up the working fluid which enters the working space of the turbine circuit with the increased kinetic energy which is further transferred to the working machine. Namely, the oil as a working fluid flows at a great speed exposed to the low pressure in the closed circulation circle formed by the blades of the working circuits. When the speed of the working oil movement is increased, the mechanical energy of the engine is transformed into the kinetic energy of the oil in the channels of the pump circuit. The reverse process takes place in the channels between the blades of the turbine circuit. The oil is slowed down there, i. e. its kinetic energy is transformed again into the mechanical

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energy of the turbine circuit. In this manner the energy transfer from the pump circuit to the turbine circuit is performed hydraulically.

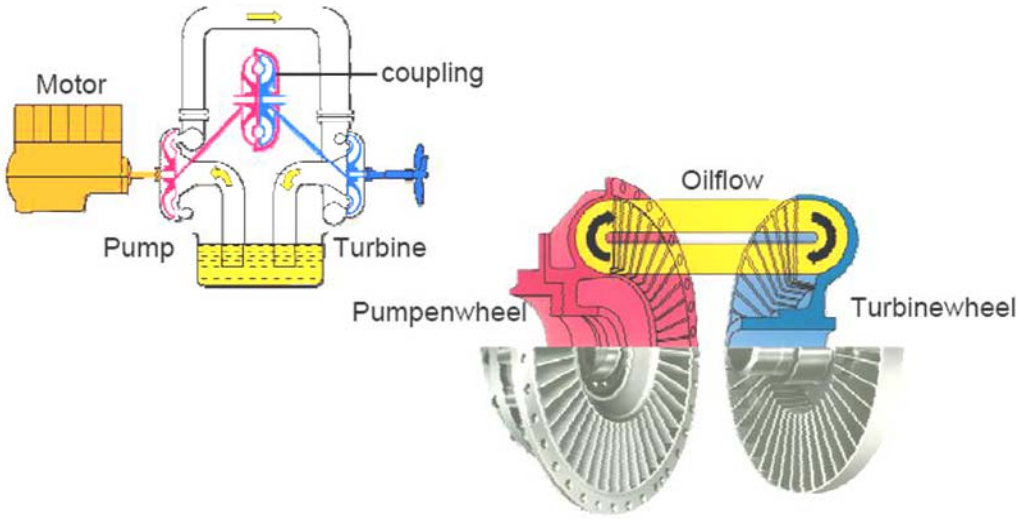



Fig. 2. The scheme of the principle of operation of the hydrodynamic coupler

## 2. THE ANALYSIS OF THE POSSIBILITY OF INSTALLING THE VOITH TURBOCOUP-LER TVVS ON THE BELT CONVEYOR

The Voith couplers are specially designed to adjust to working with different working fluids:

- Oil-standard use,
- Water-especially in underground exploitation (TVV couplers),
- EP fluid (Environment Pollution-free Fluid) – biodegradable,
- Hi-fluid (High flash point fluid) - does not contain chlorinated hydrocarbon or phosphoric ester. The fluid density is smaller than water density.

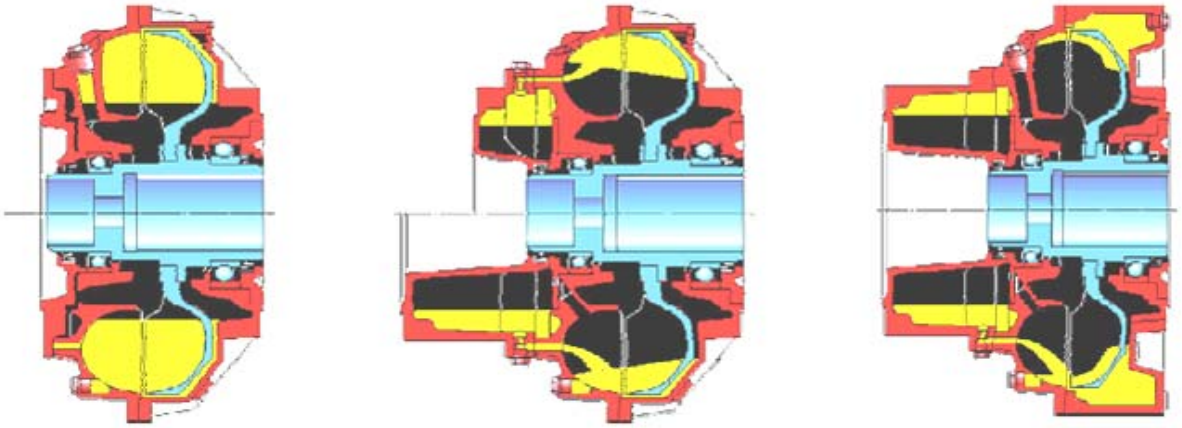


Fig. 3. The basic types of the couplers with the constant quantity of oil: T (on the left), TV/TVV (in the middle) and TVVS (on the right)

The consequences of irregular pouring of oil may be the following:

- When there is too much oil:
  - It takes more time to start the engine,
  - The engine cannot be started at all,
  - The engine cannot reach its nominal speed.
- When there is too little oil:
  - It takes more time to start the machine,
  - The machine cannot be started at all,
  - The machine operates with the increased slippage.

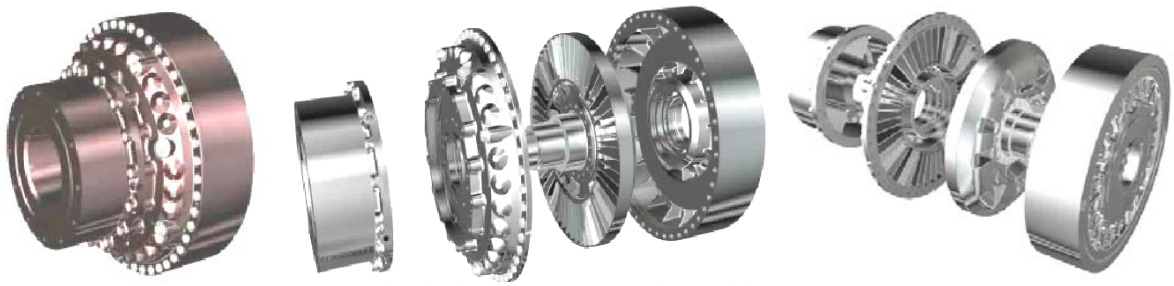


Fig. 4. The hydrodynamic coupler Voith 750 TVVS

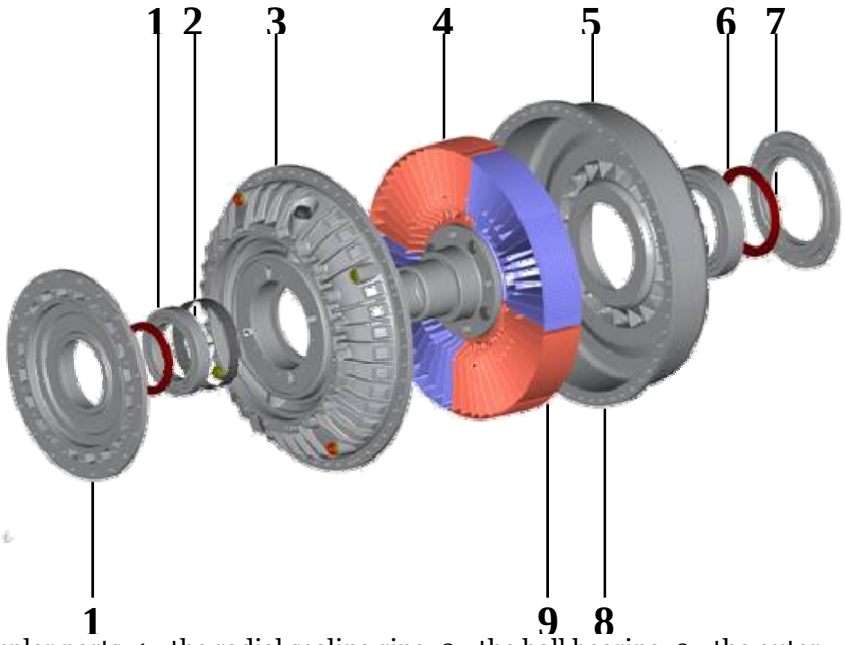



Fig. 5. The coupler parts: 1 - the radial sealing ring, 2 - the ball bearing, 3 - the outer working circuit, 4 - the inner working circuit, 5 - the coupler housing, 6 - the ball bearing, 7 - the radial sealing ring, 8 - the counterweight, 9 - the frictional covering, 10 - the lid

Table 1. The differences between the drive through the inner and the outer working circuit

| | Drive through the outer working circuit | Drive through the inner working circuit |
|---|---|---|
| The weight of the coupler | Affects the reducer shaft. | Affects the engine shaft. |
| Inertia | Less inertia on the reducer side (fewer blows in the event of a sudden blockage). | Greater inertia on the reducer side. |
| Pouring of the fluids and the amount control | Easy - the coupler housing turns around even if the brake is closed. | The entire machine must be started in order to perform inspection. |
| Starting | Always acts the same at starting. | Emptying of the slowdown chamber depends on the characteristics of starting –the starting can be problematic during the blockage of the belt conveyor. |
| Cooling | Always the best possible. | Less-especially during the starting and blockage. |
| Starting characteristics | The Voith turbo couplers are optimal for starting the belt conveyors through the outer working circuit (the mixed profile in the inner working circuit). | |
| Slippage | Less. | Greater. |
| Brake installation | The construction with a shaft / additional brake flange necessary. | The lower price for the brake installed on the elastic coupler. |

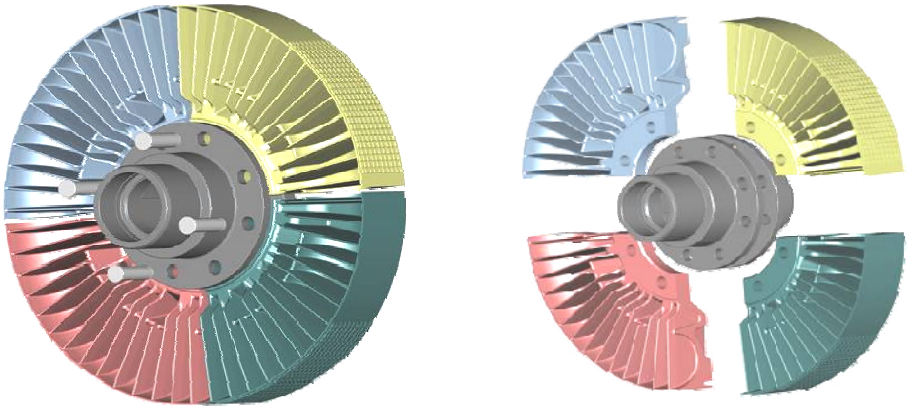


Fig. 6. The inner working circuit has freely movable separate segments

The special properties of TVVS coupler in comparison to the other types are:

- the lengthened slowdown chamber and the additional rim chamber,
- this type has thermal capacity increased by 15% which allows the coupler to be started more often,
- the heat removal is faster by 10% providing faster cooling and shortening the period between two consecutive starts.

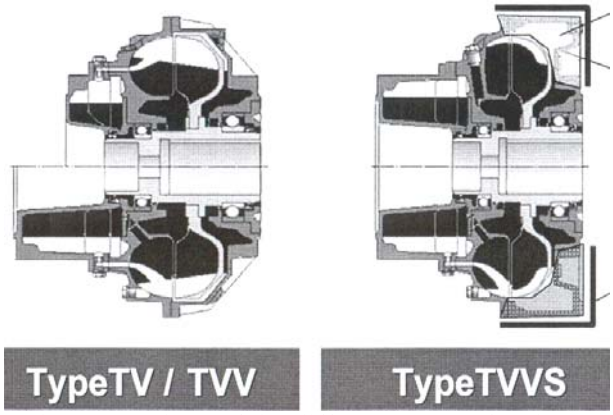



Fig. 7. The comparison of the different types of turbo couplers

## 3. CONCLUSION

Due to the characteristics of the hydrodynamic couplers, there exists the possibility of their application in belt conveyors in coal mines on condition of removing certain flaws which even this highly sophisticated equipment is not immune to. Generally speaking, the turbo couplers have many advantages and therefore should be included in exploitation as soon as possible.

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# WITH SPIDER8 ON RAILS

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**Abstract:**
The carrying of heavy trains on large inclines can produce the breaking of the draw hook. The railway freight operator, want to carry long trains because of the economic reasons. This paper will present the steps of tests performing in purpose to measure the tensile forces from the locomotive draw hook equipped with strain gages. The purpose of the tests was increasing the tonnage of the trains on the inclines (the tonnage of the trains on the inclines is restricted by railway regulations).

**Keywords:**
Hottinger, Spider8, Catman, strain gauges

## 1. INTRODUCTION

Circulation on Romanian Railways is done under regulations in purpose to ensure optimal conditions of safety for passenger and freight trains.

From the point of view of passenger options there are alternatives at trains (cars, buses etc.), but regarding the freight transport there are some products which it will be always carry by the trains (cereals, oil, coal etc.).

If the freight trains run on plate ground, there aren't any problems if there is even one electrical locomotive of 5100 kW power. But, if the train run on inclines (which in Romania can have the value of 25‰) then a second locomotive it is necessary depending of the total length of train or his weight.

Romanian railways freight operators from Romania have electrical locomotives on four or six axles. If they use more than one locomotive at one train on the inclines the solve the problem of additional needed power, but another question appears: will the locomotive hook break it?

In purpose to measure the forces which appear in the drawing hook, one of the methods which can be used is applying strain gauges on the hook and measuring of the strains during the train's circulation.

## 2. MEASUREMENT POINTS, DEVICES AND TESTS

The measurements were performed with Hottinger Spider8 device connected to a laptop. The acquisition software used was Catman 4.5 also from Hottinger.

For simple loads (tensile/compression for example) it is necessary to glue strain gauges like those presented in figure 1.a.

Because any transducer is sensitive to different types of loads in the same time, the strain gauge glued on it, measure a strain witch represents the algebraic sum of the strains for each load type. The separation for each load type can be done if are glued more strain gauges.

In the tensile load, principal strain 1 is parallel with the longitudinal axe of the elastic element and principal strain 2 is perpendicular on principal strain 1.

The coupling hook it is an assembly of many articulated components. The thread axe where the strain gages were glued is load only with tensile forces. A full

Wheatstone bridge was used for measuring the tensile forces from the drawing hook of the locomotive (figure 1.b and figure 1.c.). The strain gauges were connected to Hottinger Spider8 measuring device.

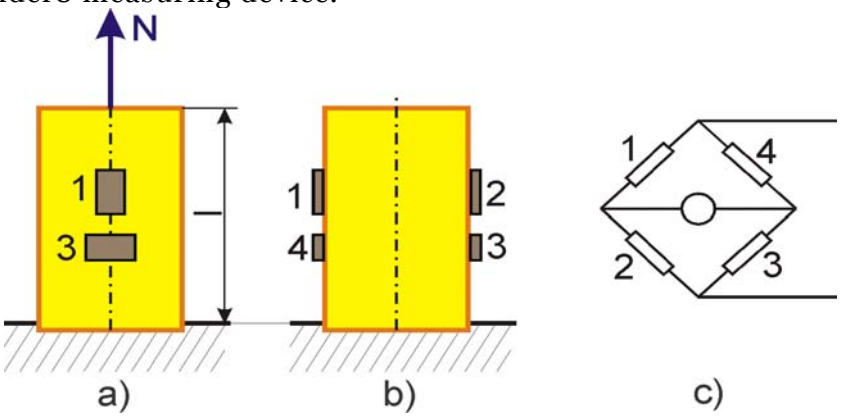



Figure 1 Tensile/compression loads transducer

In fig. 2 is shown the drawing hook of the locomotive which has strain gauges glued on it.



Figure 2 Drawing hook with strain gauges

The drawing hook was mounted the second locomotive and the first wagon of the train.

The measuring of tensile forces was performed in two variants of locomotive coupling: (EA+EC and EC+EC), where EA is electrical locomotive with six axles, 5100 kW power and EC is electrical locomotive with four axles, 3400 kW power.

The tests was done between railway stations Drobeta Turnu Severin – Şimian – Balota – Prunişor (Balota is the highest point of an incline with the maximum value of 29‰).

The performed tests were:

- Between railway stations Şimian and Balota the locomotives were coupled EA+EC, the train weight was 1218t;
- Between railway stations Drobeta Turnu Severin and Balota the locomotives were coupled EC+EC, the train weight was 1218t;
- Between railway stations Prunişor and Balota the locomotives were coupled EA+EC, the train weight was 2960t.

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## 3. RESULTS

The maximum values of measured tensile forces are presented in table 1.

Table 1. The maximum values of measured tensile forces

| Between | Force [kN] |
|---|---|
| Şimian – Balota | 470,2 |
| Dr. Tr. Severin – Balota | 384,8 |
| Prunişor – Balota | 457,6 |

The graphic representation of the tensile forces it is shown in fig. 3÷5.

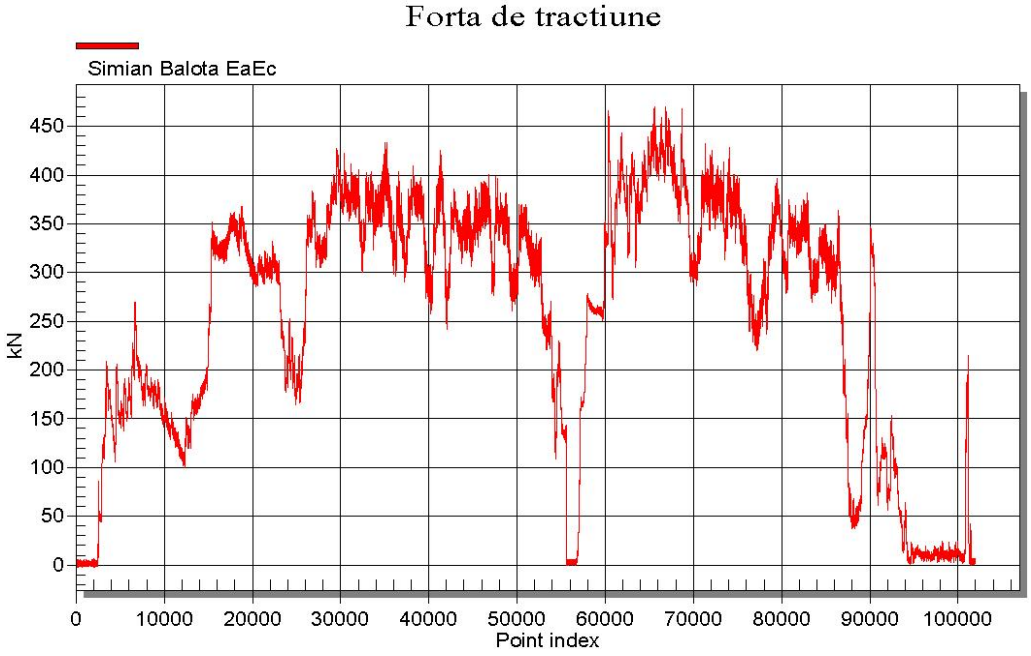



Figure 3 Locomotive coupled EA+EC

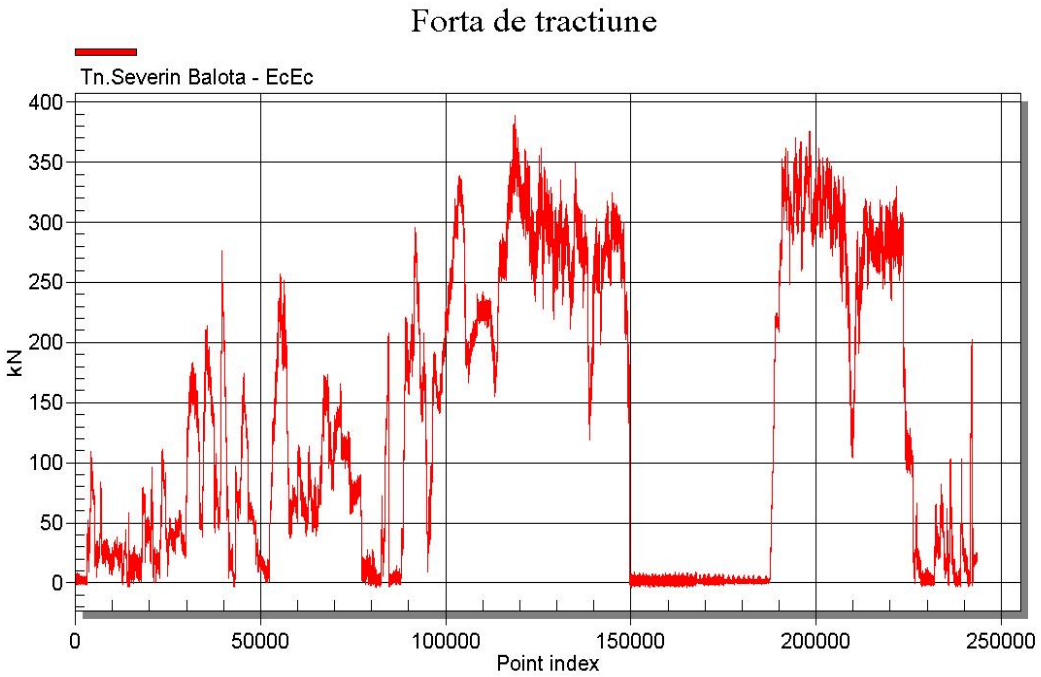



Figure 4 Locomotive coupled EC+EC

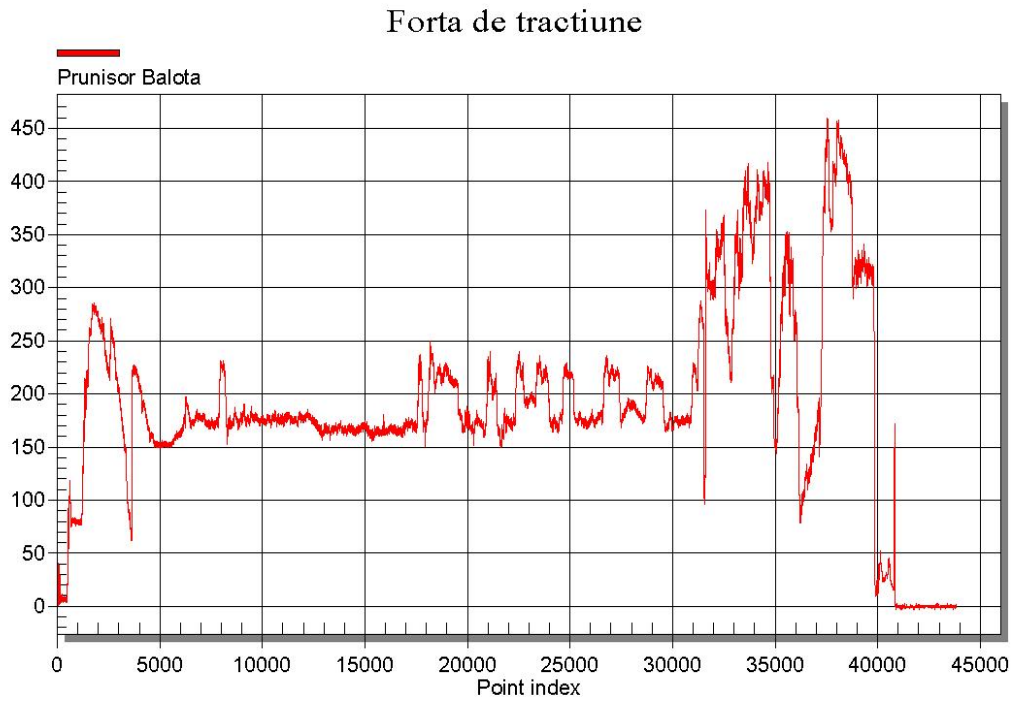



Figure 5 Locomotive coupled EA+EC

## 4. CONCLUSION

The results obtained after the finishing the tests can be used to adjust the weight of the train by increasing the weight of those but only if the technical condition of the locomotives is optimal especially from the point of view of weight balance on axle and good maintenance of the sanders.

In all cases which was study during those tests it was prove that when two locomotives are used is better that first to be an EC type locomotive.

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# EXAMINATIN OF REFRIGERATOR ENGINES WITH THE METHOD OF VIBRATION DIAGNOSIS

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**Abstract**

I have examined the bearings of three cooling-compressor engines with the intention to gather information on their status. Power of the engines 315 kW, rpm.: 2950/min. I have used a type SPM A2011 shock pulse analyzer for my examinations. With the help of this apparatus I have made shock pulse and effective vibrational force (horizontal, vertical, axial ways) measurements. I have made concluded from condition of the bearings, and the suggestion of the intervention.

Participating at: SECTION 5

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# ON THE ENERGETIC CHARACTERISTICS OF THE SHOCK INSULATORS OF RAILWAY VEHICLES

Ion COPACI

University „Aurel Vlaicu" Arad, ROMANIA

**Abstract**

The paper presents the results of experimental studies on the behaviour of bearing structures and shock insulators of railway vehicles during the shock caused by collisions.

The evolutions of energy parameteres depending on the collision velocity are highlighted as well as the experimental values of certain kinematic and force parameters as response functions of the considered mechanical system to the action of excitations caused by the shocks that appear in use.

The paper contains notions related to the theory of shocks caused by collisions of railway vehicles as well as an experimental chapter which, together with the first part, highlight the importance of using shock insulators with a higher capacity for storing potential deformation energy, in order to reduce the maximum values of of the response parameters of the considered mechanical system and also to protect the vehicles against the shocks that appear in use.

**Keywords**:

testing, collision, shock insulators, stored or dissipated potential deformation energy.

## 1. INTRODUCTION

Due to current tendencies to increase travel velocities and car masses by allowing increasingly larger axle loads, railway equipment shows a series of special problems regarding shock loads that appear during collisions. Collision of railway vehicles occurs during use, during car coupling operations, triage maneuvres and during travel, as a consequence of sudden breaking or of a change in coupling systems [1].

The shock caused by railway vehicle collisions results in the transmission of forces and accelerations of considerable magnitudes, which determine:

- strains on the resistance structure of the cars (chassis, body) and bogies;
- strains of the internal equipment and facilities of passenger cars;
- strains of different devices, mechanisms, functional equipment of freight cars;
- accelerations transmitted to the transported freight, which can endanger their integrity and that of the anchoring or packaging systems;
- accelerations transmitted to passenger cars with considerable consequences on the confort of the passengers.

In order to insulate and protect against longitudinal shocks, railway vehicles are equipped with shock insulators.

## 2. THE COLLISION PROCESS

The time evolution of the energetic parameters leads to the following observations on the collision process (figure 1) [3], [5], [6], [7]:

1. At the starting moment of the collision, $t = t_1 = 0$, the kinetic energy of the mechanical system composed of the vehicles, $E_c(t)$ is maximum.

2. On the interval $(0 - t_{12})$ the kinetic energy of the colliding car, $E_{c1}(t)$, decreases, and that of the collided car, $E_{c2}(t)$ increases. Their sum, $E_c(t)$, considerably decreases on the account of the transformation into stored potential energy by the bumpers $W_e$ , cars $W_{ev}=W_{es}+W_{eb}$ and load $W_{eî}$ .

3. At $t_{12}$, the kinetic energy of the cars is minimum:

$$E_c(t_{12}) = E_{c12} = \left[\left(m_1 + m_2\right)\cdot v_{12}^2\right]/2 \qquad (1)$$

where:

$m_1$ – mass of the colliding car;

$m_2$ – mass of the collided car;

the stored potential energy being maximum:

$$E_p = W_e + W_{ev} + W_{eî} \quad (2)$$

4. On the interval ( $t_{12}$ - $t^*_{12}$ ) the process of transforming stored potential deformation energy into kinetic energy begins, together with the process of dissipating potential energy.

5. At the moment $t^*_{12}$ the kinetic energy of the cars is equal to the kinetic energy of the cars at $t_2$:

$$E_c(t^*_{12}) = E_c(t_2) - E^*_c = E^*_{c1} + E^*_{c2} \quad (3)$$

Furthermore, the sum between stored and dissipated potential energies (by the bumpers $W_a$, the cars $W_{av}$ and the freight $W_{aî}$) is equal to the dissipated potential energy at $t_2$:

$$( W_e(t^*_{12}) + W_{ev}(t^*_{12}) + W_{eî}(t^*_{12})) + ( W_a(t^*_{12}) + W_{av}(t^*_{12}) + W_{aî}(t^*_{12})) =$$
$$= E_c - E_c(t^*_{12}) = E_c - E^*_c = W_a + W_{av} + W_{aî} \quad (4)$$

6. On the interval ($t^*_{12}$ - $t_2$ ) the kinetic energy of the cars $E^*_c$ remains constant, under the conditions of the compensation of the drop in stored potential deformation energy by dissipation of potential energy from the system.

7. At the moment $t_2$ the energy balance is:

$$E_c = \left(m_1 \cdot v_1^2\right)/2 = E_c^* + \left(W_a + W_{av} + W_{aî}\right) \quad (5)$$

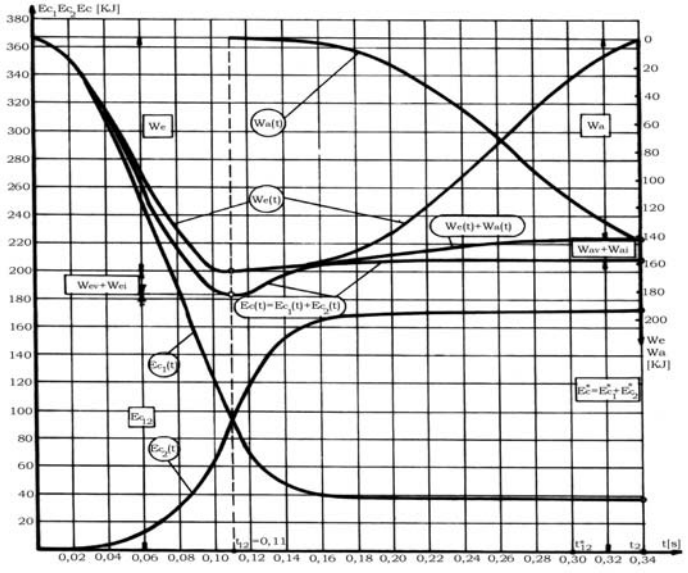



Figure 1

8. Using buffers with superior dynamic characteristics, which store an increased amount of potential deformation energy, has as a direct consequence the decrease of the effects caused by the shock due to collision.

The diagram in figure 1 was drawn experimentally for the motion and energetic parameters resulting from the collision process of two cars equiped with high capacity shock insulators, category C (UIC – 526-1), the colliding car having a mass $m_1$=80 t, and the collided car $m_2$=80 t, collision velocity $v_1$=3,028 m/s. The experimental determinations comprised of $a_2(t)$, the forces transmited through the shock insulators F(t), their contractions D(t), their stored potential energy $W_e$ as well as the dissipated energy $W_a$ .

## 3. ENERGY FACTORS OF THE SHOCK CAUSED BY COLLISION

Against shocks that appear longitudinally during the use of the cars, the railway vehicles are equipped with shock absorbers (bumpers, central coupling dampeners) [8]. [9]. The use of bumpers or central coupling dampeners with high dynamic characteristics has the following consequences:

- the spectacular decrease of the maximum transmitted forces to the vehicles, with consequences on the protection of resistance structures by decreasing specific deformations and the stresses caused by the shock of collision;
- the lowering of the level of transmitted accelerations to the vehicles, down to a value that ensures a necessary protection of the freight, vehicle equipment and amenities, as well as an increased passenger comfort.

The following specific energy factors are defined, whose variation with the collision velocity v = $v_1$ - $v_2$ represents the energy characteristics of the shock caused by the vehicles' collision occuring on the time interval (0 - $t_2$):

1. The $2\beta = f(v)$ factor [2], which characterizes the shock of railway vehicles, represents the ratio between the potential deformation energy stored by the shock absorbers $W_e$ and the potential energy stored by the system composed of the two vehicles $E_p$:

$$2\beta = W_e / E_p \quad (6)$$

2. The $2\lambda = f(v)$ factor is the ratio between the potential deformation energy stored by the bearing structures of the vehicles $W_{es}$ and $E_p$:

$$2\lambda = W_{es} / E_p \quad (7)$$

If the vehicles are identical from this point of view, then $\lambda_1 = \lambda_2 = \lambda$.

3. The $2\delta = f(v)$ factor represents the ratio between the potential deformation energy stored by the elastic elements of the vehicles' suspensions $W_{eB}$ and $E_p$:

$$2\,\delta = W_{eB} / E_p \quad (8)$$

If the vehicles' suspensions are identical, it can be considered that $\delta_1 = \delta_2 = \delta$.

4. The $2\,\chi = f_{(v)}$ factor represents the ratio between the potential energy stored by the equipment and the freigt og the vehicles $W_{ei}$ and $E_p$:

$$2\chi = W_{ei} / E_p \quad (9)$$

If the vehicles are identical from this point of view, then $\chi_1 = \chi_2 = \chi$. It is obvious that:

$$2\beta + 2\lambda + 2\delta + 2\chi = 1 \quad (10)$$

It is extremely important to take into consideration the fact that the resistance structures, the elastic elements of the suspension, the equipment as well as the nature and quantity of the freight are established by criteria other than that of the response to the longitudinal shock caused by collisions. Thus, the only practical method of reducing the effects of the shock is to increase the potential deformation energy stored by the shock insulators. Hence, it becomes clear why the $2\beta = f(v)$ factor represents the specific energy factor that characterizes the shock phenomenon in railway vehicles. This specific energy characteristic directly influences the unwanted consequences of the shock.

## 4. EXPERIMENTAL STUDY

The 95 m³ liquid tank car on 4 axles with 22,5 t/axle, was put up to the collision testing, according to the testing conditions imposed by the UIC in report RP17 of the ORE B12 commitee. The loaded car collision tests are presented, during which the tested car, with mass $m_2$= 90 t, was loaded with water and equipped with category C buffers (according to UIC 526-1); the colliding car was a freight car with mass $m_1$ = 80 t loaded with sand equipped with category C shock insulators (according to UIC 526-1) [4] .

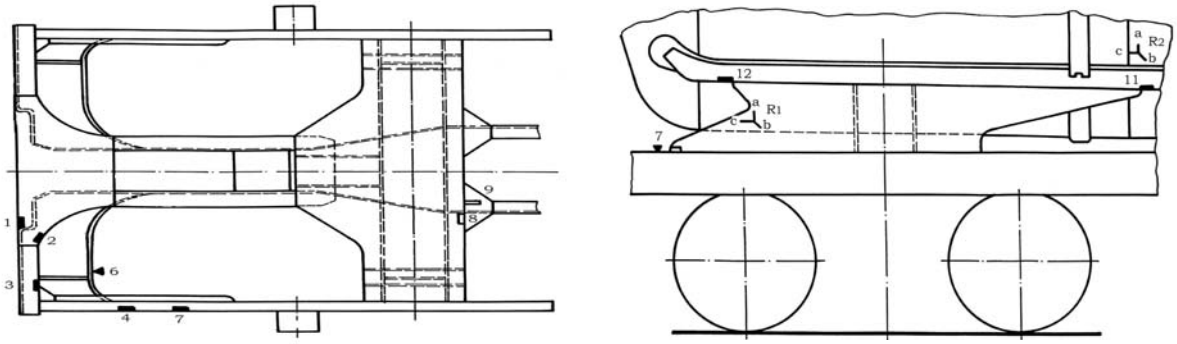



Figure 2

The placement of the transductors in order to experimentally determine the relative deformations is shown in figure 2, and the results of the measurements are presented in tables 1-3 (table 1 contains the results of the preliminary measurements, tables 2 and 3 show the results of the measurements for the series of 40 collisions).

Table 1.

| Collision no. | V(km/h) | $F_1$(MN) | $F_2$(MN) | F(MN) | a (g) |
|---|---|---|---|---|---|
| 1 | 8,9 | 0,48 | 0,57 | 1,05 | 3,04 |
| 2 | 11,2 | 0,70 | 0,79 | 1,49 | 4,19 |
| 3 | 13,5 | 0,92 | 1,05 | 1,97 | 5,33 |
| 4 | 15,0 | 0,98 | 1,14 | 2,12 | 6,09 |

Table 2.

| Collision no. | V (km/h) | TER σ[N/mm²] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 8 | 11 | 4 | 6 | 9 |
| 10 | 15,0 | 243,1 | - 123,6 | - 173,0 | - 352,8 | - 164,8 | 214,8 | - 140,1 |
| 20 | 15,0 | 247,2 | - 119,5 | - 173,0 | - 342,0 | - 160,7 | 214,2 | - 144,2 |
| 30 | 15,0 | 239,0 | - 119,5 | - 181,3 | - 349,2 | - 160,7 | 226,6 | - 148,3 |
| 40 | 15,0 | 243,1 | - 119,5 | - 173,0 | - 352,8 | - 164,8 | 222,5 | - 140,1 |

Table 3.

| Coll. no. | V (km/h) | TER σ [N/mm²] | | | ROZETA $R_2$ [N/mm²] | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3 | 7 | 12 | $\sigma_1$ | $\sigma_2$ | $\sigma_E$ | α(rad) |
| 10 | 15,0 | 292,5 | - 243,1 | 214,2 | - 77,9 | - 162,1 | 140,4 | 1,61 |
| 20 | 15,0 | 271,9 | - 247,2 | 210,1 | - 77,9 | - 162,1 | 140,4 | 1,61 |
| 30 | 15,0 | 284,3 | - 243,1 | 214,4 | - 80,2 | - 162,8 | 140,1 | 1,60 |
| 40 | 15,0 | 271,9 | - 243,1 | 197,8 | - 76,6 | - 157,4 | 136,3 | 1,59 |

## 5. CONCLUSIONS

The study of the experimental results leads to the following conclusions:

- For a collision velocity of v =15 km/h, the force transmitted to the shock insulators is in the range of (2,09 - 2,22) MN. The force F=3 MN can be reached at velocities higher than the collision velocity of v =15 km/h. Consequently, the repeated shock test (40 collision series) was conducted with the maximum collision velocity allowed by the RP17 ORE B12, meaning v = 15 km/h .
- The acceleration transmitted to the car at a collision velocity of v = 15 km/h is between (5,9 - 6,28) g, values that are inferior to those recorded in the case of using category A shock insulators.
- It is observed that the relative deformations and stresses, experimentally determined for the measurement points considered are below the flow limit $\sigma_c$ = 360 N/mm², increased by 30% in accordance to the shock behavour of the steels used in the construction of the railway car. Also, we consider that the use of shock insulators with a lower capacity for storing potential deformation energy would have led to the transmission of forces during the collision process that would have reached values of approximately 3MN, which would have led to the appearance of relative deformations in the most strained points which exceed the elasticity limit, thus creating the risk of occurence of permanent deformations.
- The resistance structure of the chassis, the fixing elements for the tank on the chassis and the tank had an elastic behaviour. Residual deformations were not recorded at any measurement point. Investigations were conducted on the state of the car resistance structure, both visually and by using the penetrating liquid method, especially in the tank fixing region (transductors 11 and 12), as well as in the high strain areas (transductors 1 and 6) of the support beam.The collision testing prove that the technical solutions adopted correspond to the requirements imposed by vehicle use.

Using shock insulators with a high capacity for storing and dissipating potential deformation energy leads to the decrease of the unwanted effects of the shock caused by collision in the use of railway vehicles:

- permanent deformations of the elements of the resistance structures of railway vehicles;
- deterioration of amenities and functional equipment;
- ensuring the integrity of the transported freight and the fixing and packaging systems;
- eliminating the consequences that must be considered in appreciating passenger comfort.

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# ON THE STATIC AND DYNAMIC CHARACTERISTICS OF THE SHOCK INSULATORS EQUIPPING RAILWAY VEHICLES

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**Abstract**

The paper presents theoretical notions regarding the shock due to collisions of railway vehicles as well as a study on the applied methodology used to experimentally determine the static and dynamic characteristics of the bumpers that equip railway vehicles. The experimental stand, the transductors, the measurement, recording and data processing apparatus are also presented.

The experimental force as a function of displacement (contraction) diagrams are presented for the shock insulators as well as the characteristics obtained during the static testing, both for normal temperature and extreme temperatures (+50°C and -40°C). Furthermore, the paper contains a study on the dynamic characteristics obtained for collision velocities between 6,15 km/h and 14,7 km/h with the appropriate conclusions regarding the category of classification of the elastic element that equips the studied bumpers (shock insulators) in order to categorize them in one of the A, B or C categories according to the international norms of the European railways, UIC 526-1.

**Keywords**:

shock insulators, static characteristics, dynamic characteristics

## 1.EXPERIMENTAL DETERMINATIONS

The testing for shock insulators [6], [8], [9], [10], [11] was conducted according to the prescription of the UIC 526-1 document. From the testing program presented in UIC 526 - 1 file the following tests were conducted:

1. Testing in order to determine the static characteristics;
2. Testing in order to determine the static characteristics at extreme temperatures -40°C and +50°C;
3. Testing in order to determine the dynamic characteristics.

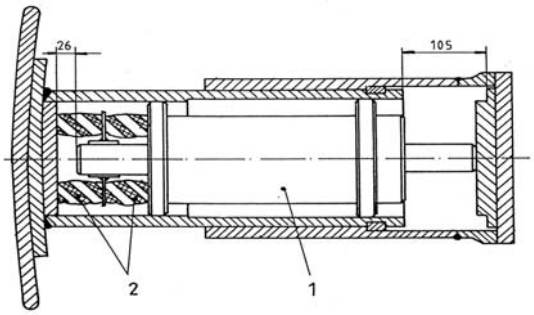



Fig.1 Shock insulator (1. Silicone dampener; 2. Rubber elastic elements)

### 1.1.Static characteristics

***Test at +15°C***. For the static test, a number of 2 shock insulators were studied (fig. 1) [4], [7]. The characteristic parameters of the category C shock insulators are imposed by the UIC 526-1 file and are the following:

- Precompression force 10 ÷ 50 KN;
- Force after 25mm compression 30 ÷ 130 KN;
- Force after 60mm compression 100 ÷ 400 KN;
- Force after 100mm compression 400 ÷ 1000 KN;

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- stored energy ($W_e$) ≥ 12.500 J;
- absorbed energy ($W_a$) ≥ 0,5 $W_e$.

The experimentally determined characteristic diagrams of the shock insulators are shown in figures 2 and 3.

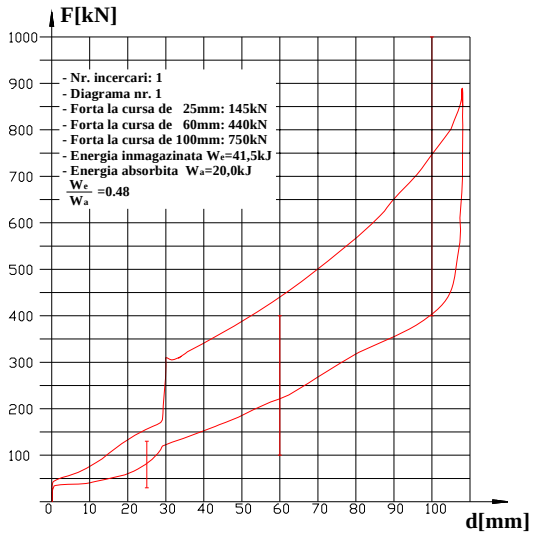



Fig. 2

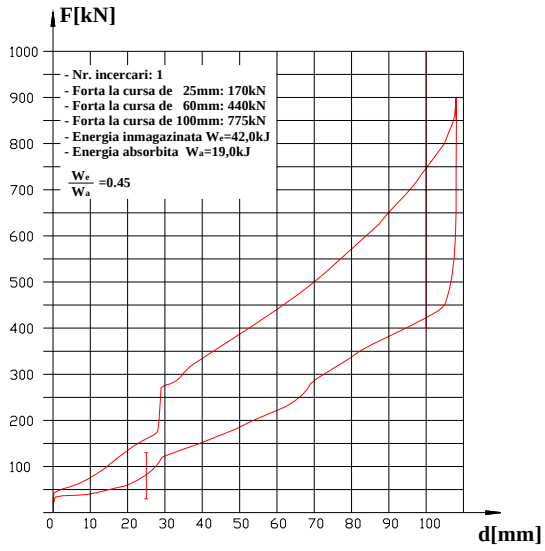



Fig. 3

From the analysis of the experimental results it is observed that for the two shock insulators tested, the force characteristics for the 25mm and 60mm compressions and the $\eta = \frac{W_a}{W_e}$ factor do not fall within the limits imposed by the UIC 526-1 file, while the other characteristics fit within the prescribed limits.

***Test at +50°C.*** The test was conducted in a sealed climate controlled chamber where the shock insulators were introduced for a period of 8 hours. The heating was done with an air heater and the temperature control was done with a thermometer..
The results of the tests with the obtained parameter values are shown in figures 4 and 5.

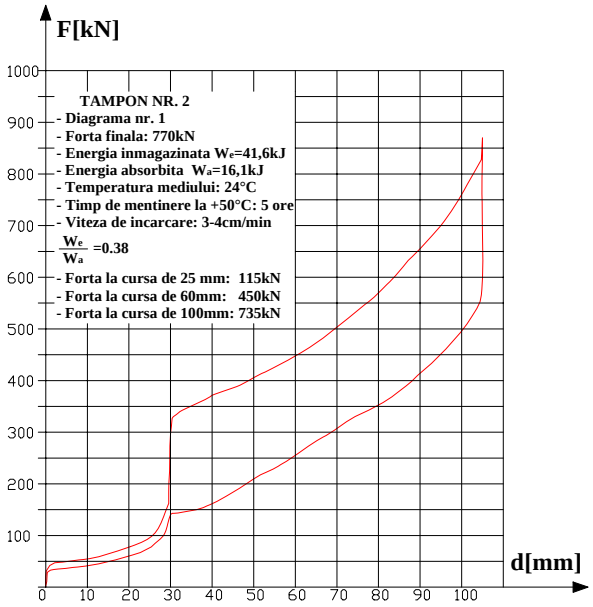



Fig. 4

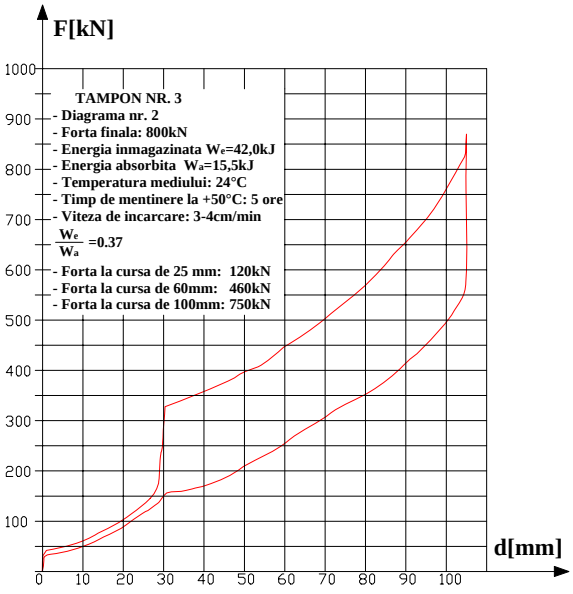



Fig. 5

Comparing the results from figures 2 and 4 for the first shock insulator, and from figures 3 and 5 for the second one, the following procentual differences are observed:

Shock insulator 1
- $\Delta F_{25}$ = 21 %

Shock insulator 2
- $\Delta F_{25}$ = 29,4 %

- $\Delta F_{60} = 2{,}2\ \%$
- $\Delta F_{100} = 2\ \%$
- $\Delta W_e = 0{,}2\ \%$
- $\Delta W_a = 20\ \%$

- $\Delta F_{60} = 4{,}5\ \%$
- $\Delta F_{100} = 3{,}3\ \%$
- $\Delta W_e = 0\ \%$
- $\Delta W_a = 19{,}4\ \%$

From the analysis of the above results it is observed that the shock insulators fit (with the exception of $\Delta F_{25}$ and the $\eta$ factor) within the 20 % tolerance admissible by the UIC 526-1.

***Test at -40°C***. In order to conduct this test, shock insulator 2 was dismantled, the elastomer capsule together with the rubber elements were inserted into feutron where they were kept at -40°C for 16 hours. After the cooling time was done, the shock insulator was reconstructed and then the experimental determinations were carried out.

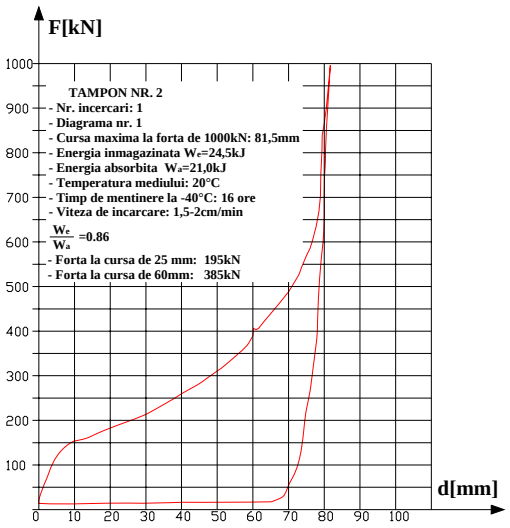


Fig. 6

The results of the tests together with the obtained parameter values are shown in fig. 6.

Comparing the results from figures 3 and 6, the following procentual differences are observed:

- $\Delta F_{25} = 34{,}4\ \%$ ;
- $\Delta F_{60} = 22{,}5\ \%$ ;
- $\Delta W_e = 41\ \%$ ;
- $\Delta W_a = 5\ \%$ .

From the analysis of the results it is observed that during the -40°C testing the buffer no longer complies with the requirements of UIC 526-1. Furthermore, the buffer only underwent a compression of 81mm.

### 1.2. Collision testing in order to determine the dynamic characteristics of the shock insulators

Collision testing was conducted according to the prescriptions of UIC 526-1. The testing was done with two cars with masses of 80t (figure 7), the collided car being equipped with category C shock insulators [1], [5]. The colliding car was equipped with category A shock insulators with rubber elastic elements.

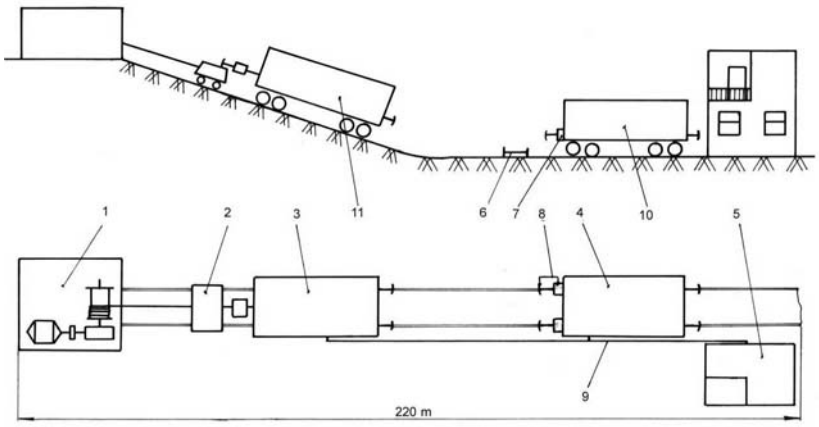


Fig. 7 Collision testing stand
( 1.whinch ; 2. Releasing cart ; 3. Colliding car ; 4. Collided car ; 5. Stand building ; 6. Velocity transductor ; 7. Force transductor ; 8. Displacement transductor ; 9. Connection cables ; 10. Acceleration transductors )

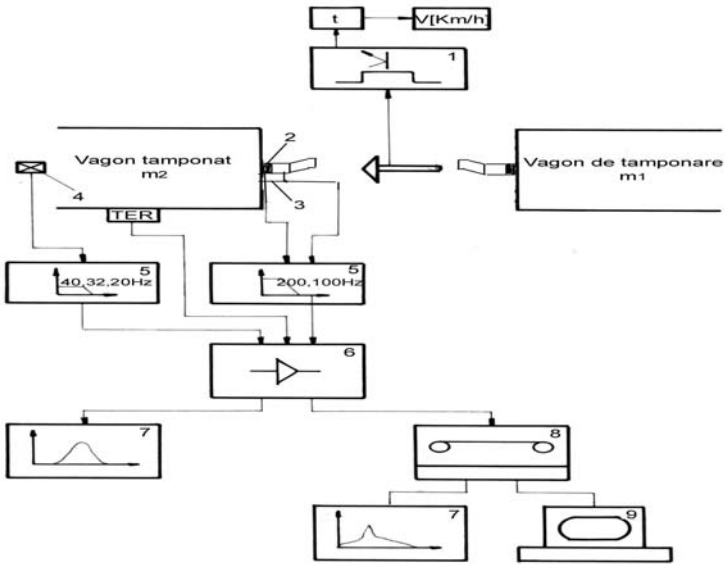



Fig. 8 Transductors, experimental data measurement, recording and analysis apparata
( 1. Velocity transductor; 2. Force transductor; 3. Displacement transductor; 4. Acceleration transductor; TER. Resistive tensometric transductor; 5.Low-pass frequency filters; 6. Measurement amplifier; 7. Ultraviolet recorder; 8. Magnetic recorder; 9. Computer)

The transductors and the measurement apparata used, as well as their placement are shown in fig. 8 [2].

The colliding car was launch at increasing velocities, up to 15 km/h towards the collided car. During the impact, the time evolutions of the following parameters were measured (table 1):

- force transmitted throufh the buffers $F_1$ and $F_2$;
- buffer compression $D_1$ and $D_2$;
- acceleration of the collided car „a".

Table 1

| No. | Velocity [km/h] | $W_{e1}$ [kJ] | $W_{e2}$ [kJ] | $W_{e\,MEDIU}$ [kJ] | $F_1$ [MN] | $F_2$ [MN] | $F_{MEDIU}$ [MN] | a (0-20Hz) [g] |
|---|---|---|---|---|---|---|---|---|
| 1. | 6,15 | 7,5 | 9,0 | 8,25 | 0,381 | 0,297 | 0,340 | 1,41 |
| 2. | 8,20 | 18,0 | 13,9 | 15,95 | 0,559 | 0,348 | 0,454 | 1,79 |
| 3. | 10,14 | 30,5 | 22,1 | 26,30 | 0,725 | 0,478 | 0,601 | 2,27 |
| 4. | 11,84 | 47,7 | 35,4 | 41,55 | 1,031 | 0,620 | 0,825 | 3,14 |
| 5. | 13,84 | 57,3 | 38,2 | 47,75 | 1,297 | 0,930 | 1,113 | 4,48 |
| 6. | 14,70 | 61,3 | 42,8 | 52,05 | 1,514 | 1,059 | 1,286 | 5,31 |

By eliminating time from the variations of force F = f (t) and compression D = f (t) the diagrams F = f (D) were obtained. From these diagrams, the following parameters were determined: $W_e$ - stored energy; $W_a$ - absorbed energy and $\eta = \frac{W_a}{W_e}$ [3].

The F = f (D) diagrams are shown in figures sunt trecute în figurile 9 and 10.

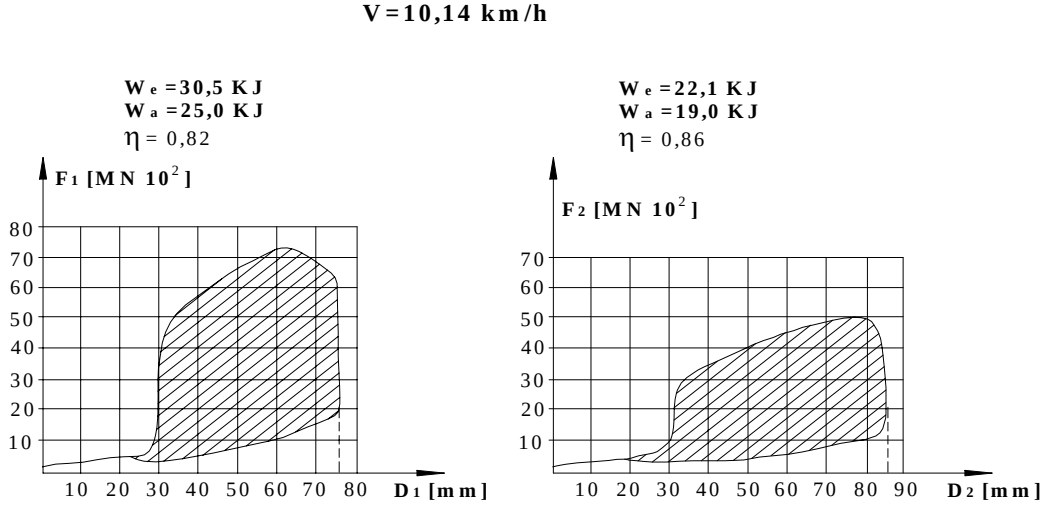



Fig. 9

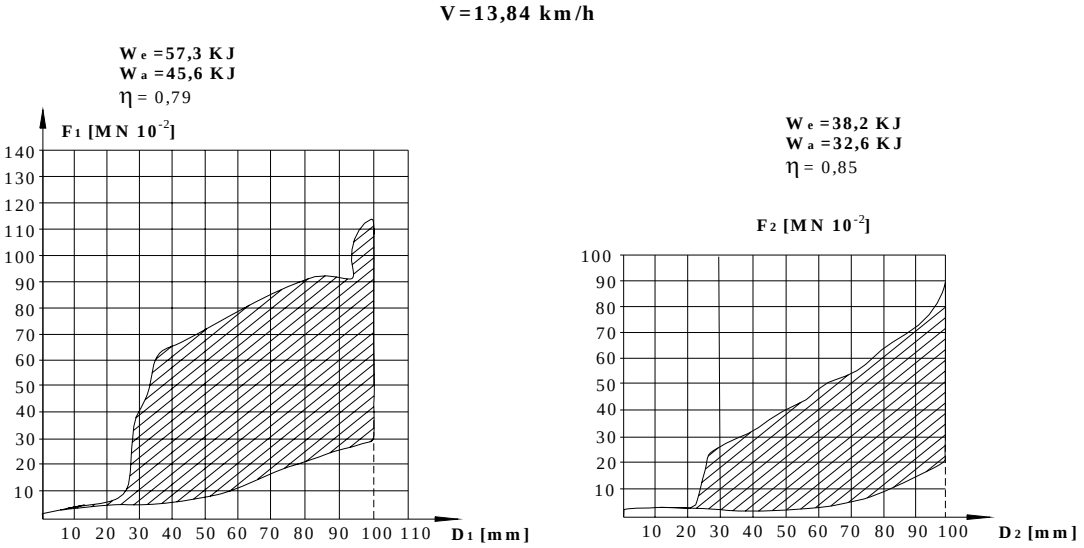
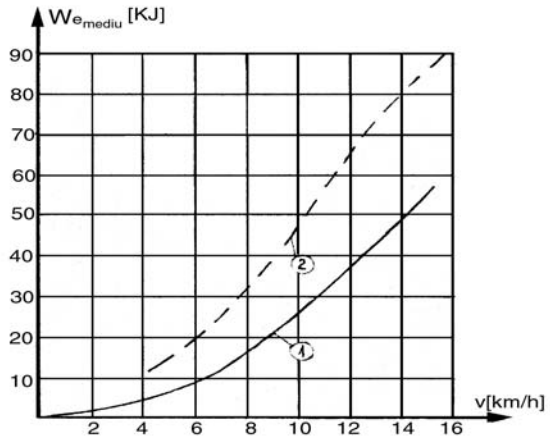



Fig. 10

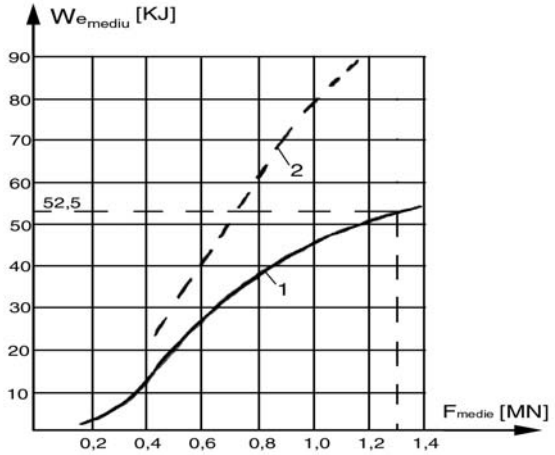
The variations of the average stored energy of the two shock insulators were represented as a function of the velocity of the collided car ( figure 11), and of the average transmitted force through the two shock insulators ( figure 12).

According to the diagram in figure 12, the average stored energy on the two studied shock insulators, $W_{e\,MEDIU}$, at the average force transmitted through the buffers of 1,3 MN is $W_{e\,MEDIU} = 52{,}5$ kJ. According to the requirements of the UIC 526-1, for category C buffers it is necessary for a value in excess of 70 kJ to be reached.




1. Cat. C buffer with elastomers
2. Cat. C buffer ICPVA

Fig. 11




1. Cat. C buffer with elastomers
2. Cat. C buffer ICPVA

Fig. 12

## 2. CONCLUSIONS

After the analysis of the experimental results, the following conclusions can be drawn:

1. In regard to the static characteristics, the buffers do not correspond to the requirements of the UIC 526-1, the values of the absorbtion coefficient η corresponding to the force at 25 mm and 60 mm does not fit within the admissible limits.
2. For the extreme temperature tests, the studied buffers do not correspond to the UIC 526-1 norms. We point out that at -40°C the buffer only underwent a compression of 81 mm and it did not return to the initial displacement, by 31mm, which, in use, determines the altering of the clearance between car buffers.

3. In regard to the dynamic characteristics, the tested buffers do not correspond to the requirements imposed by the UIC 526-1 for category C buffers. The buffers fit within the limits imposed by category B buffers.

In conclusion, the tested buffers correspond to the norms of cateory B buffers in regards to the dynamic characteristics without fulfilling the requirements for the static characteristics at extreme temperatures..

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# THE INFLUENCE OF ELASTIC SYSTEMS ON THE TRAVEL SAFETY OF RAILWAY VEHICLES

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**Abstract**

The paper presents experimental studies on the determination of the torsional rigidity of the bearing structures (carbody, bogies). The methods and the experimental technology of determining the torsional rigidity are revealed for the bearing structures of the chassis and bogies of the freight cars, as determining elements of travel safety.

Finally, a defining computational methodology is presented for establishing the derailment conditions (Nadal's formula) with the consequent conclusions.

**Keywords:**

torsional rigidity, force as a function of displacement variation, Y/Q ratio

## 1. INTRODUCTION

Travel safety is areas that belongs to the dynamics of railway vehicles and constitutes, together with bearing structure resistance and travel dynamics, preoccupations and lines of research that define the capacity of a vehicle to travel on the railway.

The possibility and chance of a vehicle to derail is in strict connection with the torsional capacity of the vehicle as a whole, wheel load, railway geometry and irregularities [3].

## 2. VERIFICATION OF WHEEL LOAD REPARTITION

The purpose of the test is determining the repartition and deviations of wheel loads. The trials were conducted in accordance with the recommendations of the testing program and the methodology of ERRI B55 Rp8, [8], [9], [10], [11].

The car was tested by positioning it successively with the two bogies on the stand with the tensometric transductors, rail type.

The car was tested for torsion by superimposing the effects of torsion on the basis of the car axle base and the bogie axle base. One of the points was put in a lifting-lowering motion, during which time at that point the displacement $\Delta h$ and the sustainment force $\Delta F$ were measured. An analog process was used for the bogie frames.

With the values of the wheel loads determined during the torsion testing, hysteresis diagrams of the unloading were drawn. From these diagrams the decreases of the wheel loads $\Delta Q_{ij}$ were determined, which were compared to the admissible limits $\lim \Delta Q_i$, according to the norms of ERRI B55 Rp8.

With the measured values of $\Delta F$ and $\Delta h$, hysteresis diagrams were drawn. The values from the diagrams and the specific technical and constructive characteristics of the car were used in the computation of safety against derailment.

The torsion to which the car is exposed during testing simulates the crossing of the car over the irregularities of the rail [2], [3], [4], [5], [6], [7].

The torsion corresponding to the car ($g^*$), and the bogie ($g^+$) is computed using (1):

$$g^* = \frac{15}{2a^*} + 2, [‰]; \quad (1)$$

$$g^+ = 7 - \frac{5}{2a^+}, [‰] \quad (2)$$

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where:

$2a^*$ is the car axle base;

$2a^+$ is the bogie axle base.

The values of the maximum admissible unloadings $\lim\Delta Q_j$ are computed for each axle, according to the following equations:

$$\lim \Delta q_j = \frac{\lim\left(\frac{Y}{Q}\right)_a - \frac{Y_{a0j}}{Q_{0j}}}{\lim\left(\frac{Y}{Q}\right)_a}, \qquad \lim \Delta Q_j = \lim \Delta q \cdot Q_{oj} \tag{3}$$

where:

$\lim\Delta Q_j$ – the maximum admissible unloading of the wheel in order to ensure against derailment;

$\lim\Delta q_j$ – relative limit value of the unloading;

$Q_{oj}$ – average wheel load at axle j;

$\lim(Y/Q)_a = 1{,}2$;

$Y_{aoj}$ – transverse guidance effort at axle j on the exterior wheel of the curvature.

The condition that the car must satisfy in order to traverse the rail torsions without any risk of derailment is that the wheel unloadings observed during testing do not exceed the admissible limit values, computed with equation (2).

The unloadings $\Delta Q_j$ of the wheels are determined by measuring with the above mentioned installation. The measurement is done progressively, starting from the situation of the car resting on a straight railway, the carbody is torsioned, then the bogies, at the values $g^*$ and $g^+$ computed with equations (1) imposed by ERRI B55 Rp8.

Finally, the following inequality is checked:

$$\Delta Q_{jk} < \lim\Delta Q_j. \tag{3}$$

In case the inequality is respected, the safety against derailment of the car is certified from the point of view of the torsional rigidity of the tested car.

## 3. DETERMINING THE TORSIONAL RIGIDITY

The torsional rigidity $C_t^*$ of a carbody with own weight and the characteristics of the elastic elements of the suspension, are criteria of appreciating the travel safety of the car [1]. [12].

The torsional rigidity $C_t^*$ is a characteristic of the carbody related to the axle base, expressed by a torsional moment $\left(\Delta F \times 2b_2^*\right)$ applied to the carbody at an angular displacement $\left(\frac{\varphi}{2a^*}\right)$ resulting in:

$$C_t^* = \frac{2a^* \cdot \Delta F \cdot 2b_z^*}{\varphi} \quad \left[\frac{KN \cdot mm^2}{rad}\right] \tag{4}$$

where:

$2b_z^*$ - distance between the suspension supports on the axle [mm];

$2a^*$ - car axle base [mm];

$\varphi$ – angular displacement [rad];

$\Delta F$ – variation of the vertical force [KN].

The angular displacement $\varphi$ [rad] can be expressed as:

$$\varphi = \frac{h}{2b_z^*} \tag{5}$$

And the expression of the torsional rigidity:

$$C_t^* = 2a^* \cdot \left(2b_z^*\right)^2 \cdot \frac{\Delta F}{h} \quad \left[\frac{KN \cdot mm^2}{rad}\right] \tag{6}$$

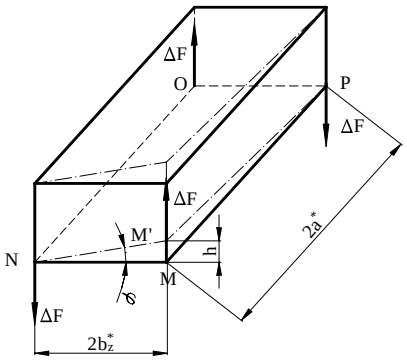



*Figure 1. Geometrical characteristics of the car*

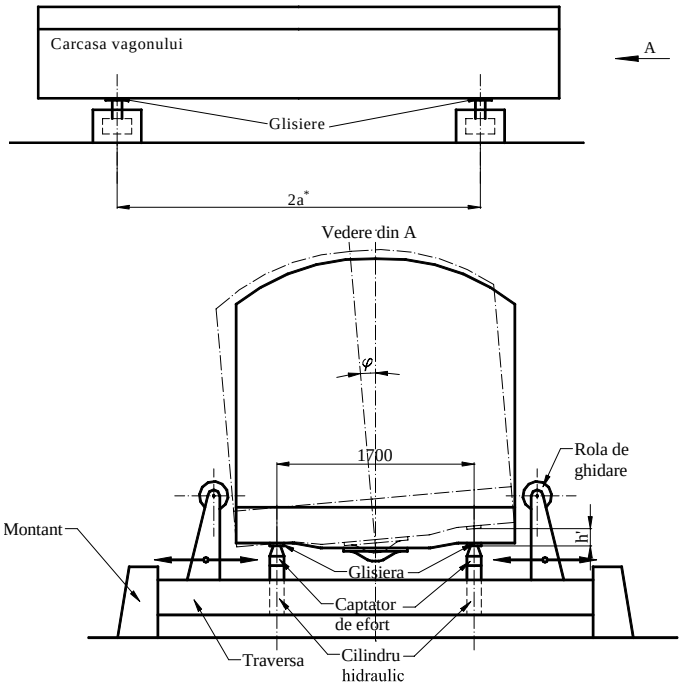



*Figure 2. The necessary arrangements for the experimental determination of the $\frac{\Delta F'}{h'}$ ratio for the vehicle without the bogies.*

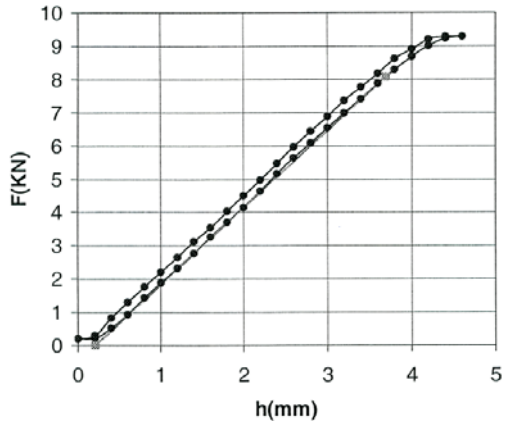
It is sufficient for the $\frac{\Delta F}{h}$ ratio to be determined experimentally in order to determine the torsional rigidity $C_t^*$.

The experimental measurements in order to determine the $\frac{\Delta F}{h}$ or $\frac{\Delta F'}{h'}$ ratios can be conducted both for the carbody and the bogie frame. For the carbody, the measurements can be conducted both in the presence of the bogies or in their absence, and in the case of cars on two axles, both in the presence of the axles and in their absence.

Figure 2 shows the arrangements necessary in order to conduct the tests to experimentally determine the $\frac{\Delta F'}{h'}$ in the case of the vehicle without the bogies.

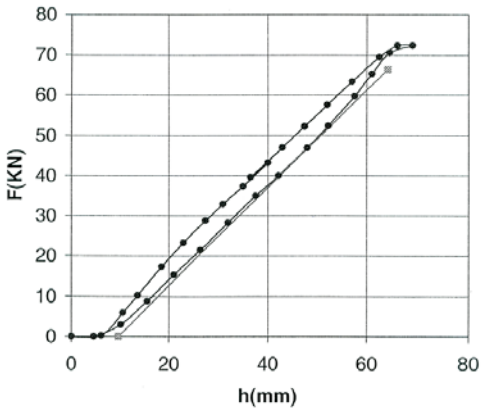
## 4. EXPERIMENTAL DETERMINATIONS OF THE WHEEL LOAD AND TORSIONAL RIGIDITY

Further on, experimental determinations of the wheel load and the torsional rigidity will be presented for the cistern car with 40m³ capacity [1], [2].




$C_t^+ = 1{,}68138 \cdot 10^{10}$ KN·mm²/rad

*Figure 3.Force-displacement diagram at the torsion of the bogie frame*




$C_t^* = 5{,}440012 \cdot 10^{10}$ KN·mm²/rad

*Figure 4.Force-displacement diagram at the torsion of the chassis*

Table 1

| Tests | Imposed values by the testing program and procedures | Values obtained from the testing |
|---|---|---|
| Verifiying wheel load repartitions, with Y25 Ls(s)d1 bogies and elastic gliders with equal 12 mm clearance | $\lim\Delta Q_{fz1}$ = 6,1149 KN | $Q_{11}$ = 29,9658 KN<br>$Q_{12}$ = 31,1832 KN<br>$\Delta Q_1$ = 0,6087 KN<br>$\Delta Q_{\mu I}$ = 1,6376 KN<br>$\Delta Q_{fz1} = \Delta Q_1 + \Delta Q_{\mu I}$<br>$\Delta Q_{fz1}$ = 2,2462 KN |
| | $\lim\Delta Q_{fz2}$ = 5,9229 KN | $Q_{21}$ = 29,2961 KN<br>$Q_{22}$ = 29,9332 KN<br>$\Delta Q_2$ = 0,3186 KN<br>$\Delta Q_{\mu I}$ = 1,6376 KN<br>$\Delta Q_{fz2}$ = 1,9562 KN |
| | $\lim\Delta Q_{fz3}$ = 5,9288 KN | $Q_{31}$ = 28,0350 KN<br>$Q_{32}$ = 31,2525 KN<br>$\Delta Q_3$ = 1,6087 KN<br>$\Delta Q_{\mu II}$ = 1,2720 KN<br>$\Delta Q_{fz3}$ = 2,8807 KN |
| | $\lim\Delta Q_{fz4}$ = 5,6175 KN | $Q_{41}$ = 27,0843 KN<br>$Q_{42}$ = 29,0906 KN<br>$\Delta Q_3$ = 1,0031 KN<br>$\Delta Q_{\mu II}$ =1,2720 KN<br>$\Delta Q_{fz4}$ =2,2751 KN |

Table 2

| Tests | Values imposed through the testing program | Values obtained from testing |
|---|---|---|
| Verifying the torsional rigidity, with Y 25 Ls(s)d1 bogies and elastic gliders with equal 12 mm clearance | | $C_t^*$ = 1,68138·10¹⁰ KN·mm²/rad<br>$C_t^+$ = 5,440012·10¹⁰ KN·mm²/rad |
| | $\lim(Y/Q)_a$ = 1,2 | $(Y/Q)_a$ = 0,926 |
| | $\lim\Delta Q_1$ = 15,9084 KN | $\Delta Q_{11}$ = 4,950 KN<br>$\Delta Q_{12}$ = 4,320 KN |
| | $\lim\Delta Q_2$ = 15,5465 KN | $\Delta Q_{21}$ = 6,880 KN<br>$\Delta Q_{22}$ = 5,540 KN |
| | $\lim\Delta Q_3$ = 15,5575 KN | $\Delta Q_{31}$ = 7,120 KN<br>$\Delta Q_{32}$ = 4,160 KN |
| | $\lim\Delta Q_4$ = 14,9709 KN | $\Delta Q_{41}$ = 6,280 KN<br>$\Delta Q_{42}$ = 4,010 KN |

**Car technical data**

- weight T=24040 kg
- Average wheel load $Q_o$=29,479 kN
- Load corresponding to the two stage primary suspension inflexion point (ERRI B 12 Rp 49) $F_{cz}$=26,2 kN
- Mounted axle weight (ERRI B 12 Rp 49) Gr =12,9 kN
- Car axle base $2a^*$= 9360 mm
- Bogie axle base $2a^+$ = 1800 mm
- Wheel base 2e=1435 mm
- Distance between rolling circles $2b_A$ =1500 mm
- Distance between suspension springs $2b_Z$ = 2000 mm
- Distance between gliders $2b_G$= 1700 mm
- Rigidity – measured value $C_t^*$= 5,440012·10¹⁰ KN·mm²/rad
- Bogie frame rigidity – measured value $C_t^+$ = 1,68138·10¹⁰ KN·mm²/rad
- Primary suspension rigidity (ERRI B 12 Rp 49) $C_{z^+1(2)}$ =1,004 KN/‰
- Glider springs rigidity ERRI B 12 Rp 49) $c_G$ = 0,57 KN/‰

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- Maximum relative deviation of wheel load $\Delta q_o = 0,2$
- Wheel radius r =460 mm
- Radius of the railway used in computation R = 150 m
- Gravitational acceleration g = 9,81 m/s²
- Derailment safety criterion $\lim(Y/Q)_a = 1,2$

**Computation of the $(Y/Q)_a$ ratio is done according to** ERRI B 12 Rp 49

- Torsioning at the car test $g^* = 15 / 2a^* + 2 = 3,603$ [‰]
- Torsioning at the bogie test $g^+ = 7\text{-}5 / 2a^+ = 4,222$ [‰]
- Exterior leading force $Y_a = 0,5319 \cdot Q_o + 1,9062 = Y_a = 17,586$ [kN]
- Interior leading force $Y_i = -0,4923 \cdot Q_o - 0,1512 = -14,664$ [kN]
- Transverse force in the axle box $H_y = -(Y_a + Y_i) = -2,922$ [kN]
- Absolute wheel load decrease due to the force
  $H_y$ $\Delta QH_y = H_y \cdot r / 2b_A = -0,896$ [kN]
- Absolute maximum wheel load deviation $\Delta Q_{Fzo} = \Delta q_o \cdot Q_o = 5,896$ [kN]
- Absolute total diminuation of the wheel load due to rail twisting on the basis of the bogie axle base

$$\frac{1}{C_{tA(2a^*)}} = \frac{10^3 \cdot (2b_A)^2}{C_t^+} + \frac{10^3 \cdot b_A^2 \cdot 4}{2a^+ \cdot b_z^{+2} \cdot c_{z1(2)}^+} \qquad \Delta Q_t{}^+ = g^+ \cdot C_t{}^+ = 3,062 \text{ [kN]}$$

- Absolute total diminuation of the wheel load due to rail twisting on the basis of the car axle base

$$\frac{1}{C_{tA(2a^*)}} = \frac{10^3 \cdot (2b_A)^2 \cdot 2}{C_t^*} + \frac{10^3 \cdot b_A^2 \cdot 2 \cdot 4}{2a^* \cdot b_z^{+2} \cdot 2 \cdot c_{z1(2)}^+} + \frac{10^3 \cdot b_A^2 \cdot 2 \cdot 4}{2a^* \cdot b_z^{+2} \cdot c_G}; \quad \Delta Q_t{}^* = g^* \cdot C_t{}^* = 2,419 \text{ [kN]}$$

- $(Y/Q)_a$ ratio $\left(\frac{Y}{Q}\right)_a = \frac{Y_a}{Q_0 - (\Delta Q_t + \max \Delta Q_{fz0} + \Delta Q_{Hy})} = 0,926$

In order to perform the theoretical calculation regarding safety against derailment (Y/Q), for the tested car, the following were considered:

a. With the empty car the Ist suspension level (I) steps into action;
b. In quasistatic conditions, it is acceptable in calculations, for the travel velocity, transverse acceleration and overheightening the use of the values: v = 0, a = 0, u = 0.

## 5. CONCLUSIONS

In conclusion, it can be considered that the value of the Y/Q ratio of 0,926 is situated under the UIC admissible limit of 1,2 and thus there is a certitude of the elimination of derailment.

Torsional rigidities $C_t^*$ and $C_t^+$ of the car and bogie respectively, significantly influence travel safety since they can cause large values of the unloading $\Delta Q_t^*$ and $\Delta Q_t^+$ when the bearing structures of the car and the bogie have large torsional rigidities and a low elasticity.

The existence of an adequate elasticity of the car and bogie structure thus leads to an improvement of the vehicle behaviour in regards to the derailment risk.

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# ON THE DYNAMIC CHARACTERISTICS OF THE DAMPENER WITH ELASTIC RUBBER ELEMENTS USED ON A SUBURBAN TRANSPORT VEHICLE (EGYPT)

Mihai SÂRB, Ion COPACI, Aurelia TĂNĂSOIU

Universitatea ”Aurel Vlaicu”, Arad, ROMANIA

**ABSTRACT**

The paper presents a study on the determination of the elastic dynamic characteristics of the shock insulators that equip railway vehicles. The work underlines the fact that the most appropriate method for determining these characteristics is the colliding of vehicles in the conditions that mimic those that appear during their use.

The paper, by adopting original technical solutions, imposed the designing and production of force transductors and their attachment apparatus on railway vehicles in order to experimentally determine the diagrams for the static and dynamic characteristic of the dampener.

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# A CONSTRUCTIVE SOLUTION FOR A SOLAR COLLECTOR WITH ALUMINUM ABSORBER

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Banja Luka University, Faculty of Mechanical Engineering, BOSNIA & HERZEGOVINA

**Abstract:**

The paper presents a constructive solution of a solar collector made of a series of aluminum lamellas, placed in aluminum thermo-isolated box. The shape and the profile of lamella make the collector absorber original, and its design has a number of advantages compared to the usual technical solutions. A significant effort has been made to find the geometric profile of ribbed lamella, which would meet all the requirements, starting from design, production and assembly, to high thermal and electric power characteristics. The surface protection was made by way of special procedure of electrochemical protection, thus obtaining a high quality selective surface of absorber. The collector is intended for conversion of solar into thermal energy, and its vast application is possible in heating of sanitary or technological water in boilers, reservoirs, pools, etc.

**Keywords:**

Solar radiation, solar collector, absorber, aluminum lamella, heat conversion

## 1. INTRODUCTION

Solar energy, as an energy source is gaining in importance daily. There are several reasons for that, some of them are that solar energy is free and easily accessible to everyone, it is ecologically clean and does not pollute the environment. It is inexhaustible for both the present and future generations, and falls in the group of renewable energy sources. The reason why it has not been exploited sufficiently so far can certainly be found in its "dispersion", that is to say, its relatively low density compared to conventional sources, and in the fact that for its "capturing" and conversion relatively big solar surface should be installed which, already at the beginning, requires significant investment from an investor. This is why this investment is a privilege of well-off individuals and countries, which however, after a relatively short repayment period, provides free of charge and clean energy throughout its useful life. The ways of "capturing" solar energy are diverse. This paper focuses on an innovated technical solution of a solar collector designed for heat conversion, that is to say, primarily for hot water preparation. Photovoltage collectors that perform conversion of solar into electric energy also have a significant role as far as application is concerned, but they will not be discussed in this paper.

## 2. CONDITIONS AND POSSIBILITIES FOR USING SOLAR ENERGY

The power of the radiation of the Sun on the surface of the Earth is within the range of 1000 W/m$^{2}$[2], which depends on a number of factors, latitude, position and the surroundings of the facility being radiated, cloudiness, etc. The time period during which solar energy can be efficiently and effectively used in our climatic area is from March through October and especially during the summer months when the abundance of the Sun is great and ranges from 1100–1500 kWh/m$^{2}$/year (Figures 1. and 2.).

According to the PVGIS database, the average yearly global irradiation on horizontal plane in Europe is 1096 kWh/m$^{2}$/year. If we consider only built up areas, than the average is 1130 kWh/m$^{2}$/year. To better see the geographical distribution, the colors in the legend were modified to see the deviations from the value of 1000 kWh/m$^{2}$/year.

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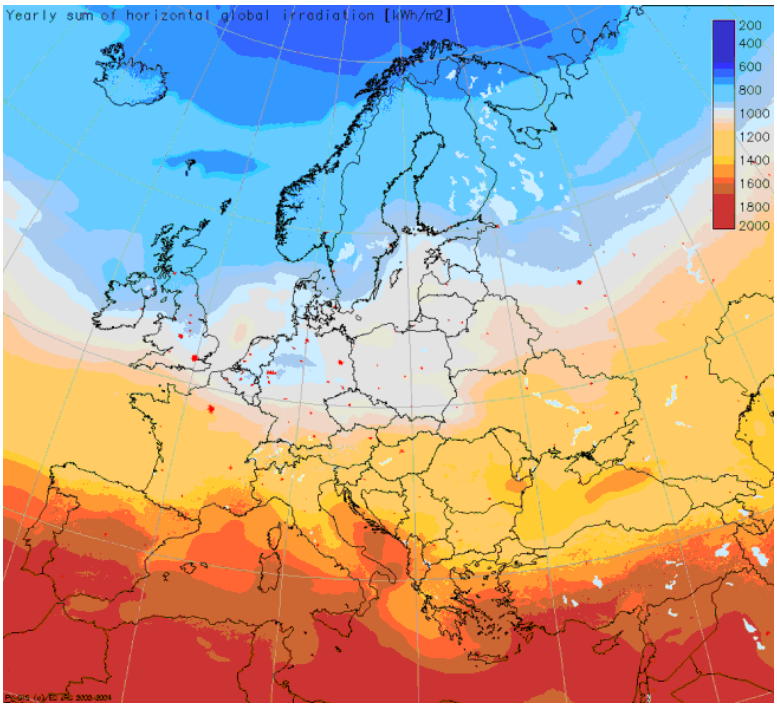



Figure 1. Yearly sum of global irradiation on horizontal surface [kWh/m²]

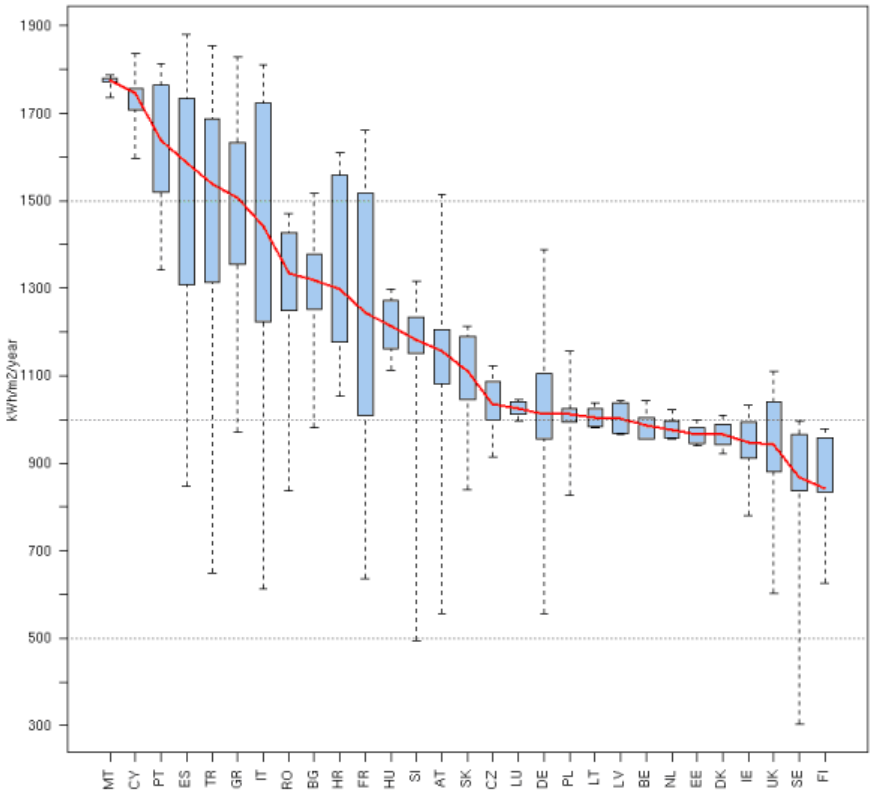



Figure 2. Global horizontal irradiation in EU25 countries [kWh/m²/year]

This time period coincides with naturally increased needs for water consumption due to bigger individual consumption, the summer season of bathing in outdoor pools, etc. That fact inevitably leads to the idea and the need for more intensive utilization of free and ecologically clean solar energy during that period, which can be efficiently solved by using solar collectors. The collectors have already found their place and application and are present in a number of different versions and technical solutions.

From the point of view of transformation technology, solar receivers, as devices that serve for capturing that is to say, receiving the energy of radiation of the Sun, can be divided into two basic groups, more precisely:

- collectors designed for thermal conversion, during which the energy of the Sun is directly converted to heat; their most frequent application is in heating systems and preparation of hot water for consumption;
- photovoltage panels designed for direct conversion of solar into electric energy which makes their use exceed the domain of thermal and technical systems and this is the reason for their much wider application in other fields too.

Of a number of collectors, i.e. systems, designed for thermal conversion, it is important to point out flat low-temperature receivers of solar energy, primarily because these systems are the cheapest and the simplest, and can easily find mass application, and thus produce significant economic and ecological effects.

There was a considerable number of producers of low-temperature solar panels of various types in the territory of former Yugoslavia; their production mostly stopped. However, the new producers with new solutions have been emerging. They are aware of the need and importance of using „free" energy, especially having in mind that energy, being a strategically important resource is becoming more and more expensive every day. In addition to that, in recent years there has been a major change in overall attitude toward preserving the environment, and this has also been given a legal form in many countries and international organizations. The fact that classic energy sources, like coal and oil, are inevitably polluters, and that they incur additional expenses in terms of maintenance of the systems within permitted limitations of work, leaves more and more space for utilization of alternative, ecologically clean systems that use free energy of the Sun, the wind, etc. This context was borne in mind while designing this technical solution of low-temperature flat solar collector (Figure 3). The aim was to achieve the biggest possible level of efficiency of heat conversion, decreasing the weight and the price, to accomplish longer duration of the device, as well as the simplest possible installation and operation.

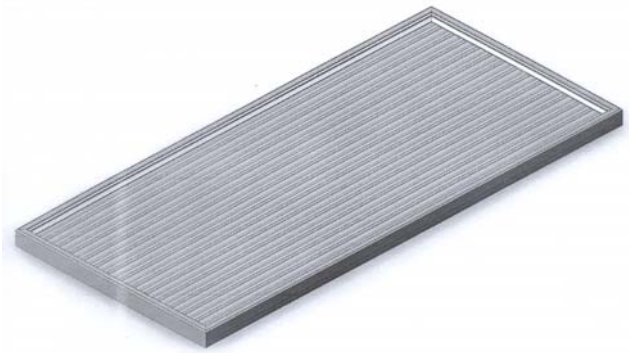


Figure 3. Solar collector

## 3. TECHNICAL AND GEOMETRIC CHARACTERISTICS OF THE ABSORBER

Having in mind that the absorber (Figures 4. and 5.) is the basic and the most important part of any solar receiver, it should be paid special attention during its constructive design. The efficiency of the entire device mostly depends on the absorber, but during the design process itself attention should be paid to technological possibility of making and installation of the elements, mass, price as well as to other factors.



Figure 4. The layout of the lamella of solar absorber

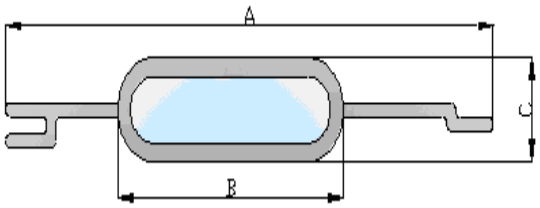



Figure 5. Lamella of absorber (cross-section)

In connection with that, aluminum was chosen as a material for making the absorber (i.e. aluminum alloy). It is significantly lighter than copper, material normally used for making this type of solar collectors. Weight is certainly something that should be taken into account, not only because of the price, but primarily because of the load on the roof structure, which can be significant, especially if a considerable number of collectors are placed on the roof, and having in that this type of load is frequently overlooked by civil engineers. Besides its being lighter, aluminum is also much cheaper material than copper and has good technical characteristics in the sense of heat conducting, the possibility of applying appropriate long-term surface protection, all of which provides the ground for expectation that this type of product can last longer.

The idea around the construction of the absorber itself was to assemble it of elements – lamellas, which are actually a substitute for usual classic collector pipes. The internal cross-section of the lamella through which the medium flows has a shape of a stretched circle; on the external cross-section two ribs from the left and the right side can be seen. The main task of the ribs is to directly conduct the collected energy of radiation from the surface which they cover to the medium.



Figure 6. Connected absorber lamellas (cross-section)

The edge of the rib is adjusted and shaped for fitting into and connecting with the adjacent rib (Figure 6.), so that after assembling all necessary ribs the final surface of the absorber is obtained, of a slightly wavy shape, but of quite satisfactory external appearance. In this way the laying of the cover upper sheet metal board has been avoided, which is in classic pipe collectors usually placed over the pipes and which serves as an absorber, but first of all as a mask - curtain. That role has been assumed here by lamellas. In this way, there is one less position in the assembly, and better conditions for transfer of heat to the medium are created by avoiding the contact resistances that inevitably appear with classic collectors on the place of contact of the upper board and the pipe. In this case the beams fall directly on the lamellas in which water flows.

Two aluminum collector pipes that have a role of a distributer, that is to say collector of the medium (most frequently water with addition of an anti-freeze agent), are connected from the upper and lower side of the lamella, thus ensuring circulation of the medium through the collector. However, if more than one passage through the same collector needs to be provided, then not all the lamellas are connected with a single collector pipe, but only a certain number of lamellas, whereby the medium is returned back through the collector by the subsequent same number of lamellas thus making more passages through the collector. This can be done thanks to the fact that the number of lamellas installed in one collector is not limited, nor is their length which is obtained by cutting lamellas to the desired length from the finished profile. This ensures the projected speed of circulation through the collector, and an influence is made on the ratio of heat transmission from the wall to the fluid, as well as on the overall circulation resistance, output temperature of the fluid, etc. Also, the frame of the collector box does not limit forming of the size of the collector, because the frame itself is formed according to the requirements of the collector dimensions from custom-made Al profiles. Therefore, during designing of a concrete solar system (e.g. water heating for the needs of hotels, multistorey buildings, pools, etc.), it is easy to form a collector of certain dimensions adjusted to that specific requirement.

The surface protection of the absorber itself has a key role in absorption of the radiation of the Sun; having said that, it is necessary to achieve the goal of the biggest possible absorption and the smallest possible emission and reflection of radiated energy on the surface of the absorber. A selective coating was applied by way of an electrochemical process; it was kept during a certain time period in the solution of exactly determined concentration in order to obtain a coating of necessary chemical composition and thickness. Besides good absorption characteristics, this coating also shows good persistence during the exploitation conditions, unlike classic coatings that most frequently peel and decay with time. The

selection of the process itself of applying and achieving the best selective coating has been done in accordance with the diagram in Figure 7 [3], which shows dependence of emissivity on thickness of oxide coatings formed in solutions of different acids.

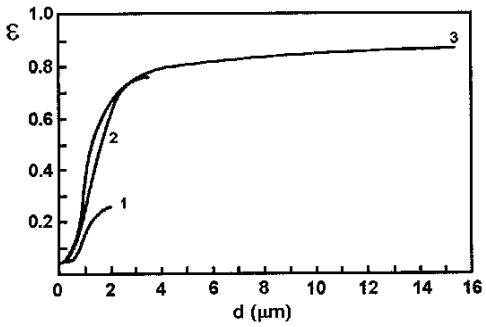



Figure 7. Emissivity depending on thickness of oxide coating made in solution of 1. phosphorous, 2. chrome and 3. sulphur acid

Protection of the box-frame of the absorber has also been done by way of electrochemical protection with parameters that underline more permanent resistance to atmospheric influences.

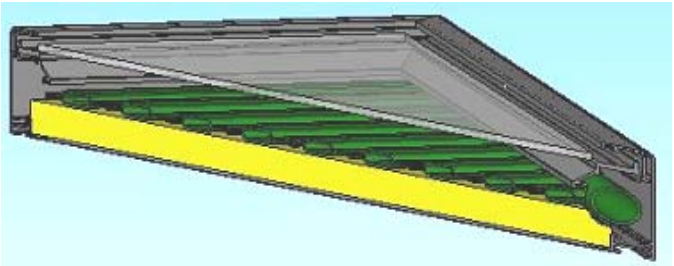


Figure 8. Cross-section of solar collector

Thermal isolation and protection of the absorber (Figure 8) against external influences has been done in the aluminum box which is isolated with polyurethane foam from the bottom side, and from the upper side with one glass board. Dimensions of the box, as well as of the thermal isolation and the glass board are reduced to minimum, having in mind that the operation of this absorber is preferred during the summer time as well as the transitional period when maximum energy effects are obtained.

## 4. INSTALLATION AND USE OF THE COLLECTOR

The collector has been designed for assembling in classic solar installations for preparing hot water in individual or joint containers for several consumers, for supplementary heating of the facilities, as a support to classic heating system, for supplementary heating of water in outdoor or indoor swimming pools, etc.

The hot water container should also be equipped with the pipe heater through which exchange of heat from the fluid-carrier of the heat to the consumer hot water is carried out. Besides standard components, the pump, the expansion receptacles and the pipe installations, there should be also automation installed in the system that will perform regulation of processes, that is to say, start and end of circulation, in order to prevent the loss of already accumulated heat in the container and increase the efficiency of the entire system. If there are more collectors installed in the system, their connecting can be done in a series, in parallel or in a combined manner, depending on the requirement of the project itself. The support structure is being adapted and delivered depending on the characteristics of the place of installation (gable roof, flat surface, etc.).

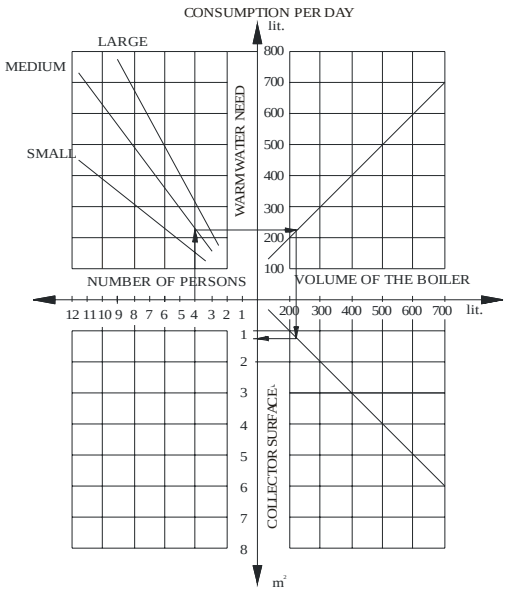



Figure 9. Determining the size of the boiler and the collector depending on the size of the household

Figure 9. [1] presents a diagram for rough selection of size, i.e. number of solar collectors and hot water containers.

## 5. CONCLUSION

The paper presents an original technical solution of a solar energy receiver, designed for heat conversion, which can be effectively used for preparation of hot water in boilers, containers, pools, etc. A solar receiver of high technological and energy performances is obtained through significantly adjusted geometric shape of the

absorber, quality surface protection and simple assembly of pre-fabricated elements. This is more than enough as a reason for the beginning of serious application this ecologically clean system in our area of, which ensures capturing and the use of abundant and free of charge heat of the Sun. In this way significant savings in the consumption of expensive conventional fuels will be achieved, especially having in mind that those fuels are polluters of the environment that is already to a large degree jeopardized and the protection of which will have to be intensively implemented in all countries in the world, on the basis of both current and future International treaties. Bearing in mind that these standards are to a large degree already in effect in EU countries, their application in our country is also expected, as well as the significant support to these projects by the Government. This solution also helps achieve considerable financial effects and savings compared to the utilization of conventional energy resources.

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# THE INFLUENCE OF LOW TEMPERATURES ONTHE MECHANICAL CHARACTERISTICS OF THE 34MoCrNi15X-RS STEEL UNDERGOING SHOCK-BENDING, DEPENDING ON THE SAMPLING POSITION

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**Abstract**

The paper introduces the tests of shock bending undergone over the 34MoCrNi15X-RS steel, carried out on Mesnager test bars (the groove depth
h = 2mm), under low temperatures. The test bars were longitudinal, respectively cross-sectional samples of semi-finished sections of ingot middle. We first described the cooling room we used, then gave the experimental results obtained and analyzed the influence of the main alloy elements on the values of resilience.

**Keywords**

shock bending, low temperatures, cooling room.

## 1. GENERAL NOTIONS

The principle of the shock-bending test consists in breaking at a single blow, with a pendulum hammer, under determined conditions, of a test bar having a groove at its middle, **U** or **V** shaped, freely placed on two supports.

The shock-bending test is dealt with in **SR EN 10045-1:1993**, where general considerations are being given with respect to the conditions for low temperature tests. Although this European norm replaces **STAS 6833 -79**, which sets the conditions for shock-bending under low temperatures, the **standard** products are still being processes according to the national standards.

In order to carry out shock-bending tests under low temperatures we need the following elements: test bars of a well-determined shape and size; a cooling-room for cooling the test bars down and a pendulum-hammer provided with a scale, (Charpy hammer). The special character of this test consists in the fact that the test bars are being cooled down in a cooling room, which is out of the work area of the pendulum-hammer. Generally it is necessary to, sub-cool the test bars in the cooling room and to reduce the handling time to 5 seconds at most.

## 2. THE ROOM FOR COOLING TEST BARS

We used for the tests a cooling room built by the author, which uses as cooling agent solid carbon dioxide and as cooling medium acetone or ethylic alcohol. We thus have a liquid cooling agent.

This cooling room [3], cylinder-shaped, is shown schematically in fig.1.

Between the inner pot (1) mage of stainless steel and the exterior one (2) there is a thermal insulation(5) made of mineral cotton. At the top, the two pots are connected by a textolite flange (3) provided with a mounting (9) made of asbestos plate. Between the posts, at the bottom, there is an oak grate (6) to support the inner pot.

In order to level the temperature of the cooling agent, the room has a stirring device (4), mounted on the cover of the room through the leading hub (13) and worked upon by means of a textolite piece (14).

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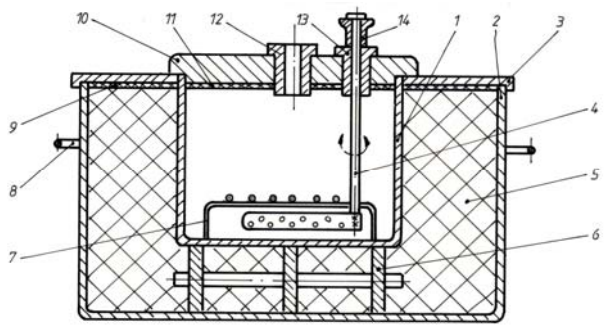


Fig.1. Cooling room with liquid cooling agent

On the bottom of the pot there is a stainless steel wire grate (7) on which the test bars to be cooled are placed.

The cooling room has a cover (10) made of textolite, muffled with asbestos (11), and meant to close the workroom at the top. The cover is provided with a leading hub (12) through which the thermometer or the thermo-couple can be introduced, in order to measure the temperature of the cooling agent.

## 3. THE TEST BARS USED IN THE TEST

The **34MoCrNi15X-RS** steel is used for welded joining. Unlike with other steel grades, the determination of the mechanical characteristics is carried out on test bars that are samples of rolled sections that have undergone thermal treatments.

The experiments have been carried out on Mesnager-type test bars (the groove depth h = 2 mm) that are longitudinal, respectively cross-sectional samples of semi-finished sections of ingot middle. The low temperature used for shock-bending tests was -30°C (243K).

## 4. THE RESULTS OF THE EXPERIMENTS AND CONCLUSIONS

As a result of the shock-bending tests at room and low temperature (-30°C) for the **34MoCrNi15X-RS** steel, we obtained medium values for every three steel charge and they were given in table 1.

Table 1. The Chemical Structure and the Values of Resilience KCU2 for the 34MoCrNi15X-RS Steel

| Charge No. | C | Mn | S | P | Cr | Ni | Mo | +20°C(293K) | | -30°C(243K) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | % | % | % | % | % | % | L | T | L | T |
| | | | | | | | | [J/cm²] | | [J/cm²] | |
| 1 | 0,31 | 0,47 | 0,015 | 0,018 | 1,56 | 1,44 | 0,16 | 96,33 | 53,66 | 65,33 | 43 |
| 2 | 0,32 | 0,52 | 0,012 | 0,020 | 1,40 | 1,45 | 0,16 | 171 | 62 | 123,66 | 40 |
| 3 | 0,33 | 0,43 | 0,008 | 0,018 | 1,46 | 1,64 | 0,19 | 166 | 62,66 | 145 | 45,33 |
| 4 | 0,32 | 0,44 | 0,010 | 0,018 | 1,55 | 1,45 | 0,21 | 172 | 90,66 | 148,33 | 66 |
| 5 | 0,31 | 0,50 | 0,012 | 0,017 | 1,60 | 1,42 | 0,17 | 166 | 78,33 | 119 | 54,66 |
| 6 | 0,33 | 0,44 | 0,022 | 0,024 | 1,46 | 1,42 | 0,22 | 139 | 68,66 | 85 | 45 |
| 7 | 0,38 | 0,57 | 0,010 | 0,016 | 1,54 | 1,45 | 0,22 | 134,6 | 91,33 | 89 | 61,33 |
| 8 | 0,32 | 0,55 | 0,016 | 0,018 | 1,55 | 1,51 | 0,18 | 182,6 | 62 | 141,33 | 56,33 |
| 9 | 0,34 | 0,57 | 0,015 | 0,018 | 1,46 | 1,49 | 0,17 | 138,6 | 68 | 93,66 | 46,33 |
| 10 | 0,33 | 0,47 | 0,020 | 0,020 | 1,58 | 1,44 | 0,17 | 162,3 | 72 | 118,66 | 58 |
| 11 | 0,34 | 0,51 | 0,014 | 0,025 | 1,74 | 1,42 | 0,25 | 148 | 56 | 91,66 | 35 |
| 12 | 0,35 | 0,59 | 0,011 | 0,014 | 1,48 | 1,57 | 0,20 | 186,6 | 118,6 | 137,33 | 82,33 |
| 13 | 0,35 | 0,44 | 0,013 | 0,018 | 1,51 | 1,54 | 0,17 | 147,6 | 68,33 | 105,33 | 42,66 |
| 14 | 0,36 | 0,45 | 0,020 | 0,019 | 1,48 | 1,51 | 0,23 | 155,6 | 66,33 | 107,33 | 44 |
| 15 | 0,35 | 0,44 | 0,016 | 0,018 | 1,48 | 1,46 | 0,21 | 131,3 | 60,33 | 108,33 | 46,33 |

The variation of resilience at low temperature according to the main elements of the chemical composition is as follows: the influence of Nickel contents - fig.2.a.; the influence of Chrome contents - fig.2.b and the influence of Carbon contents - fig. 2.c.

By analyzing the graphs in the given figures we notice that the values of resilience we obtained for test bars that are cross-sectional samples are smaller than for the longitudinal ones; yet, a certain equal distance is preserved between the variation curves, which show that different contents in **Ni**, **Cr** and **C** have no influence upon these differences.

Fig.2.a shows an increase in the value of resilience alongside with the increase in the contents of **Ni**. For the longitudinally sampled test bars the value KCU2/-30 is higher than the minimum one required for room temperature tests (KCU2 = 62,5 J/mm²). Even for the cross-sectionally sampled test bars taken from charges having contents in **Ni** higher than

1,6%, KCU2/-30 is higher than KCU2. These results prove that nickel is the alloy element that ensures steel a high tenacity even at low temperatures.

The chrome contents required by this steel grade are 1,40... 1,70%. Fig.2.b shows a decrease of resilience KCU2/-30 when the contents in chrome increase.

Fig.2.c. proves that resilience KCU/-30 has a maximum value for both longitudinally and cross-sectionally sampled test bars, when the contents in carbon are 0,34%, which corresponds to the mean of the interval 0,30%...0,38% carbon, requested by this steel grade.

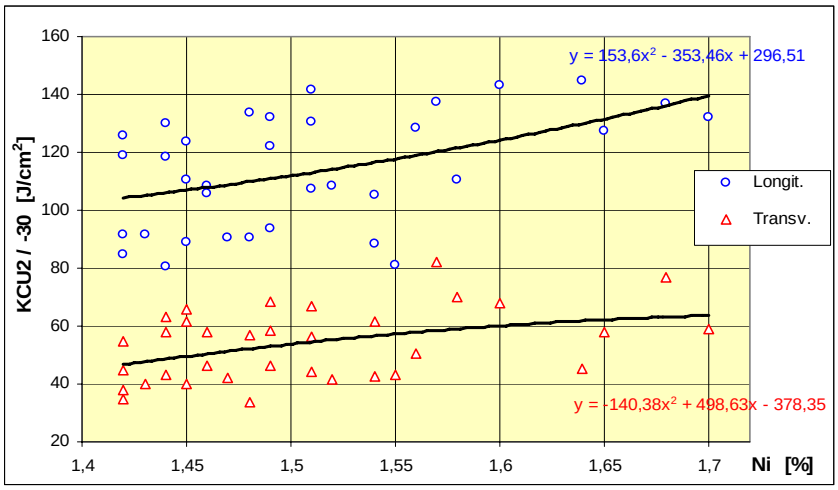



Fig.2.a. The variation of resilience KCU2/-30 according to the contents in Ni

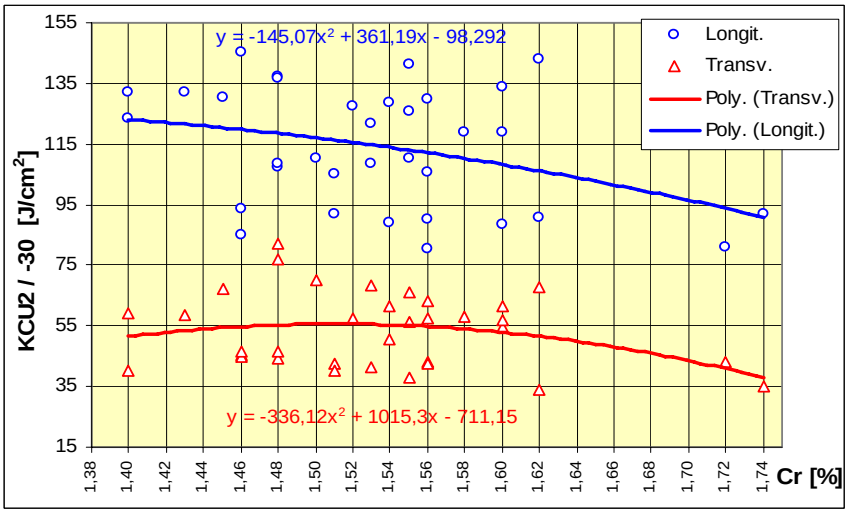



Fig.2.b. The variation of resilience KCU2/-30 according to the contents in Cr

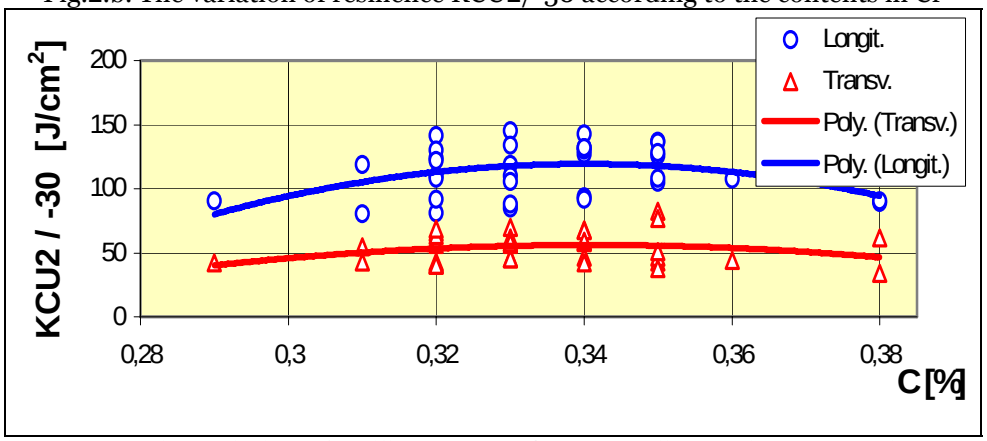



Fig.2.c. The variation of resilience KCU2/-30 according to the contents in C

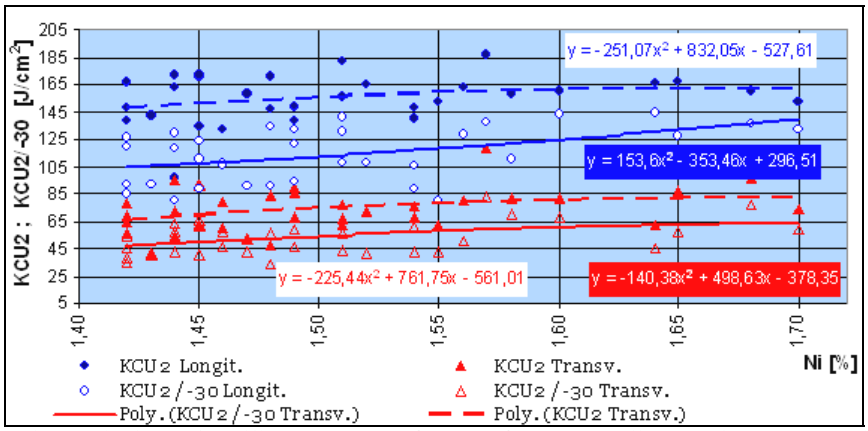



Fig.3 The variation of resiliences KCU2/ KCU2/-30 according to the contents in Ni

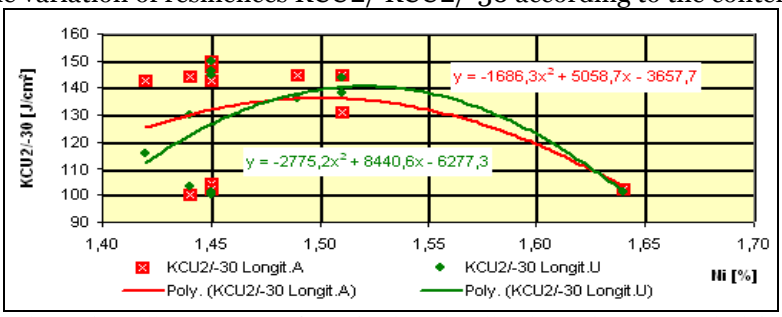



Fig.4.The variation of resilience KCU2/-30 for longitudinal test bars sampled from ingot butt, respectively ingot crop, according to the contents in Ni

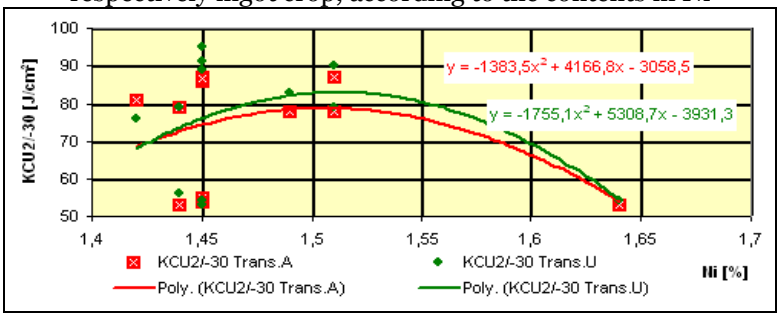



Fig.5. The variation of resilience KCU2/-30 for cross-sectional test bars sampled from ingot butt, respectively ingot crop, according to the contents in Ni

Fig.3 gives the comparative variation diagrams for resiliences at room temperature (KCU2) respectively at low temperature (KCU2/-30), for test longitudinal and cross-sectional bars, according to the contents in nickel.

The maximum values of resiliences correspond to the contents of 1,7% Ni, which represents the top limit of the domain requested by this chemical structure and steel grade.

For the **34MoCrNi15X-RS** steel we performed tests at -30°C on test bars coming from ingot butt (**A**), respectively ingot crop (**U**).

The variation of resilience for low test temperatures depending on the contents in nickel and the place of sampling is given as follows: for the longitudinal test bars sampled from ingot butt, respectively crop - fig.4 and from the cross-sectional test bars sampled from ingot butt, respectively crop - fig.5.

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# THE TORSION MECHANICAL CHARACTERISTICS UNDER LOW TEMPERATURE OF 34MoCrNi16X STEEL

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**Abstract**

The paper introduces the torsion tests under low temperature for steel grade 34MoCrNi16X, carried out on round test bars, respectively on thin-walled tubular test bars, thus achieving a homogenous bi-axial strain. We described the shape and dimensions of the test bars, the test machine, the cooling room we used and we gave the experimental results we obtained.

**Keywords**

low temperatures, cooling room, torsion tests.

## 1. GENERAL NOTIONS

The torsion test is not subject of international norms, although it constitutes a way of examining metal behavior under the force of tangent strains. The results of the test allow considerations on the tenacity of metals [3] by the determination of their torsion resistance and deformability.

The low temperature tests are carried out, methodologically, as in the case of tests at room temperature, the particular characteristic consisting in the fact that the mechanical trial has to be done in the moment the entire mass of the test bar has a certain low temperature, within a certain limit tolerance for the testing temperature [1]; [3].

In the cross-sections of the test bar on which torsion momenta are applied, there appear tangent strains, and the sections twist around their axis at an angle $\varphi$ which, up to a certain limit is proportional to the distance l between the planes of the charging couples [1]; [2]; [3]. The maximum angular deformation, called specific slide is calculated by means of relation:

$$\gamma_{max} = \frac{r \cdot \varphi}{l} = \frac{d \cdot \varphi}{2 \cdot l} \quad (1)$$

The maximum tangent strain, called torsion resistance is calculated by means of relations:

$$\tau_r = \frac{12M_r}{\left(\pi d^3\right)}, \quad \text{for the circular-section test bars;} \quad (2)$$

$$\tau_r = \frac{12M_r}{\pi\left(D^3 - d^3\right)}, \text{ for the ring-section test bars.} \quad (3)$$

## 2. EXPERIMENTAL TEST STAND

For the torsion tests under low temperatures, we used test stand made up of:

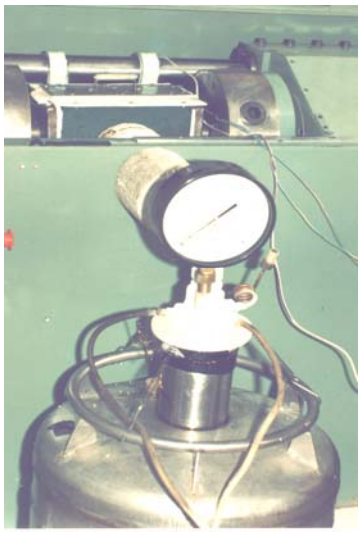
- the torsion test machine;
- the cooling room;
- Dewar vessel for keeping the solid nitrogen;
- device for the automatic regulation of low temperature.

The torsion tests for the circular, respectively ring-section test bars have been carried out on a machine model MODELL TAD III, available in the laboratory of Material Resistance of the Engineering Faculty of Hunedoara. This machine, described in [4]; [5] and [7] has the following characteristics:

- the loading rate, expressed in rotations/min has four work values (6, 12, 30, respectively 60 rot/min.), button selected;

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- the mechanism for measuring the torsion momentum has four work domains (15, 30, 75 and respectively 150 Kf·m), to be obtained by attaching standard weights to its pendulum;
- the torsion test can be carried out clockwise or anticlockwise.



Picture 1. The cooling room mounted on the torsion test machine

For the torsion test under low temperatures we attached a cooling room [4]; [5]; [7] using nitrogen vapors as cooling agent to the test machine.

In order to store the liquid nitrogen we used a 40 l Dewar vessel. In the case of using nitrogen vapors as cooling agent we used a charge resistance immersed in the liquid nitrogen and warmed up so that the vapors at the upper part of the Dewar vessel be exhausted through a transfer pipe connected to the cooling room.

The device of automatic temperature regulation [4]; [6] controls the charge resistance and ensures a flow of nitrogen vapors, at a pre-selected temperature and over the period covering the entire torsion test.

Picture 1 shows the cooling room mounted on the torsion test machine as well as the Dewar vessel with its pressurizing system.

## 3. THE TEST BARS USED IN THE EXPERIMENT

The aim of the experiment consists in the determination of the torsion characteristic curve of the material, showing the dependency of the tangent strain $\tau$ on the specific slide $\gamma$. This curve is obtained by processing the diagram drawn by the recording system of the test machine, which represents the dependency between the torsion momentum ($M_r$) and the torsion angle ($\varphi$).

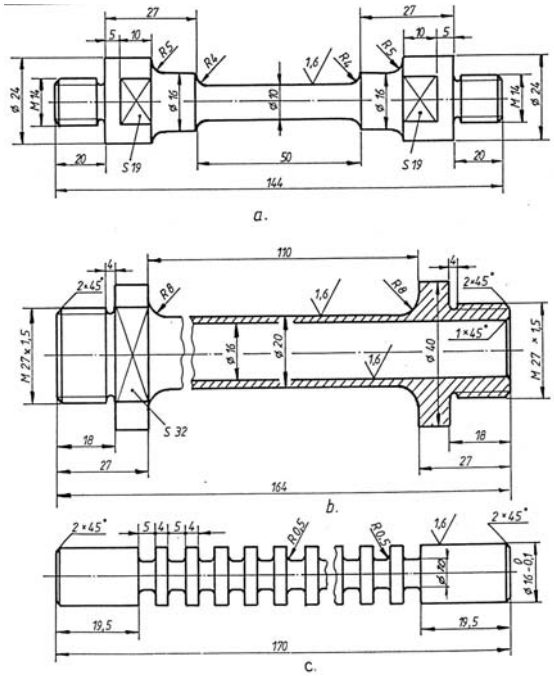



Fig.1.The shape and dimensions of the test bars used for torsion tests at low temperatures

As the torsion test is not nationally standardized, the shape and dimensions of the test bars are not unanimously accepted. Thus, different authors [1]; [2]; [3] recommend different values for the length of the test bars over the calibrated section, the diameter of the test bar (in the case of circular cross-sections), the ratio between the exterior diameter and the thickness of the wall (for the tubular test bars).

Taking into account what we have mentioned above, the author has chosen dimensions which would best rank within these recommendations. The shape of the test bars used for the torsion tests at low temperatures are given in fig.1.

The circular-section test bar (fig.1.a.) have the calibrated area 50 mm long and the diameter of 10mm (L/d = 10), and the joining radius between this zone and the ends is 4 mm.

The tubular test bars with thin walls have the shape and dimensions given in fig.1.b. Thus, the calibrated area is 110 mm long, the exterior diameter of 20 mm and the inner diameter of 16 mm, and the wall is 2 mm thick (L/d = 5,5; D/s = 10). The joining radius between this zone and the ends is 8 mm.

In order that the tubular test tube keep its stability along the torsion test we introduced in it an iron core, having the shape and dimensions given in fig.1.c. It has two cylindrical zones at the ends, while the central area is worked so as to allow the leading of the test tube long ring-shaped portions.

## 4. THE RESULTS AND CONCLUSIONS OF THE EXPERIMENT

The torsion tests have been done for the steel grade 34MoCrNi16X, which is a highly alloyed steel, worked by plastic deformation and used in machine parts (piston rods, shafts, large toothed wheels, etc.), after thermal treatment. The chemical structure, the mechanic characteristics, the thermal treatment applied, etc. observe STAS 791-88.

Out of the characteristic curves, fig.2 gives the ones obtained for circular-section test-bars for test temperatures of +20°C, -40°C and -80°C and fig.3 those resulting from torsion tests on ring-shaped test bars at test temperatures of +20°C and -40°C. For each level of the test temperature we used two test tubes, the charging rate being 6 rot/min.

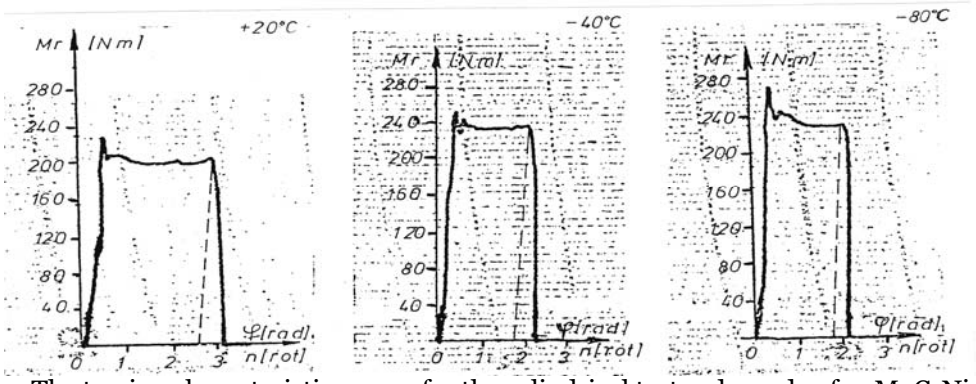



Fig.2.The torsion characteristic curves for the cylindrical test rods made of 34MoCrNi16X

The torsion resistance has been calculated by means of relations (2), respectively (3) and the specific glide by formula (1).

The magnitudes measured and calculated are given in table 1 (for the cylindrical test bars) and in table 2 (for the thin-walled, tubular test bars).

Table 1. The mechanic torsion characteristics of 34MoCrNi16X steel determined on cylindrical test bars

| No. | Test | $(M_r)_{max}$ | | n | $\varphi_{max}$ | $\tau_r$ | $\gamma_{max}$ |
|---|---|---|---|---|---|---|---|
| | temperature [°C] | [kgf·m]* | [N·m] | [rot] | [rad] | [N/mm²] | [rad] |
| 1 | | 22,51 | 220,823 | 2,53 | 15,88 | 843,909 | 1,588 |
| 2 | +20 | 21,78 | 213,661 | 2,41 | 15,13 | 816,538 | 1,513 |
| Media | | 22,14 | 217,193 | 2,47 | 15,51 | 830,223 | 1,551 |
| 1 | | 22,82 | 223,864 | 2,24 | 14,06 | 855,531 | 1,406 |
| 2 | -20 | 22,61 | 221,804 | 2,18 | 13,69 | 847,658 | 1,369 |
| Media | | 22,71 | 222,834 | 2,21 | 13,87 | 851,594 | 1,387 |
| 1 | | 24,75 | 242,797 | 1,73 | 10,86 | 927,886 | 1,086 |
| 2 | -40 | 23,94 | 234,851 | 1,68 | 10,55 | 897,519 | 1,055 |
| Media | | 24,34 | 238,824 | 1,70 | 10,70 | 912,703 | 1,070 |
| 1 | | 25,32 | 248,389 | 1,65 | 10,36 | 949,257 | 1,036 |
| 2 | -60 | 24,95 | 244,759 | 1,59 | 9,98 | 935,384 | 0,998 |
| Media | | 25,13 | 246,574 | 1,62 | 10,17 | 942,321 | 1,017 |
| 1 | | 27,22 | 267,028 | 1,62 | 10,17 | 1020,489 | 1,017 |
| 2 | -80 | 28,12 | 275,857 | 1,58 | 9,92 | 1054,230 | 0,992 |
| Media | | 27,67 | 271,442 | 1,60 | 10,05 | 1037,359 | 1,005 |

* The scales of the test machine are standardized in kgf.m

Table 2. The mechanic torsion characteristics of 34MoCrNi16X steel determined on tubular test bars

| No. | Test | $(M_r)_{max}$ | | n | $\varphi_{max}$ | $\tau_r$ | $\gamma_{max}$ |
|---|---|---|---|---|---|---|---|
| | temperature [°C] | [kgf·m]* | [N·m] | [rot] | [rad] | [N/mm²] | [rad] |
| 1 | | 53,25 | 522,382 | 1,98 | 12,43 | 511,934 | 1,11 |
| 2 | -+20 | 54,12 | 530,917 | 1,90 | 11,93 | 520,298 | 1,07 |
| Media | | 53,68 | 526,649 | 1,94 | 12,18 | 516,116 | 1,09 |
| 1 | | 68,25 | 669,532 | 1,62 | 10,17 | 656,141 | 0,91 |
| 2 | -40 | 67,52 | 662,371 | 1,71 | 10,73 | 649,123 | 0,96 |
| Media | | 67,88 | 665,951 | 1,66 | 10,45 | 652,631 | 0,94 |

* The scales of the test machine are standardized in kgf.m

The characteristic curves of the cylindrical test bars differ from those obtained for steel grade 10Ni35R, [4] inasmuch as after the maximum value for the torsion momentum has

been reached, at the end of the linear variation zone, it decreases and then stays approximately constant up to the breakpoint (see fig.2).

The explanation consists in the fact that, as steel possesses a relatively high resistance to torsion, in the zone in which it passes from the elastic behavior to the elasto-plastic, respectively plastic one, there arises a heating which is only partially compensated by the low temperature.

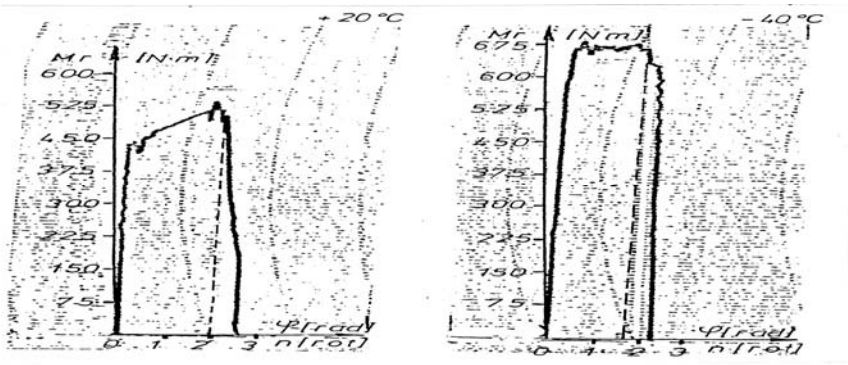



Fig.3 The torsion characteristic curves for tubular test bars made of 34MoCrNi16X

Fig.4 gives the variation curves of characteristics $\tau_r$ and $\gamma_{max}$ with respect to the test temperature for the circular-section test bars.

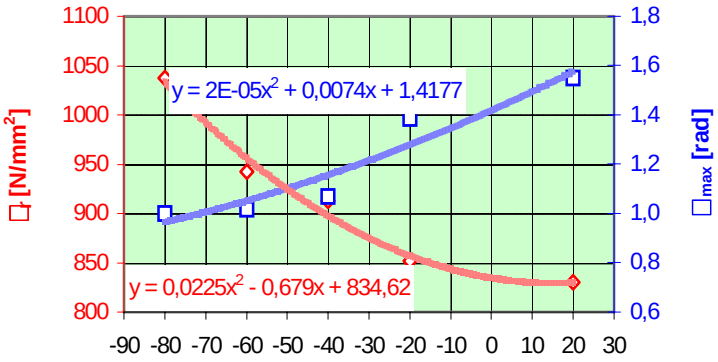



Fig. 4.The variation of the mechanical torsion characteristics with respect to the test temperature

We noticed an increase of the resistance to torsion, respectively a diminishing of the specific glide as the test temperature decreased. At -80°C the resistance to torsion is approximately 25% higher than the one obtained for +20°C.

For the ring-cross section test bars, the resistance to torsion at -40°C is 26% higher than at +20°C.

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# DYNAMICS OF WORKING PROCESS OF FLAT SIEVES

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**Abstract:**
The operation of separation of seeds is realized due to the vibration of sieve. The operation of separation is analyzed with the help of the particle model which executes vibration motions on a plane with friction. There are analyzed displacement regimes of particle by forward sliding and back sliding without detachment. Because of velocity discontinuity which appears as consequence of friction between particle and plan or of dropping on plan in the case of detachment, vibro-impact motion regimes appear. That is why, for the study of motion, there are applied the specific methods, concerning the vibro-impact regimes.

**Keywords:**
Motion, flat sieves, dynamic model, sliding regimes

## 1. INTRODUCTION

Generally, the phenomenon of vibro-transfer is essentially influenced by the material behavior, characterized by composition, humidity, adherence, nature etc. In the first approximation, the experiences shown that the material can be schematized by a simple material particle which moves with friction on the vibrating surface (Figure 1).

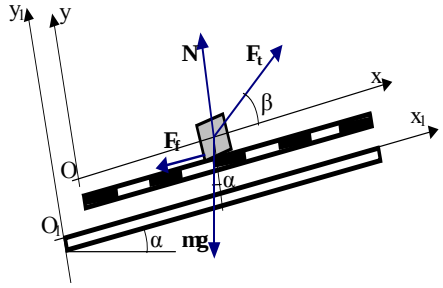



Figure 1. Dynamic model

The particle of mass $m$ is supposed to be placed on the vibrating plan, inclined to the angle $\alpha$, in relation to the horizontal surface. It is supposed that the vibrating plan executes a vibration translation motion on a direction which makes the angle $\beta$ with the inclined plan and it has the amplitude $r$. Thus, a current point of the plan executes a vibration displacement, given by the law $r\sin\psi$, on a direction which makes the angle $\beta$ with the inclined plan, where $\psi=\omega t$. So, in relation to the fixed frame $O_1x_1y_1$ , the coordinates of the point $O$, the origin of the mobile frame $Oxy$, bound to the inclined plan, (figure 3.1), at a certain moment are

$$x_0 = r\cos\beta\sin\psi \quad \text{and} \quad y_0 = r\sin\beta\sin\psi\,. \tag{1}$$

The differential equation of relative motion of particle of mass $m$ has the form

$$m\bar{a}_r = \bar{F}_f + \bar{N} + m\bar{g} + \bar{F}_t\,. \tag{2}$$

Because the transport force of inertia is $\bar{F}_t = -m\bar{a}_t$ , where $a_t$ is the acceleration of transport of particle, identical to the acceleration of the point $O$, the components of the transport force of inertia are

$$F_{tx} = -m\ddot{x}_0 = mr\omega^2\cos\beta\sin\psi\,, \tag{3}$$

$$F_{ty} = -m\ddot{y}_0 = mr\omega^2\sin\beta\sin\psi\,.$$

As consequence, the differential equation of relative motion (2) has the following projections on the axes of the frame $Oxy$:

$$m\ddot{x} = -\mu N\,\mathrm{sign}\,\dot{x} + mr\omega^2\cos\beta\sin\psi - mg\sin\alpha\,, \tag{4}$$

$$m\ddot{y} = N + mr\omega^2\sin\beta\sin\psi - mg\cos\alpha\,.$$

Taking into account that there are considered only the motions of particle, in contact to the plan, it must be put $y=0$, so that from the second equation (4), it results

$$N = m\left(g\cos\alpha - r\omega^2\sin\beta\sin\psi\right). \tag{5}$$

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## 2. CHARACTERISTICS OF MOTION OF SLIDING

As a principle, the particle which is situated in the rest position, at a certain moment becomes to slide on the plan, forward or back.

For the beginning it is supposed that the particle executes a forward sliding motion in relation to the sieve. On the particle act the force of weight $mg$, the normal reaction $N$, and the force of friction $F=\mu N$; the motion of transport being a translation, the Coriolis force of inertia is null.

If the expression (5) of the normal reaction $N$ is introduced in the first differential equation in (4), it arrives at the following relation:

$$\ddot{x} = -\frac{g\sin(\alpha+\phi)}{\cos\phi} + \frac{r\omega^2\cos(\beta-\phi)}{\cos\phi}\sin\psi\ ,\ (\psi=\omega t). \tag{6}$$

This relation represents the fundamental equation for the study of the forward motions of sliding on the vibrating sieve.

The beginning moment of the forward sliding is denoted by $t=t_1$ and so, $\psi_1 = \omega t_1$. It can mention that this moment corresponds to the condition that the acceleration $\ddot{x}$ to be null.

If the acceleration (6) is made equal to zero, it is obtained the following equation, in the initial moment of the forward motion of sliding:

$$\sin\psi_1 = \frac{g}{r\omega^2}\cdot\frac{\sin(\alpha+\phi)}{\cos(\beta-\phi)}. \tag{7}$$

Taking into account the relation (7), the fundamental equation (6) can be also written

$$\ddot{x} = r\omega^2\frac{\cos(\beta-\phi)}{\cos\phi}(\sin\psi - \sin\psi_1). \tag{8}$$

The forward motion of sliding is characterized by $t > t_1$ and so, $\psi > \psi_1$.

Considering the function $\dot{x} = \dot{x}(t)$, if $\ddot{x}>0$, the function $\dot{x}$ is increasing. Thus, from the moment $t = t_1$ when the velocity is nullifying, i.e. $\dot{x}(t_1)=0$ and $\ddot{x}>0$, it results $\dot{x}>0$. So, the forward motion of sliding takes place. Thus, from the relation (8), written for the moment given by $\psi_1$ it must be satisfied the inequality

$$\sin\psi > \sin\psi_1. \tag{9}$$

From the relation (7), written for $\psi_1$ it can be supposed that $\psi_1 \in \left(0;\frac{\pi}{2}\right)$ which, in accordance to the inequality (9), leads to the condition $\psi \in (\psi_1;\pi-\psi_1)$.

By integrating the differential equation of sliding motion which begins for $t=t_1$ it is found

$$\dot{x} = -r\omega\frac{\cos(\beta-\phi)}{\cos\phi}\left[\cos\psi - \cos\psi_1 + \sin\psi_1\cdot(\psi-\psi_1)\right]. \tag{10}$$

The forward regime of sliding stops at the moment $t = t_1'$, respectively the angle $\psi = \psi_1'$ which corresponds to the nullifying of the relative velocity, $\dot{x}=0$. So, by nullifying the expression of $\dot{x}$, it is deduced the equation

$$\sin\psi_1 = \frac{\cos\psi_1' - \cos\psi_1}{\psi_1 - \psi_1'}. \tag{11}$$

This equation permits the calculus of the moment $t = t_1'$, corresponding to the cessation of sliding.

The distance, covered in the case of the forward sliding is given by the integral

$$s_{1,2} = \int_{t_1}^{t_1'}\dot{x}\,dt \tag{12}$$

Taking into account the relation (10), after the effecting of calculus, the integral (12I) becomes

$$s_1 = -\frac{r\cos(\beta-\phi)}{\cos\phi}\left[\frac{(\psi_1'-\psi_1)^2}{2}\sin\psi_1 + \sin\psi_1' - \sin\psi_1 - (\psi_1'-\psi_1)\cos\psi_1\right]. \tag{13}$$

If in the relation (13) it is replaced $\sin\psi_1$ given by the equation (11), then for the displacements with forward sliding, it can be written the relation

$$s_1 = \frac{r\cos(\beta-\phi)}{\cos\phi}\cdot\Phi(\psi_1), \tag{14}$$

In an analogous way it is treated the case corresponding to the back motion of sliding. By back sliding it means the relative motion with friction of the material particle on the vibrating sieve, in the negative direction of the *Ox* axis, i.e. in opposite direction to the transporting one.

Taking into account that the force of friction is orientated in the positive direction of the *Ox* axis and projecting the differential equation of the relative motion, it is obtained

$$m\ddot{x} = \mu N - mg\sin\alpha + mr\omega^2\cos\beta\sin\psi \tag{15}$$

or, if it is taken into account the equation (2), it results

$$\ddot{x} = -\frac{g\sin(\alpha-\phi)}{\cos\phi} + r\omega^2\frac{\cos(\beta+\phi)}{\cos\phi}\sin\psi\,. \tag{16}$$

This relation represents the fundamental equation for the study of the back motions of sliding on the vibrating sieve.

The back sliding begins at the moment $t=t_2$ and $\psi_2 = \omega t_2$, when $\ddot{x} = 0$.

From the expression (16) of the acceleration, made equal to zero, it is obtained the equation

$$\sin\psi_2 = \frac{g}{r\omega^2}\cdot\frac{\sin(\alpha-\phi)}{\cos(\beta+\phi)}. \tag{17}$$

Taking into account the relation (17), the fundamental equation (16) can be also written as fallows:

$$\ddot{x} = r\omega^2\frac{\cos(\beta+\phi)}{\cos\phi}(\sin\psi - \sin\psi_2). \tag{18}$$

Because the back motion of sliding begins at the moment $t=t_2$ and it correspunds to the interval $t > t_2$, respectively $\psi > \psi_2$, in the same way as in the previous case, it is considered the function $\dot{x} = \dot{x}(t)$ which, for $\ddot{x}<0$, is a decreasing one. Thus, begining with the moment $t=t_2$ for wich $\ddot{x}(t_2) = 0$, the velocity $\dot{x}$ is negative ($\dot{x} < 0$), so that a back motion of sliding takes place.

In accordance to the relation (18) and from the condition $\ddot{x}<0$, it results

$$sin\psi < sin\psi_2. \tag{19}$$

Supposing $\psi_2$ given by the relation (17) in the first quadrant, i.e. $\psi_2 \in \left(0;\frac{\pi}{2}\right)$, it results that the angle $\psi$ must be in the interval $\psi \in (\pi-\psi_2;2\pi)$.

By the integration of the differential equation (18), it is obtained the expression of the velocity:

$$\dot{x} = -r\omega\frac{\cos(\beta+\phi)}{\cos\phi}\left[\cos\psi - \cos\psi_2 + \sin\psi_2\cdot(\psi-\psi_2)\right]. \tag{20}$$

The end of duration of the back sliding is obtained by nullifying the expression of the velocity $\dot{x}$, given by the relation (20). The final moment, denoted by $t = t_2'$, respectively the angle $\psi = \psi_2'$, is obtained by solving the transcedental equation

$$\sin\psi_2 = \frac{\cos\psi_2' - \cos\psi_2}{\psi_2 - \psi_2'}. \tag{21}$$

The distance, covered in the case of the back sliding, is given by the integral

$$s_2 = \int_{t_2}^{t_2'}\dot{x}dt \tag{22}$$

Taking into account the relation (20), after effecting the calculus, becomes

$$s_2 = -\frac{r\cos(\beta+\phi)}{\cos\phi}\left[\frac{(\psi_2'-\psi_2)^2}{2}\sin\psi_2 + \sin\psi_2' - \sin\psi_2 - (\psi_2'-\psi_2)\cos\psi_2\right]. \tag{23}$$

If in the relation (23), it is replaced $sin\psi_2$ given by the equation (21), then for the displacements with back sliding, it can be written the relation

$$s_2 = \frac{r\cos(\beta+\phi)}{\cos\phi}\cdot\Phi(\psi_2), \tag{24}$$

If during the time $T = \frac{2\pi}{\omega}$, the material particle moves by forward and back sliding, the advance in the positive direction of the axis $O_1x_1$ has the value

$$s = s_1 - s_2; \tag{25}$$

and the average velocity of particle is

$$v_m = (s_1 - s_2)\frac{1}{T} = (s_1 - s_2)\frac{\omega}{2\pi}. \tag{26}$$

The graphical representations of the absolute velocity v, transport velocity $v_t$ and displacement $s_t$ with sliding along the vibrating sieve, on which there are superposed the slips $s_1$ and $s_2$, are shown in Figure 2, for a cycle of vibration.

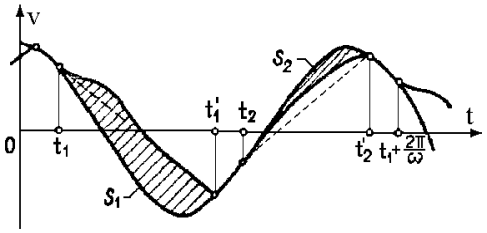



Figure 2. Absolute velocity, transport velocity and displacement

## 3. CONCLUSIONS

All obtained results correspond to the case of sliding motion, without detachment, i.e. for N > 0. In accordance to the relation (5), it results

$$\sin\psi < \frac{g}{r\omega^2}\cdot\frac{\cos\alpha}{\sin\beta}. \tag{27}$$

The analysis of possible motion regimes can be more easily made with the help of the kinematical index:

$$K = \frac{r\omega^2}{g}. \tag{28}$$

Thus, a condition for do not exist detachment, in accordance to the relation (5), is that the equation N=0 do not have solution, that leads to the inequality

$$K < \frac{\cos\alpha}{\sin\beta}. \tag{29}$$

Now, it is supposed the condition (27) as satisfied, so that all regimes of motion are with sliding, only. The characteristic indexes of forward and back motions of sliding are denoted by the parameters

$$K_{1,2} = \frac{\sin(\alpha \mp \phi)}{\cos(\beta \pm \phi)}. \tag{30}$$

As consequence, the relation (7), with the notations (29), becomes

$$\sin\psi_{1,2} = \frac{K_{1,2}}{K}. \tag{31}$$

For the beginning, it is considered $K_1<K_2$. Then, there are the following possible situations:

a) $K_1<K<K_2$ for which the angle $\psi_2$ can not exist, situation that corresponds to a sliding motion, forward only ($AI_t$);
b) $K<K_1<K_2$ when no one of the angles of motion initiation is possible, that corresponds to the situation of rest (R);
c) $K_1<K_2<K$, situation when both types of sliding are possible ($\psi_1<\psi_2$), and the regime of motion is with forward and back sliding ($AI_t+AI_p$).

For the situation when $K_1> K_2$ the possible cases are as follows:

a) $K_2<K<K_1$ for which the moment $\psi_1$ does not exist, which shows that the only possible regime of motion is with back sliding ($AI_p$);
b) $K<K_2<K_1$, where initial moments for motions with sliding do not exist, i.e. there is the rest, only (R);
c) $K_2<K_1<K$ where there are possible solutions for both initial moments ($\psi_1 <\psi_2$) and so, the regime of motion is with forward and back sliding ($AI_t+AI_p$).

Finally, in accordance to the relations (31), it can be written

$$K_1 - K_2 = -\frac{\sin 2\phi\cos(\alpha+\beta)}{\cos(\beta+\phi)\cos(\beta-\phi)}. \tag{32}$$

The conditions $K_1<K_2$ are realized if $\cos(\alpha+\beta)>0$, that leads to $\beta<(\pi/2)-\alpha$. The other situation, $K_1> K_2$ can appear if $\cos(\alpha+\beta)<0$, i.e. only for $\beta>(\pi/2)-\alpha$.

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# THE ATTEMPT TO TRACTION OF THE INSULATION OF THE CABLE LAY-UPS FROM CARS

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**Abstract**

The correct operation of the cars is the result of correctness output of the execution and the fitting ensembles, building blocks and the marks components. After make, each among these are submissive of a specific testing which have the fate to confers them a certainty of good operation in exploitation.

The cable lay-ups, as components of the electric plant, are submissive of attempts which visa the workstations and the insulation. In this work are analyzed the insulations of a cable lay-ups. The results, obtained abaft their attempts to traction, are processed with specialized software Weibull+ + 7, who permits the determination of reliability parameters of the cable lay-ups and therewith we can do appreciations about material quality used to the manufacture of the coatings and the correctness they were made.

## 1. INTRODUCTION

The electric equipment of the cars has the role assured the electric energy for the input of electric apparatus as much stationary, quotients and to the movement of the cars.

Component of electric equipment is: the feeder plant, the consumers and the central office with the specific annexes. This rearward contains the contact with spanner, isolators, switches, safeties etc. and the cable lay-ups which do the connection between elements of the electric equipment.

The conductors, as and components ale the cable lay-ups, can be down stress and of high stress. They are made from multiform cupriferous wire, of section and different insulation (figure 1). The conductors who have approximate same direction are made grouped with special par tape and are fixed with staples and metallic or plastic clamping jaws. They are put in places safe from leakages of oils, fuels, water and how much beyond the which part emanates excessive heat (across 100°C).

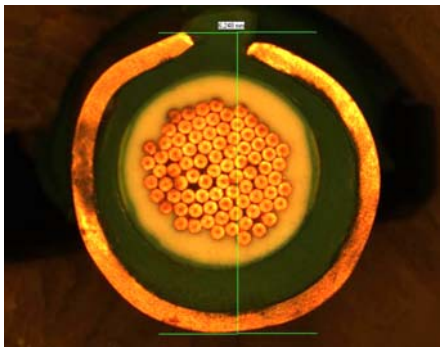


Figure 1. Section through the electric conductor

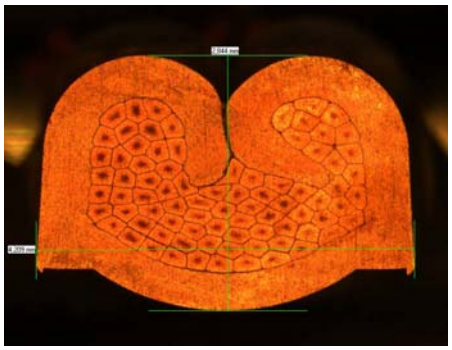


Figure 2. Section through the terminal

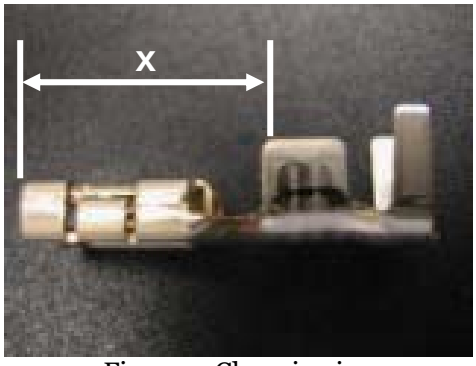


Figure 3. Clamping jaw

The conductor terminals (figure 2) used for the fixation to the elements of electric equipment are made in the shape of mules, clamping jaws (figure 3), clamping ring, clutches from brass latten or bronze. All the terminals are protecting with fittings of rubbers or plastics, of diverse forms.

## 2. Procedures of quality

The quality auditing activity of the cable lay-ups is done in special workspaces for ultimate check, utilizing the documents, the middles and the specific proper methods.

The documents of quality are constituted from: procedures and cautions of specific quality of the place of labor, standards of quality, plugs of measurements and specific registrations.

Used-up middles to the check quality can be: standards, equipments of testing, gauges and check (the tape measure, the ruler, caliper, micrometer and dynamometer) and specific characters (section the thread, color the thread, the bandage type, plan of dusk, numerical codes components).

The quality auditing methods can be: visual checkout, compare to the standards, measure, monitoring and functional testing.

### Testing to traction the insulation of the cable lay-ups

In this paper is analyzed the comportment to traction of the insulation cable lay-up with following nominal sizes:

*Strip Length (mm):* 6.00
*Conductor crimp height (mm):* 2.80
*Conductor crimp width (mm):* 4.20
*Insulation crimp height (mm):* 6.35
*Insulation crimp width (mm):* 6.36

A number of 10 of identical cable lay-ups were stretched by a special machine up to rupture the insulations. Is registered the values of the forces (table1) which results the deterioration of the insulations.

Table 1. Experimental results

| Nº | Insulation crimp height [mm] | Tensile result [N] |
|---|---|---|
| 1 | 6.350 | 27.41 |
| 2 | 6.340 | 29.18 |
| 3 | 6.370 | 27.77 |
| 4 | 6.370 | 22.61 |
| 5 | 6.350 | 17.00 |
| 6 | 6.360 | 19.58 |
| 7 | 6.350 | 27.14 |
| 8 | 6.370 | 25.64 |
| 9 | 6.370 | 20.94 |
| 10 | 6.370 | 24.41 |

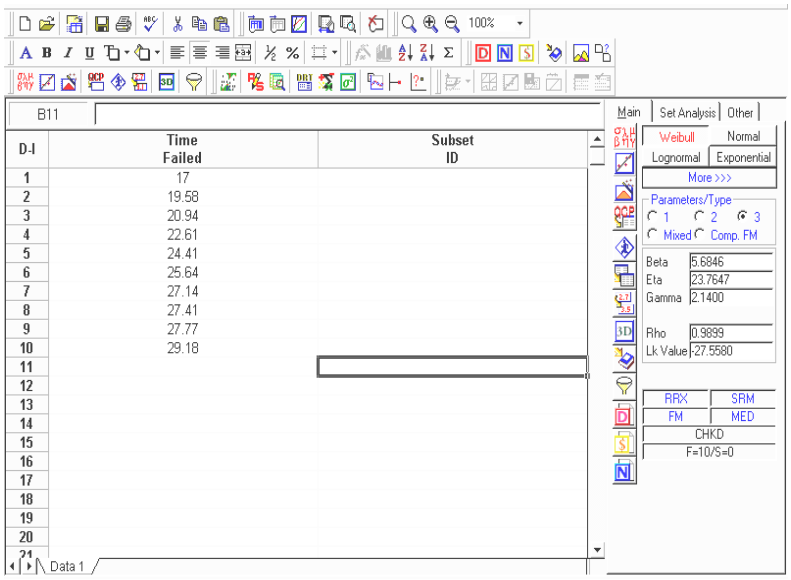


Figure 4 Introducing of experimental data

The insulations of the cable lay-ups are subdued also of a thermal stress which consists to heating of the samples to 120ºC and maintain their 120 of hours, thereto is done just a visual check of integrity of the insulations.

**The processing of experimental date**

The values of the forces of destruction are entered in the program Weibull++7 of the Reliasoft corporation, just as is seen in the figure 4.

Launching in execution of the program show that the repartition rule values, of forces which destroy the insulations, is Weibull with three parameters: $\beta = 5.6846$, $\eta = 23.7647$ şi $\gamma = 2.14$; which fact is can also see from the Allan-Plait diagram (figure 5).

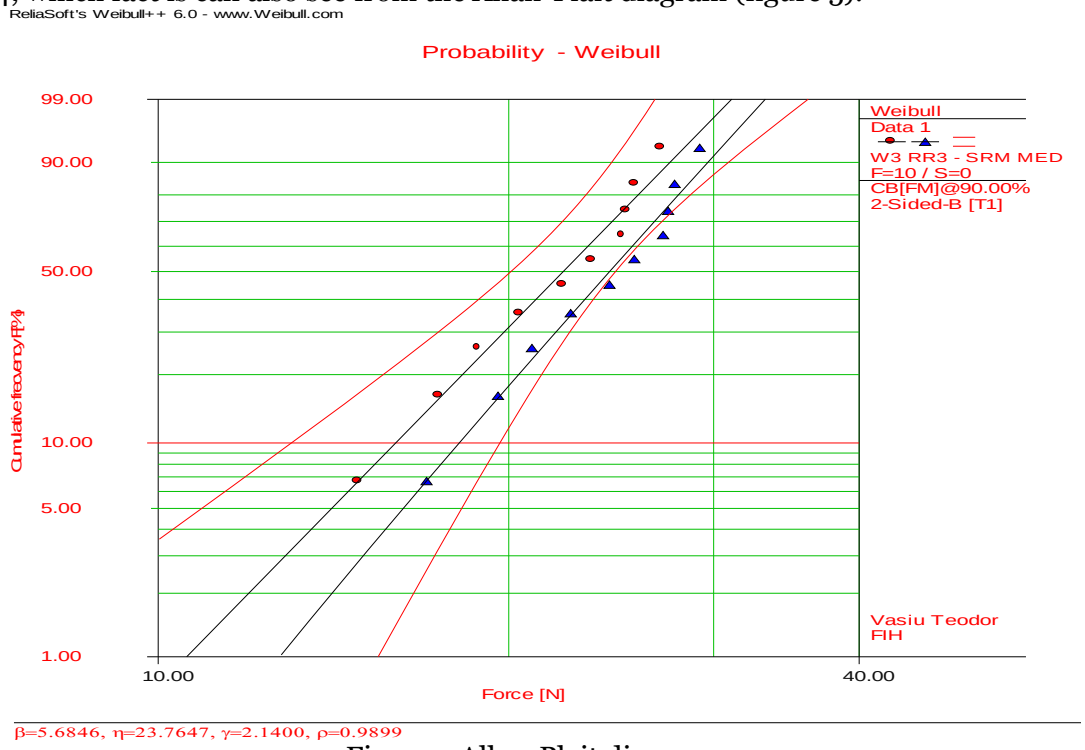



Figure 5 Allan-Plait diagrams

Knowing the rule of repartition it can be traced the reliability of the insulations of the cable lay-ups depending on force tensile (figure 6), the variation accordingly the failure rate (figure 7) and the Likelihood function surface (figure 8).

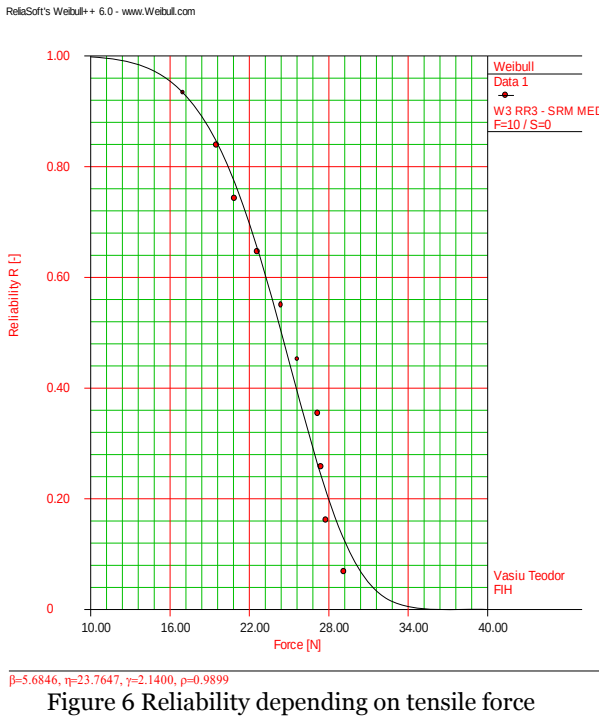



Figure 6 Reliability depending on tensile force

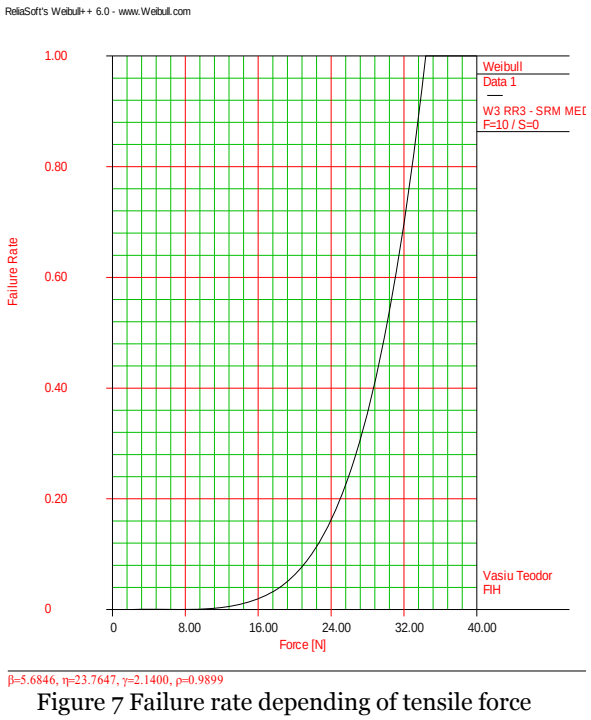



Figure 7 Failure rate depending of tensile force

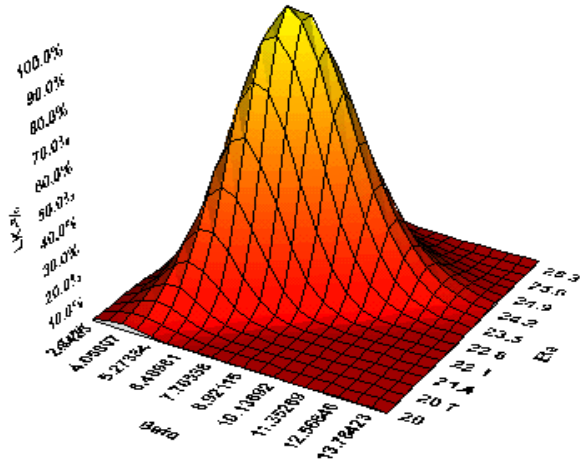



Figura 8 Likelihood function surface

## 3. CONCLUSIONS

The value parameter β show that insulations are in last period of life (the material from which they are made is olden), in which the ruptures can appear anytime to stretch forces bigger of 2N (γ = 2.14). Between 2 and 8N is estimates that appear just fissures which must be analyzes carefully of the electricians auto. Across 8N (the failure rate grows suddenly opening with this value) can appear detachments of insulations, fact that can produce short-circuits whose consequences are hard to advance.

In other words, is recommended either the carefully leverage the cable lay-ups, either improvement the material from which is executed insulations. Last solution, which presupposes the enlargement of reliability is proves always the viability in time.

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# SOLUTIONS FOR BREED THE AVAILABILITY OF THE PARALLEL GANG SHEARS ASSIGNED FOR CUTTING THE METALLURGICAL PRODUCTS

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**Abstract:**

In this paper proposed some solutions for the decrease of the unschedule stops of the 8000Kn shear with parallel gang assigned for cutting the metallurgical products. Analysis of data collected through observation of operation/failure of the shear allow construction of the so-called Pareto diagram, which is an analysis and assessment method that at the same time allow identification of several failures on which should be droved with priority. Based on the study which has been performed is proposed solutions meant to increase the availability of the 8000 kN shear, existent in exploitation.

## 1. INTRODUCTION

Analyse yes obtained from the observation operation/breakdown of the scissors permits the construction of the Pareto diagram which is a method of analysis and of permissive evaluation therewith the identification of the categories of which bugs must resolve without delate.

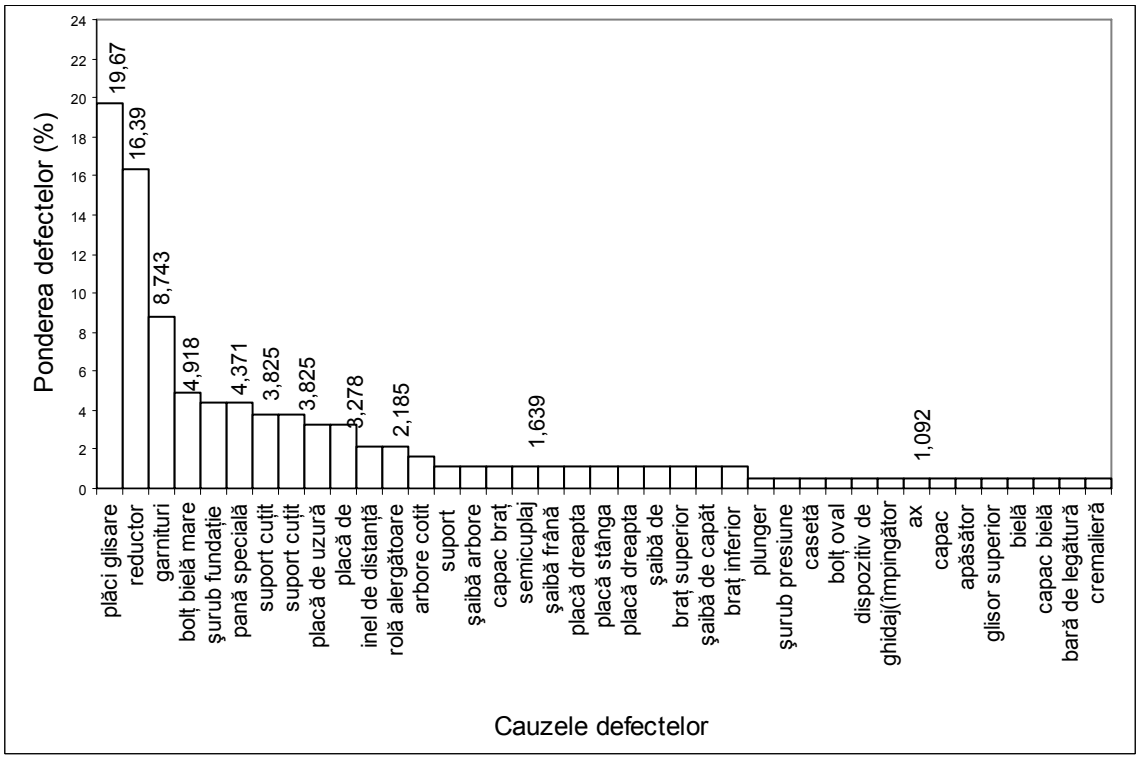



Figure 1. Pareto Diagram for scissors of 8000kN.from the framework of the line of rool S.F.1

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From the figure 1. consisted as through his degrease the dismission of the bonus forteen guys of out of order, the number accidental stops are reduced with approximate 80% [2].

According to the results obtained by *Pareto diagram*, elements with the highest percentage of failure weight observation (19,67%) are the *sliding plates* which are mounted on the shear body, at the contact area of the upper slide.

## 2. SOLUTTIONS FOR BREED THE AVAILABILITY

Sliding plates are performed currently from CuZn37. As per gives obtained from exploitation and through the determination reaction from the translational couple is can caused the speed of effeteness volumetrically scilicet v=0,42380mm$^3$/s.

A proposal for the decrease of the speed of coupled respectively is the execution sliding plates from steel OL60 and these veneering with an alloy a cast-iron appointed sormait for witch by-pathes characteristic date in the table 1.

Table 1. Characteristic date of the alloy a cast-iron appointed sormait

| sormait | Addition agents [%] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C | Si | Mn | P | S | Ni | Cr | Cu | Mo |
| | 3,46 | 3,28 | 1,35 | 0,066 | 0,070 | 2,0 | 21,65 | - | - |

The sormait due to of a big content of silicon (3,28%), assure a higher resistance to abrasive effeteness and the mechanical sock. In this choice the cemented carbide he considered the chemical composition satisfies following condition:

- the contents of carbon and the chromium, of which it depends the amount of primary carbides the eutectic, assure a optimal combination between resistor to effeteness and the tenacity of the layer applied;
- the content silicon, manganese, molybdenum, nickel and cooper am thus choosed that the plated its layer don't contains the pearlite in the structure.

Experimental tests to determine the wear speed for the coupling sormait-OT50-3 have been accomplished on an existent installation at the Specialized Laboratory of the faculty of Engineering in Hunedoara, the results being shown in figure 2.



Figure 2. Installation for attemps

The attempts they did so that coupled cylinder-disk is like with the bearing load from couple Sliding plates - upper slide.

Following of tests has been determined a volume wear speed of 4,71·10$^{-3}$mm$^3$/s, which is much lower that the one obtained through exploitation.

Also, according to the same Pareto diagram, at the 4th position is placed the pin of the upper bar with a weight observation of failures of 4,918%. This pin is manufactured of OLC 35 and the diameter of 370mm. In that coupling, pin – big connecting rod, appears the

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phenomenon of semi-wet friction. This leads to high values of friction coefficient, intense wear.

Another proposals meant to reduce the non-programmed entity shutting downs are manufacturing the pin of 28TiMnCr12 and its cementation (face hardening). This type of steel [3], after the thermic specific treatment has a top-side constitute from martensite of return with erect content of carbon, verry hard and a resistant core but tenacios ghift with a ferrito structure. The manganese from the content of the steel raises resistance traction, limit of flow the steel, and the chromium confers the great effeteness resistance and good qualities of chip removal.

Forwards, has been performed the analysis of pin resistance by the method of finite element using a specialized software (Algor) in the two alternatives of materials: *OLC35 and 28TiMnCr12*.

## 3. ANALYSE THE RESISTOR OF THE BOLT THROUGH METHOD OF FINITE ELEMENTS

Analyse the mechanical systems through the method of finite elements, represents solution mathematics of the engineering problems, what it has to base division the studios bodies in discreet elements (finite) formally of a cubbies or tetrahedrons. Analyse through the method of finite elements permits the determination of the stress distribution, specifically strains, to the movements, analyse vibrations, etc, for requirement of connection and load yes. Analyse the mechanical systems through the method of finite elements can be done with matrical calculation complex utilizing software packages such as: Algor, Ansys, Cosmos, etc. Afterwards, is presented the analyse of the pin resistance with help of the program Algor4.

Analyse of the pin resistance with software specialized presupposed run next stages:

- the transfer of the pin model from Inventor in Algor (stp. format) and the settlement type of the analyse (static analyse), the figure 3.

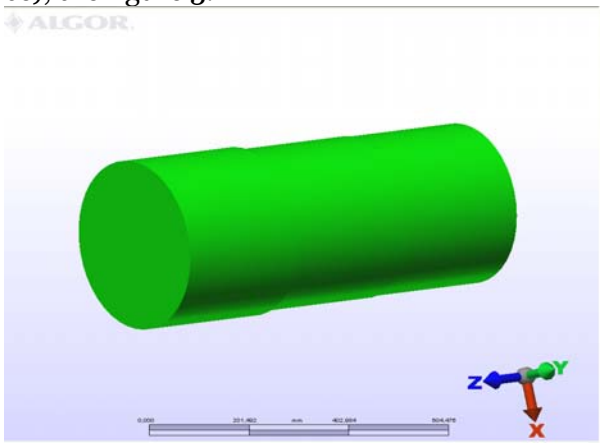



*Figure 3. Transfer of the pin model*

- the settlement parameters digitization and the digitization (mesh area) the model (figure 4.)

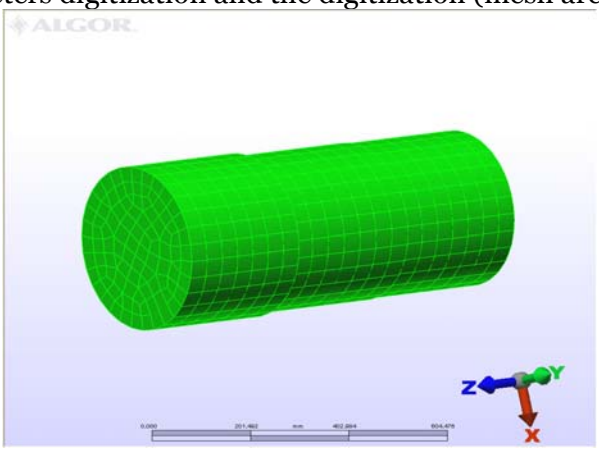



*Figure 4. Digitization the model*

- the settlement of the compulsions motional in the linkers, respectively shall kept the motion of rotation around axis Z as per the figure 5;

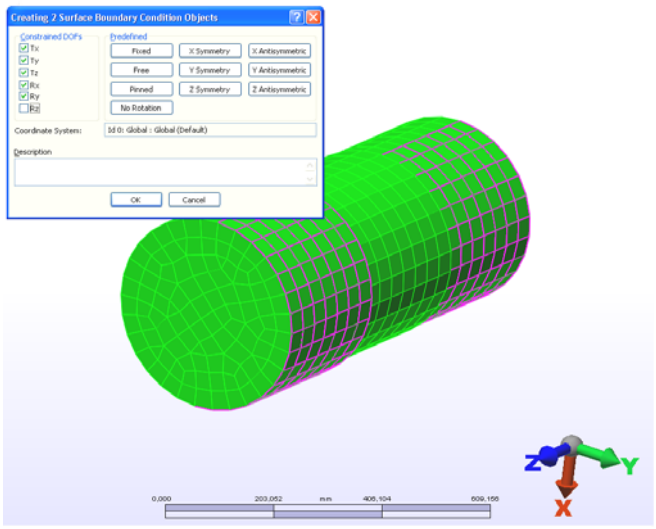



*Figure 5. Settlement of the compulsions motional*

- the settlement of the load: reaction from couple big bolt has the maxim value $7{,}384 \cdot 10^6$N. With this value, can cause the bearing load between elements (71,27Mpa), as per figure 6;

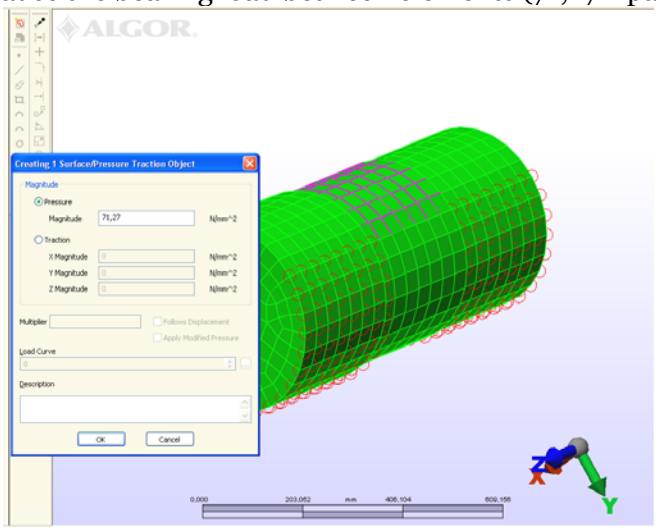



*Figure 6. Settlement of the load*

- analyse own saied the bolt executed from OLC35, the state tensional von Misess (figure 7), the specific deformation (figure 8) and the nodal movements (figure 9);

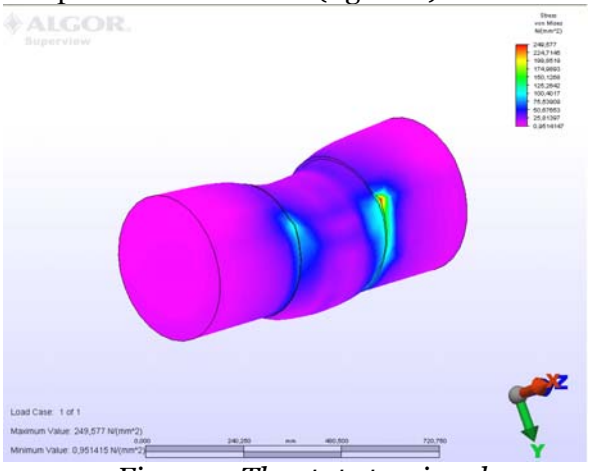



*Figure 7. The state tensional*

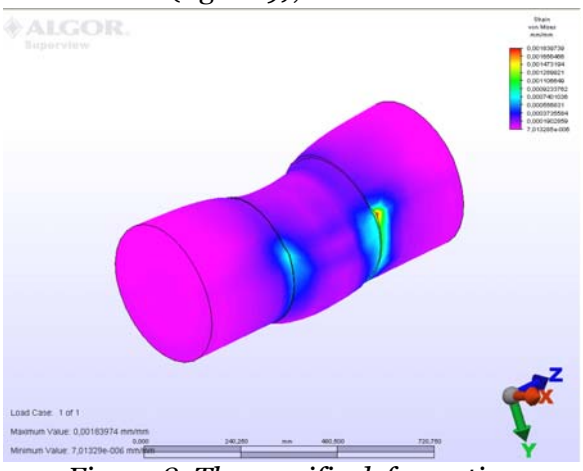



*Figure 8. The specific deformation*

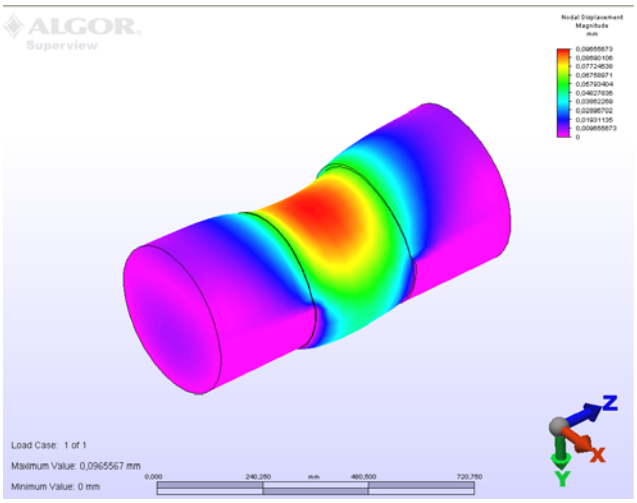



*Figure 9. The nodal movements*

Afterwards, is presented the analyse of the bolt executed from 28TiMnCr12, the state tensional von Misess (figure 10), the specific deformation (figure 11) and the nodal movements (figure 12):

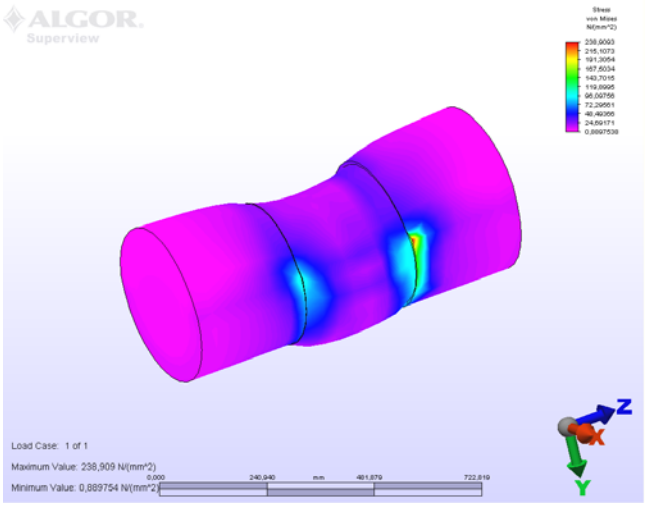



*Figure 10. The state tensional*

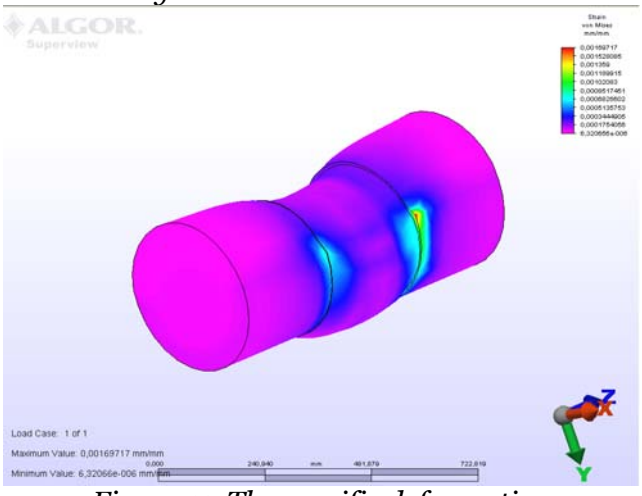



*Figure 11. The specific deformation*

From analysis presented on the two types of materials has been ascertained that in the situation of the cementation alloyed steel, *28TiMnCr12,* both specific deformations and node movements are smaller for the same burden.

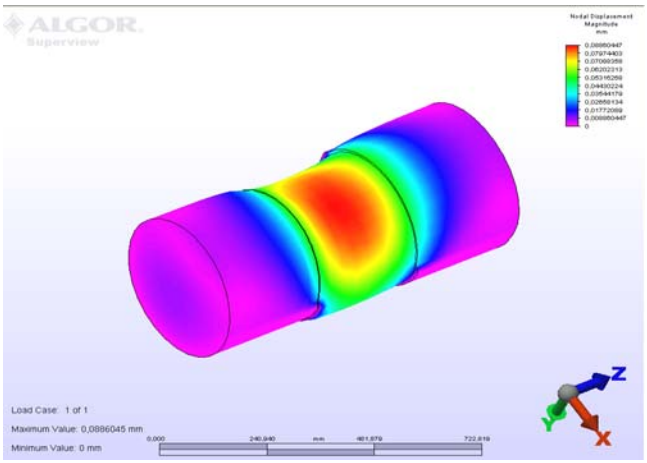



*Figure 12. The nodal movements*

Other proposals meant to reduce the non-programmed entity shutting downs are manufacturing the pin of OL37 and its plating with polytetrafluor-ethylene. The polytetrafluor-ethylene abreviated PTFE [5], [6], can replaced material metallic antifrictions in certain conditions presenting the plasticity, god thermic resistance and reduced friction coefficient. Is proof to the low and higer temeratures and presented the chimical resistance to the most corrosive agents. It present notably non-adhesiviness.

The features the mechanics for polytetrafluoroethyls are presented in the table 2.

Table 2. The features the mechanics for PTFE

| Mechanical property | Method of test ISO(ASTM) | Stone | Valori |
|---|---|---|---|
| Attempts to traction: | | | |
| - Limit of flow/resistance to rupture through traction | 527 | MPa | 15,2/28 |
| - The breaking elongation through traction | 527 | % | 300 |
| - The module of longitudinal elasticity | 527 | MPa | 625 |
| - The module of transversal elasticity | (D790) | MPa | 562 |
| Hardness Shore | 2039-1 | Sh.D | 57 |
| Densitate | - | g/cm$^3$ | 2,17 |
| To temperature | - | $^o$C | -200...250 |

The dynamic friction coefficient, without lubrication is contained between 0,04... 0,1.

## 3. CONCLUSIONS

Consequently, the proposed solutions: plating of sliding plates with Sormait, manufacturing of the pin of OL37 steel and its plating by polytetrafluor-ethylene and manufacturing the pin of cementation alloyed steel using a specific thermal and chemical treatment are accomplishable and relative easy from technological point of view and with the best practical results.

The suggested solutions, if they shall be selected, can reduce the times of maintenance preventively.

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# INTERACTIVE AND COLLABORATIVE LEARNING IN MECHANICAL ENGINEERING USING INTERNET

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**Abstract:**

In the process of preparing tomorrow's engineers and scientists, the universities are facing the challenge of gradually teaching students a reality of modern mechanical engineering, namely the mechanisms that occur from the interaction between different parts of complex technical systems. The use of Internet in the classroom offers the opportunity of efficiently adopting methodologies and advanced learning systems that can help the students to expand their views and explore new frontiers. This paper describes our experience concerning the possibility of using dedicated software (via Internet), for an interactive and collaborative learning in mechanical engineering.

**Keywords:**

mechanical engineering, educational dedicated software resources.

## 1. INTRODUCTION

Globalization and advances in information technology have prompted a change in the credentials of the engineers today. Industry needs engineers who can work in a distributed, multifunctional, cross-cultural and multidisciplinary avenue. For responded to this change, in the process of preparing tomorrow's engineers and scientists, the universities are facing the challenge of gradually teaching students a reality of modern engineering, namely the mechanisms that occur from the interaction between different parts of complex technical systems.

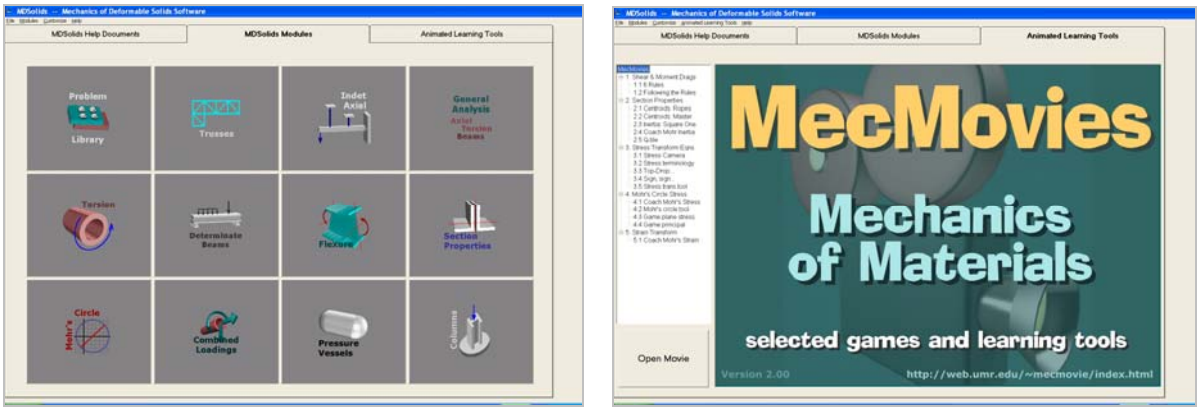
The formal lecture, the oldest teaching methods, has been widely use in higher education for centuries. But lecturing alone cannot ensure that students become active learners. Generally, using lectures in combination with other kinds of instruction, such as discussion and cooperative learning, can increase their effectiveness.

The activities used to reach students with different learning styles are very important, while people have different preferences for processing new information. One recent "*hot topic*" in higher education has been the different ways in which students learn: some students prefer to learn by listening, others like visual representations, and still others learn by doing. Incorporating of various resources into lectures and seminar applications improves the chance of understanding of concepts by students with different learning styles. Possibilities include demonstrations, role plays, discussions, simulations, problem-solving, real-world applications, or multi-media.

## 2. USING OF THE DEDICATED EDUCATIONAL SOFTWARE IN MECHANICAL ENGINEERING EDUCATION

In mechanical engineering education, the concepts developed in the mechanics of materials course, essential in preparation for design courses in the engineering technology disciplines, provide the designer with the tools needed to choose an appropriate material and to establish the necessary sizes for the machine or structure. For the student, the key to success in the course is to develop technical problem-solving skills by working a number of problems taken from a wide variety of mechanical and structural situations.

This paper exposed our experience on the use of the educational software, exemplified with the software called MDSolids, [2], a computer program dedicated to aid students in the study of Mechanics of Deformable Solid. MDSolids was conceived as a tool to help students solve and understand homework problems typically used in the mechanics of materials course and consists of a number of modules, Figure 1a, each focusing on a type of problem typically studied. The software features educational routines for beams, flexure, torsion members, columns, axial structures, statically indeterminate structures, trusses, section properties, Mohr's circle analysis and stress and strain transformations.




a. b.

Figure 1. MDSolids Modules (a); Games and Learning Tools Modules (b)

Also, MDSolids contains modules of Animated Games and Learning Tools, Figure 1b, for topics such as: Shear force and bending moment diagrams, Section properties (centroids, moment of inertia, Q), Stress transformation equations and Mohr's circle stress and strain transformations.

Concerning the MDSolids style, this educational software varies from a slideshow presentation of lecture notes to a MathCAD- or TKSolver-type of equation worksheet to a full structural analysis software package. The analysis routines are grouped in modules devoted to particular problem types. These modules focus on specific mechanics of materials concepts and problem-solving methods. MDSolids is powerful enough so that many different combinations of structure configuration and loading can be solved within each module, and it is coordinated so that results from one module can be used in related modules. The modules are constructed so that data for a particular problem can be entered directly and intuitively from a textbook (see Figure 3). MDSolids does not require the user to know a particular sign convention or to enter the data in a particular set of units. Where necessary, the software presents these options in either a pictorial or descriptive fashion.

MDSolids' solutions give the final number and, also, show a picture of how the structure deforms and how the stresses are distributed.

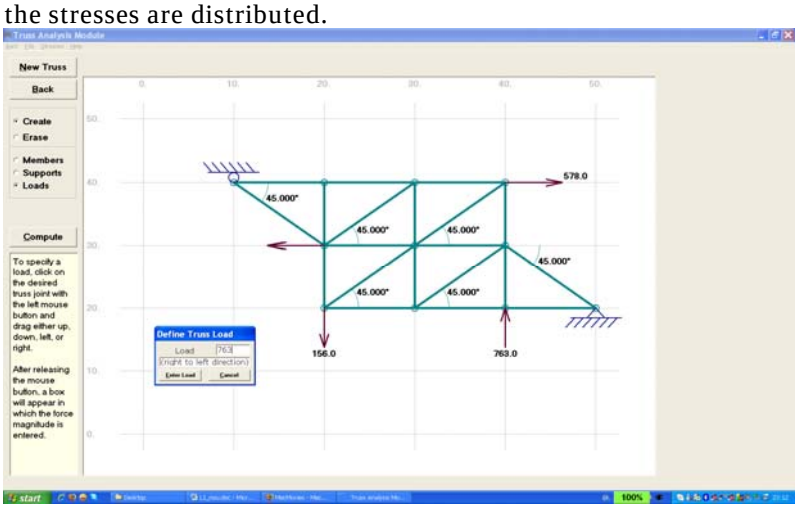



Figure 3. Sample of particular values entering

So, for the student, MDSolids can be helpful in several ways:

- The MDSolids solution can confirm the results obtained by hand calculations. If the hand calculations are incorrect, the complete solution provided by MDSolids can be used to track down errors in the hand calculations.
- The solution of typical mechanics of materials problems can be somewhat lengthy. With the MDSolids solution as a reference to keep the hand calculations on track, more problems can be attempted and solved. This problem-solving practice is essential to firmly understand the concepts.
- MDSolids can build confidence in the problem-solving method needed for the various types of problems included in the modules. The software can also help the student to develop a "feel" or intuition for what the correct answer should be. Confidence in the method plus engineering intuition about the outcome will conquer most of the difficulties commonly encountered in the mechanics of materials course. (Figure 4 and Figure 5).

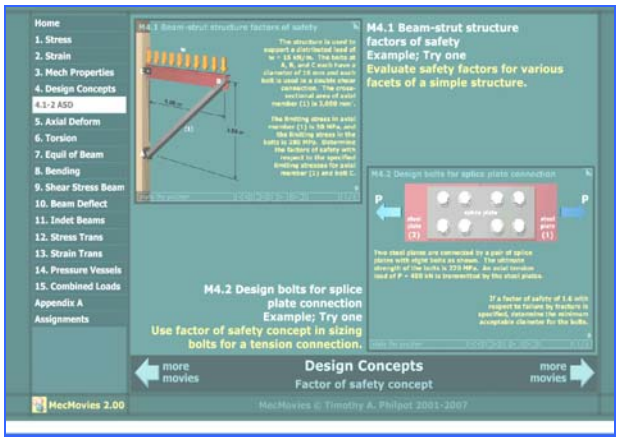



Figure 4. The Safety factor Concept in MecMovies Module

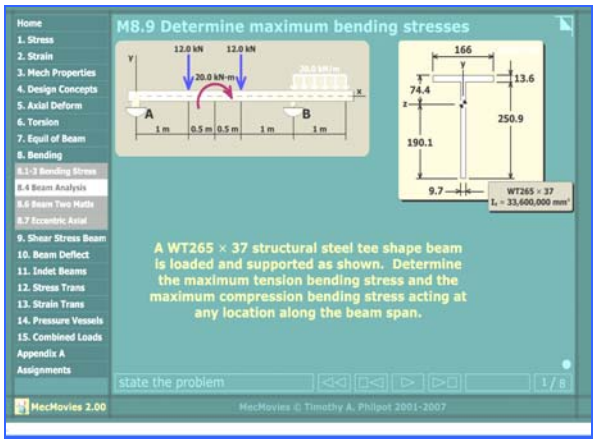



Figure 5. Beam analysis in the Design Concepts Module of MecMovies

- MDSolids provides brief text commentary describing the solution, Figure 6. These explanations can help students develop the problem solving skills needed to succeed in the mechanics of materials course. The mechanics of materials course can be a much more satisfying educational experience if students get some extra help from a program such as MDSolids so that they can get themselves on the right track from the start.

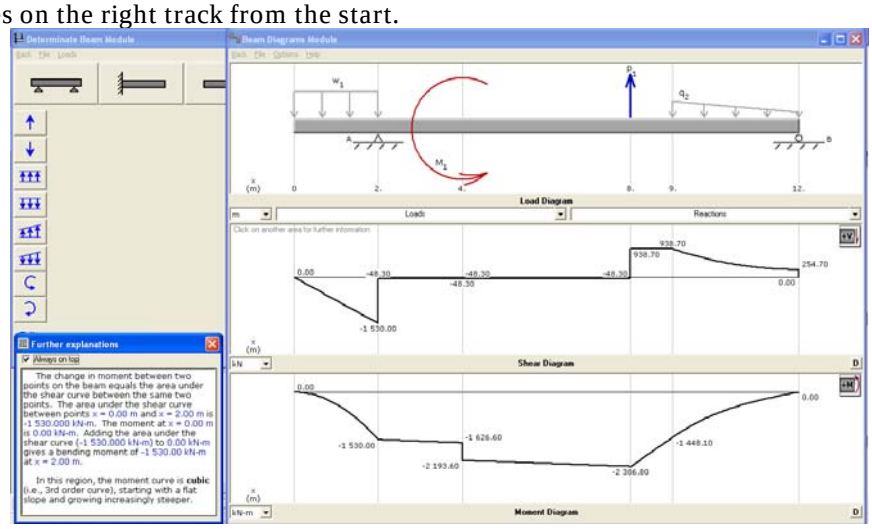



Figure 6. Comments on the solution in the describing box

- MDSolids has a Help folder to provide additional information about using the software and the software "navigator". The Help folder also contain a number of files with worked examples that describe the procedures used to solve the problems. The MDSolids Navigator is intended to help the software in the context of Mechanics of Materials studies. At opening of a book that corresponds to class textbook, will find a list of problems that can be solved and explained by MDSolids. By click on a problem number, the MDSolids Navigator will briefly describe the steps that are required to make MDSolids solve the problem.

## 3. DISCUSSIONS, APPROACHES AND INTERPRETATIONS

To develop the student understands of the mechanics of materials topics, homework assignments are the primary device used. The typical assignment can be somewhat lengthy; therefore, only selected problems can be assigned. Professors may expect that their students will work enough extra problems so that the fundamentals are firmly grasped, but students sometimes struggle just to keep up with the homework and exam schedule. To supplement the student's educational development, the self-study potential offered by software would seem to be the ideal means of filling the gap between the material presented in lectures and the understanding and skills expected in homework and exams.

Educational Benefits to use dedicated software, with on-line accessibility:

- This can help students study mechanics of materials and develop the necessary problem solving, skills in several ways that are not inherent in lectures or customary assignments.
- Obtain correct Solutions and Intermediate Results: when learning a new concept, it's very helpful

to use the correct solution as a benchmark. Knowing that the problem has been solved correctly gives the student confidence in their problem-solving skills and thereby provides a foundation for more challenging problems. Every textbook provides answers to selected problems for this reason. Software can provide the student with the correct solution for a particular problem, but in addition to the final answer, software can provide intermediate solutions that can be used to confirm the calculations along the way. These intermediate results can be helpful in tracking down faults in the problem-solving approach.

- What-If Analyses: Observing a cause-and-effect relationship can be quite helpful to students. For example, a student can develop a sense of the column buckling phenomenon without calculating a single number by assuming various end support conditions and then observing the effects on the buckled shape. This can help students to develop engineering intuition that will help them know what the correct solution should be before they calculate a single number.
- Availability: In the evening hours, during weekends or when working at home (which may be distant from the classroom), students don't have access to professors, graduate assistants, or others who can help them understand the course material. Having a versatile software tool at hand to supplement the textbook and lecture notes can be a big asset.
- Repetition: Some people must see or perform more repetitions involving a concept before they begin to fully understand it. Time limits the number of examples that can be presented in lectures and textbooks can present only a few examples. With software, students can drill themselves, trying various numeric combinations for a particular problem type until they feel confident in their understanding of the concepts.
- Visualization: Software can depict deformations or show stress distributions produced in the problem being considered. Visualization of the material's behavior in response to the loads acting on it can help the student to understand the relevant theory and to develop engineering intuition.

## 4. CONCLUSIONS

According to the exposed ideas, for a modern education in mechanical engineering field, there is a need to change the traditional lecture based of a passive learning methodology to an active technology using interactive and collaborative learning and the facilities offered by the information technology.

A very good and already experienced example can be the using of MDSolids software (by Timothy A. Philpot at Murray State University, [2]). That offers students numerical, descriptive, and visual results and details that illustrate and explain many types of problems in introductory mechanics of solids courses.

Compared with traditional instruction techniques, the using of educational software supports a learner's development of basic concepts and problem-solving skills through self-study.

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# INTEGRATION OF INTERACTIVE MULTIMEDIA LEARNING SOFTWARE INTO MECHANICAL ENGINEERING COURSE'S

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**Abstract:**

The integration of Information Technology in the applied educational activities of mechanical engineering, offers an excellent opportunity of improving the level of understanding achieved by the students. This paper describes the progress and results of our project, in testing the use of specific pedagogical resources in the teaching process of basic engineering disciplines, such as Fundamentals of Mechanical Engineering, Mechanics of Materials and Mechanical Vibration, in the inter disciplinary laboratory-classroom.

**Keywords:**

interactive desktop applications, virtual laboratory modules and experiments, computer based simulations, Java Applets

## 1. INTRODUCTION. CURRENT MECHANICAL ENGINEERING EDUCATIONAL SOFTWARE

The complexity of many of current mechanical systems has been growing exponentially. Unfortunately, it can be said that, generally, the Romanian higher education system has not kept pace with these needs. Existing undergraduate and graduate science and engineering programs need to incorporate more material on engineering educational software. An approach to using computers to enhance engineering mechanics education at our faculty involved the use of computer interactive desktop applications, virtual laboratory modules and experiments, computer based simulations, Java Applets, etc. This approach was motivated by the fact that the concepts taught in introductory engineering mechanics courses are often difficult for students to visualize and fully grasp. According to [6], an effective multimedia program should clarify abstract topics that are difficult to understand using traditional teaching media and focus on teaching concepts rather than entertaining students with shallow special effects. Software is currently being developed for Mechanics fundamentals, Dynamics and vibration and Strength of materials which focuses on illustrating theory, presenting relevant examples, and supplying quizzes for users to work. Many students first encountering mechanics have problems identifying what is wanted, how to decompose the problem into simpler segments, and what information they need to solve the problem. For such students, the authors believe that a directed learning procedure similar to that presented as examples in this paper is an appropriate procedure.

## 2. THE CASE STUDY

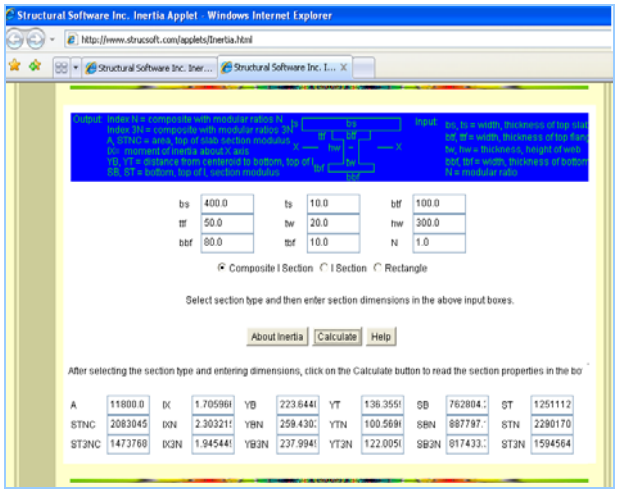
As a teacher team that has expertise in engineering of mechanical systems field, we have proposed two year ago a project for an interdisciplinary virtual laboratory-classroom equipped with computers network and educational software. This laboratory is currently operational in our faculty and is dedicated our students, future mechanical engineers, who can use here innovative and advanced educational software solutions. In this interdisciplinary laboratory, over the winter semester of the current academic year, we have developed a test program regarding the use of specific pedagogical resources in the teaching process of basic engineering disciplines, such as Fundamentals of Mechanical Engineering,

Mechanics of Materials and Mechanical Vibration. This test program is continued during the summer semester in aim to investigate how educational soft wares can aid our students to involved their design and structural analysis competences.

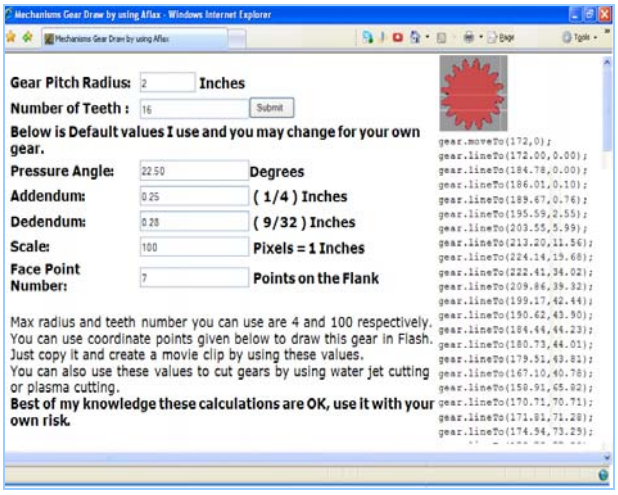
During the preparation period of this test program, our team devotes considerable resources to identifying the latest developments of dedicated and, if it is possible, free accessible software's, in order to update and review the packages installed on the network. In Figure 1a-1f and Figure 2a-2d, we are exemplified some of teaching resources used in our virtual laboratory-classroom.

In the domain of mechanical engineering, most of the current existing educational software can be grouped, generally, in the following categories: tutorials, worksheets, and basic analysis packages.

- Tutorials direct the student through a series of prepared screens, each focused on a specific concept or skill. In this manner, tutorials are like lectures delivered in a different format. Tutorials such as the Multimedia Engineering series feature impressive presentation complete with animation, video clips, and audio files. [2]. Despite excellent presentation, however, tutorial products are limited in applicability. The student must follow the sequence of the tutorial presentation in the same way that they would follow along in a lecture. Also, the student must master the concept presented by the tutorial and then apply that concept to the particular problems that they are asked to solve in their homework assignments.
- Worksheets for equation-solving software such as Mathcad, MATLAB, etc, have also been developed to supplement the mechanics engineering courses [3]. One drawback of worksheets is that the student must be somewhat familiar with the host software package in order to use the worksheet. This disadvantage can also be viewed as an advantage since worksheets encourage the student to develop some command of the equation-solving software, and familiarity with the equation-solving software is a skill that is useful in later engineering courses. However, to the student whose immediate goal is learning the mechanics of materials concepts, the added burden of gaining proficiency with the equation-solving software can be daunting.
- Basic analysis packages have been included in several widely available mechanics of materials textbooks such as [4], [5]. These programs are useful as tools for assisting students in fundamental skills such as plotting shear and bending moment diagrams or performing Mohr's circle calculations. Basic analysis programs may require students to define nodes and elements and to assign section properties and material constants to the elements.

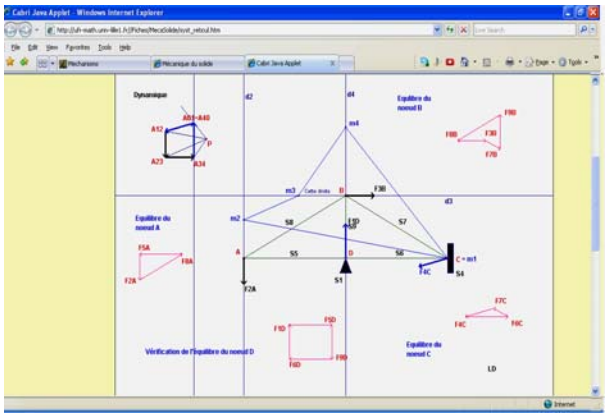



a. Inertia.class Applet
(source Structural Software, Inc.,
http://www.strucsoft.com )

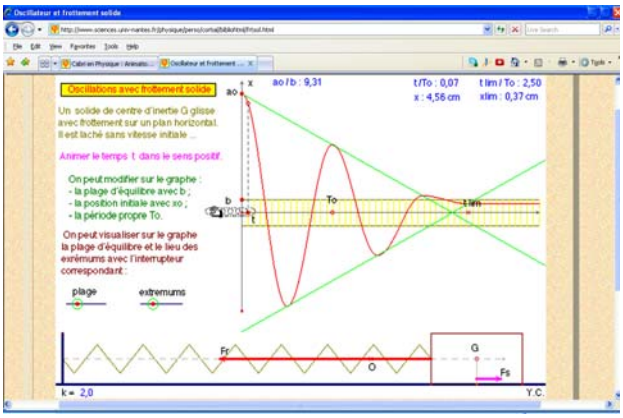



b. Mechanism Applet
Index, Linkage Mechanisms, Gears, Pneumatic Systems (source of the applet
http://www.mekanizmalar.com/gear_draw.cgi )

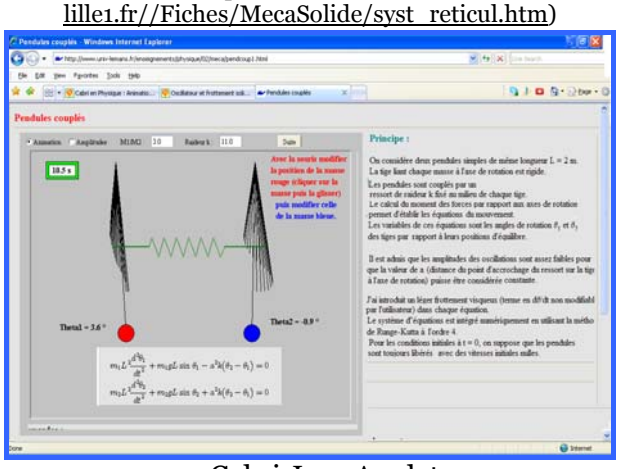
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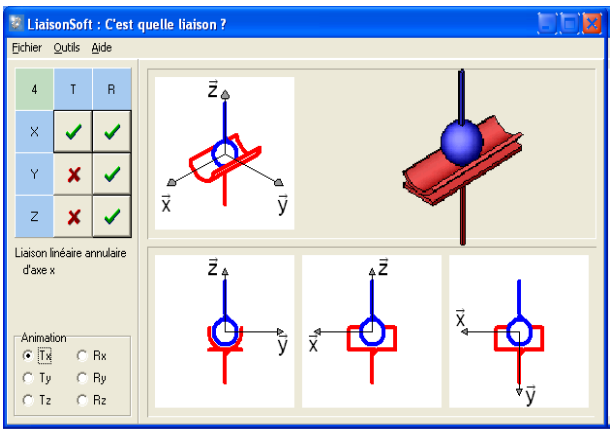
c. Cabri Java Applet
Equilibre de systèmes réticulés
(source Laboratoire virtuel- Université de Lille, France, http://ufr-math.univ-lille1.fr//Fiches/MecaSolide/syst_reticul.htm)



d. Cabri Java Applet
Oscillateur. Ressort avec frottement
(source Laboratoire-Université Nantes,France, http://www.sciences.univ-nantes.fr)

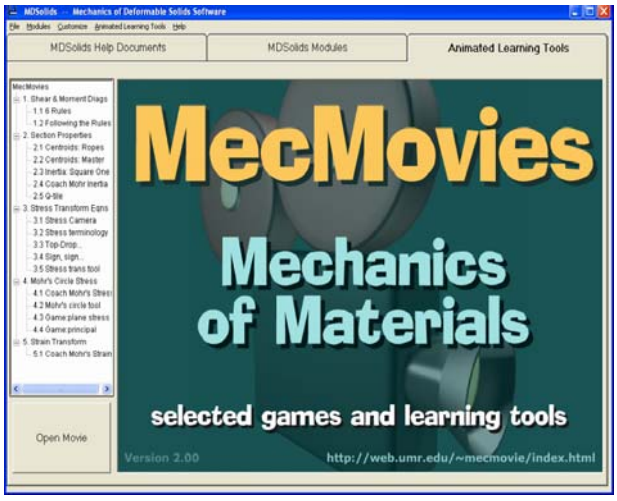


e. Cabri Java Applet
(source Laboratoire-Université Nantes,France, http://www.sciences.univ-nantes.fr)

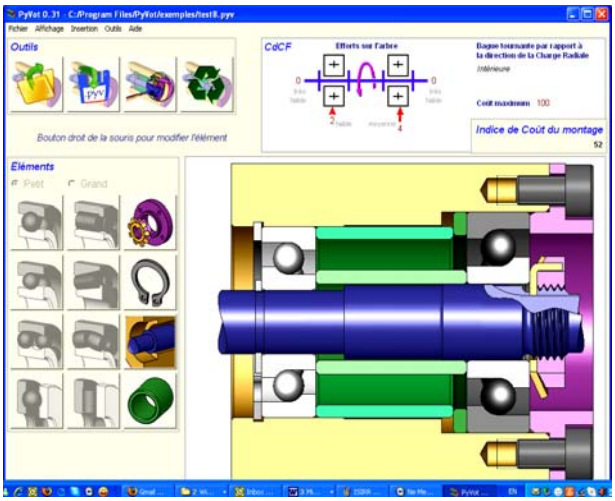


f. Educational software MecaTools
(source Laboratoire-Université Nantes,France, http://www.mecatools.new.fr )

Figure 1. Teaching resources used in the virtual laboratory-classroom
Java Applets and Educational software

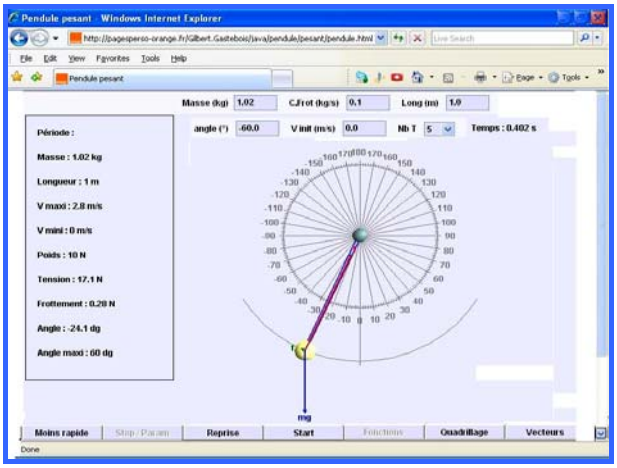


a. Educational software MdSolids
Animated Learning Tools Module
(source http://www.mdsolids.com )

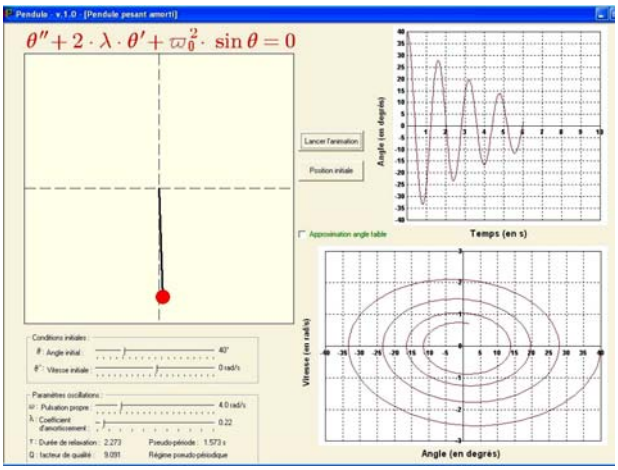


b. Educational software PyVot
Bearing assembly Analyzer
(source http://pyvot.fr )

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c. Educational software
Simulations in physical sciences
(source http://pagesperso-orange.fr/ java/accueil.htm)




d. Educational software Pendulo
Engineering sciences
(source http://www.sciences-edu.net/)

Figure 2. Educational dedicated software used in the virtual laboratory.

Input for these programs has typically been very text-based, often requiring a user's manual to ensure that the proper data and sign conventions are used and to help in interpreting the program output.

The novice engineer may feel overwhelmed by the attention to detail needed to set up an analysis model and may have difficulty visualizing and interpreting the resulting tables of numerical output.

## 3. ANALISES, DISCUSIONS, APPROACHES, INTERPRETATIONS

The final goals of our work initiative in the virtual laboratory-classroom are listed below. These objectives are more detailed described in the laboratory project proposition.

1. Use hands-on and visualization tools to aid students in problem formulation and enhance learning opportunities.
2. Integrate software simulation experiences into lectures.
3. Ensure that the equipment that is developed has an impact on core courses in Statics and Solid Mechanics as well as advanced courses in the Mechanical engineering programs.
4. Improve the critical thinking and problem solving skills of students by engaging them in the learning process, allowing individual experimentation and providing for interchangeability of the tools.
5. Ensure material is taught in variety of ways to benefit students with various learning styles.

During the implementation period of the project, we consistently that, generally, a fairly consistent part of the educational softwares are developed from the professor's point of view, emphasizing lecture topics or permitting the student to perform more advanced calculations.

But, to be successful, educational software should be developed from the student's point of view. Rather than forcing the student to solve a problem posed by the software, the software should solve the problem of interest to the student.

To do this, educational software must be:

- versatile in the types of problems that can be solved;
- strongly visual to illustrate the behavior of materials or of mechanical systems;
- informative in explaining how and why the calculations are performed;
- intuitive and easy-to-use so that the student is presented with just the right amount of information and analytical power.

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## 4. CONCLUSIONS

Today, engineering education can be considered realizing the potential of multimedia as learning and teaching tool.

The use of computer multimedia offers several tools that are useful in general engineering education and, particularly, in mechanical engineering education. Classical engineering graphics topics using a combination of animation, audio description, and interactive exercises can help the students

The most important benefit provided by multimedia can be considered the possibility of interaction. Many studies indicating that interacting with information can be a positive effect on learning since people remember/internalize more information if they interact with it (e.g. hears, see, and do).

Multimedia provides an excellent means of generating interaction through interfaces that require the user to make choices and perform actions.

Results of surveys indicate that the use of multimedia educational software in the virtual laboratory-classroom was extremely well received by the students and helped with the understanding of the training material in mechanical engineering field in mechanical engineering domain.

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# EVALUATION OF THE SMOKE DEGREE AND $CO_2$ EMISSION IN CORRELATION WITH THE DISTANCE COVERED BY ROAD VEHICLES

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**Abstract**

The paper presents the evaluation of the smoke degree in correlation with distance covered by a road vehicle, based on experimental measurements and theoretical modellations through mathematical functions. The evolution of $CO_2$ emission is avaluated using a specific software (DEKRA)

**Key words**:

smoke degree, $CO_2$ emission, DEKRA

## 1. GENERAL

The particles emitted by diesel engines consist mainly of soot, generated during the combustion (carbon graphite) and hydrocarbons adsorbed or condensed. Particles are defined in the law of the material (except water) that is collected on a Teflon filter to shift gas emitted by motor burned, previously diluted with filtered air, dilution with clean air is provided to meet the filter temperature be less than 52 ° C to avoid volatilization of hydrocarbons and water condensation.

Measurement of particle is based on previous definition and involves a complicated procedure, which involves diluting the exhaust gas (or part of them), the precise measurement of the ratio of dilution, weighing filters before and after sampling in a controlled atmosphere, knowing the exact diluted gas flow passing through the filter during sampling.

Since particle measurement is an operation with many phases, expensive and lengthy, there were many attempts to correlate measurements with gravimetric particle measurements of smoke index, using ordinary fummeter (Bosch, Hartridge) or other instruments not placed on the market. Most studies on this subject have obtained correlations between the numbers of smoke and soot concentration measured in undiluted exhaust emissions. Therefore, it will aplicativitatea existing correlations in smoke-soot mass emission estimates for particulate matter and will investigate the relationships between particles, soot and smoke, and in correlation with the distance traveled by vehicles.

## 2. MEASURED VALUES

Measurements were made on a car brand Vokswagen Sharan - 1.9 TDI with measuring devices owned by two measuring stations, measuring smoke according with TÜV - Germany rules, in connection with Annexes XIa and IXa StVZO (a), recpectively the tests in relation with Annex VIIIa and IXa StVZO (b).

For the two types of tests, the following values were selected:

- at relanti speed: according to (a) – $n_o$ = 700 ... 950 rpm
  according to (b) – $n_o$ = 770 ... 940 rpm
- at rated speed: according to (a) – $n_n$ = 4700 ... 5200 rpm
  according to (b) – $n_n$ = 4800 ... 5200 rpm
- for absorption coefficient KM: according to (a) – $K_M$ = 0.43 $m^{-1}$
  according to (b) – $K_M$ = 1.85 $m^{-1}$
- number of kilometers covered: 20.000 km

Table 1 and figure 1 presents data for the smoke, estimated by the coefficient of absorption $K_M$, depending on the number of km traveled.

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Table 1

| Crt. no. | Absorbtion coefficient Hartridge $K_M$ [m$^{-1}$] | Traveled distance [km] |
|---|---|---|
| 1. | 0,43 | 20.000 |
| 2. | 0,9 | 30.000 |
| 3. | 1,25 | 40.000 |
| 4. | 1,51 | 50.000 |
| 5. | 1,751 | 60.000 |
| 6. | 2,0 | 70.000 |

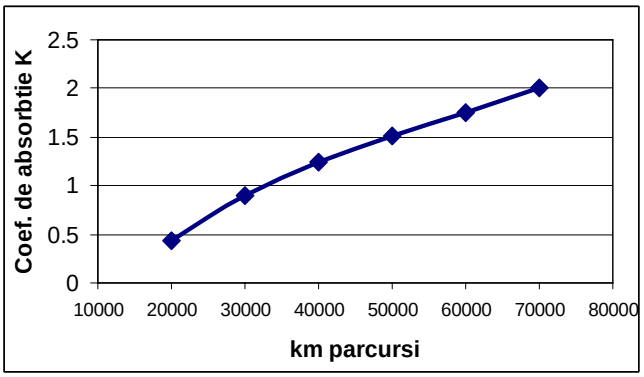



Figure 1. The absorbtion coeficient evolution vs. traveled distance

Table 2 give the data obtained through the exploitation of the DEKRA Soft Programme - Germany - 2007, for the route fuel consumption Cc [l/100km], specific $CO_2$ emissions - $E_{CO2}$ [g / km], that the total mass of $CO_2$ exhausted - $M_{CO2}$ [ kg], depending on the number of km traveled by car.

Table 2

| Crt. no. | Route fuel consumption $C_c$ [l/100km] | Nr. of km traveled [km] | Specific emission of $CO_2$ $E_{CO2}$ [g/km] | Absolute emission of $CO_2$ $M_{CO2}$ [kg] |
|---|---|---|---|---|
| 1. | 6,8 | 20.000 | 180,2 | 3604,8 |
| 2. | 6,9 | 30.000 | 182,9 | 5485,5 |
| 3. | 7,0 | 40.000 | 185,5 | 7420,0 |
| 4. | 7,1 | 50.000 | 188,1 | 9407,5 |
| 5. | 7,2 | 60.000 | 190,8 | 11448,0 |
| 6. | 7,3 | 70.000 | 193,9 | 13541,5 |

## 3. MATHEMATICAL MODELS

In all technical fields and not only, for studying of a certain process for establishing of a mathematical model, as a form of expression of the synthetic target and deployment process, that can later be used in different theoretical approaches. It follows that establishing the mathematical model based on experimental data is one of the main aims pursued by carrying out tests which should not be so to be repeated.

Obtaining non-linear models is more difficult due to the lack of a general theory that the uniform linear, therefore, most often resulting study nonlinear processes in particular cases. There are some treatment unit and the non-linear models, but still only valid for certain special cases, such as the polynomial models.

Thus, the size of the result y and x variable factorial model has polynomial general form:

$$y = \sum_{i=0}^{m} a_i x^m \qquad (1)$$

For example, for a two-degree polynomial expression (1) becomes:

$$y = a_2 x^2 + a_1 x + a_0 \qquad (2)$$

Relations were presented in full polynomial structure, so with all the expression characteristics terms. If using an unfully polynomial structure, missing at least one term, for example, in absence of the free term model (2) becomes:

$$y = a_2 x^2 + a_1 x \qquad (3)$$

Using a cubic polynomial expression, relation (1) takes the form:

$$y = a_3 x^3 + a_2 x^2 + a_1 x + a_0 \qquad (4)$$

Obviously, if considered a linear model, then the relationship (1) became:

$$y = a_1 x + a_0 \qquad (5)$$

Starting from data presented in Table 1, considering the evolutionary curve of the

absorption coefficient Hartridge $K_M$ according to the distance D traveled by the vehicle as a parable of second degree and applying relation (2), the following relationship which considers the evolution of $K_M$ is obtained:

$$K_M = -0{,}023 \cdot D^2 + 0{,}521 \cdot D - 0{,}52 \quad (6)$$

The coefficients $a_0$, $a_1$ şi $a_2$ of the relationship (20 were obtained by applying the experimental results. Thus were obtained the following values:

$$a_0 = -0{,}52 \; ; \; a_1 = 0{,}521 \; ; \; a_2 = -0{,}023$$

There was not found major deviations from the experimental curve (Figure 1), the calculation curve is well overlapped above the theoretical, obtained by mathematical modeling - fig. 2.

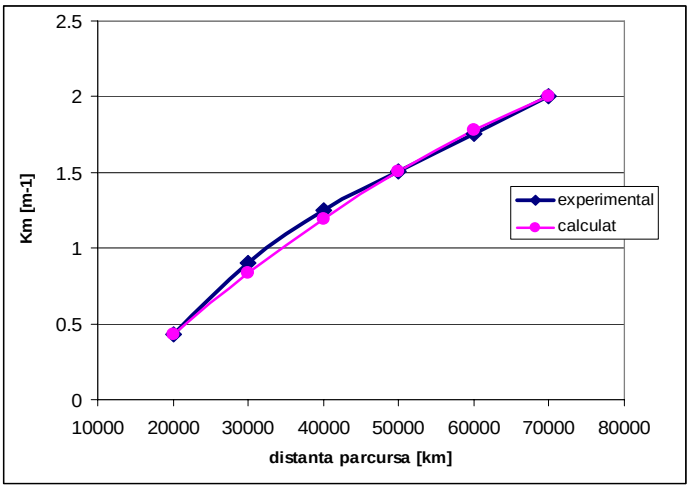



Figure 2. Comparison between absorption coefficient – experimental and calculated

For the intermediate points, i.e. those who have not served for establishing the constants $a_0$, $a_1$, $a_2$, there was obtained deviations between 1.52 ... 4.32%, which are acceptable from a technical standpoint.

Accepting the mass particle content (GFC) evolution as a parable of a second degree, with the coefficients $a_0$, $a_1$, $a_2$ determinated as reasoning presented above ($a_0$ = - 0,016; $a_1$ = 0,062 ; $a_2$ = - 0,002), the following function is obtained:

$$GFG = -0{,}002 \cdot D^2 + 0{,}062 \cdot D - 0{,}016 \quad (7)$$

In Figure 3 presents graphically dependence GFG = f(D). Deviations between theoretical and experimental points are below 2%, which corresponds to the aim pursued.

Table 3

| Crt. no. | No. of km traveled D [km] | Absorbtion coefficient $K_M$ [$m^{-1}$] | Mass particle content GFG [$g/m^3$] | Hartridge smoke degree HSU [%] |
|---|---|---|---|---|
| 1. | 20.000 | 0,43 | 0,10 | 1,0 |
| 2. | 30.000 | 0,90 | 0,16 | 1,4 |
| 3. | 40.000 | 1,25 | 0,20 | 1,9 |
| 4. | 50.000 | 1,51 | 0,24 | 2,3 |
| 5. | 60.000 | 1,75 | 0,28 | 2,5 |
| 6. | 70.000 | 2,00 | 0,32 | 2,7 |

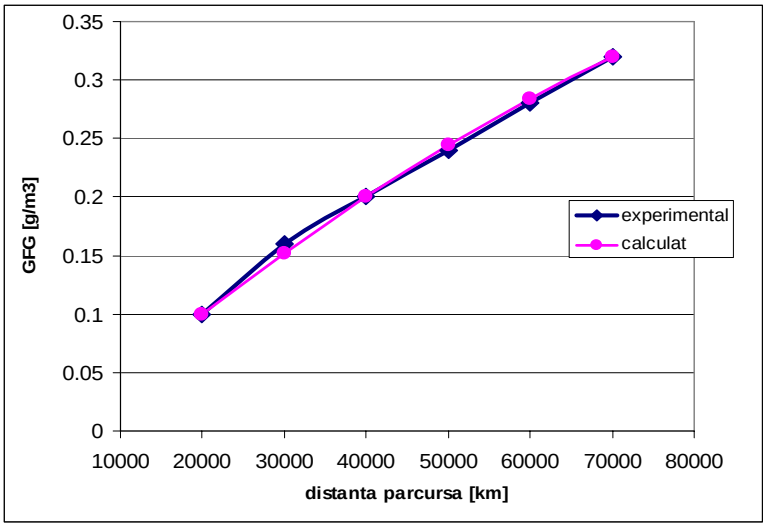



Figure 3. Comparison between mass particle content (experimental and calculated) vs. traveled distance

Modeling the evolution of $CO_2$ emission and route fuel consumption in relation to distance traveled for the analyzed car was realized also by functions. Experimental data for calibration are presented in Table 4.

Table 4

| Nr. crt. | Route fuel consumption $C_c$ [l/100km] | Nr. of km traveled D [km] | Speciffic emision of $CO_2$ $E_{CO2}$ [g/km] |
|---|---|---|---|
| 1. | 6,8 | 20.000 | 180,2 |
| 2. | 6,9 | 30.000 | 182,9 |
| 3. | 7,0 | 40.000 | 185,5 |
| 4. | 7,1 | 50.000 | 188,1 |
| 5. | 7,2 | 60.000 | 190,8 |
| 6. | 7,3 | 70.000 | 193,9 |

Specific emission of $CO_2$ - estimated through DEKRA 2007 software, the function which describes the evolution is linear type:

$$E_{CO2} = 2{,}66 \cdot D + 174{,}88 \quad (8)$$

Is founds a good correlation of experimental data with those obtained by mathematical modeling with functions, deviations were recorded are virtually negligible.

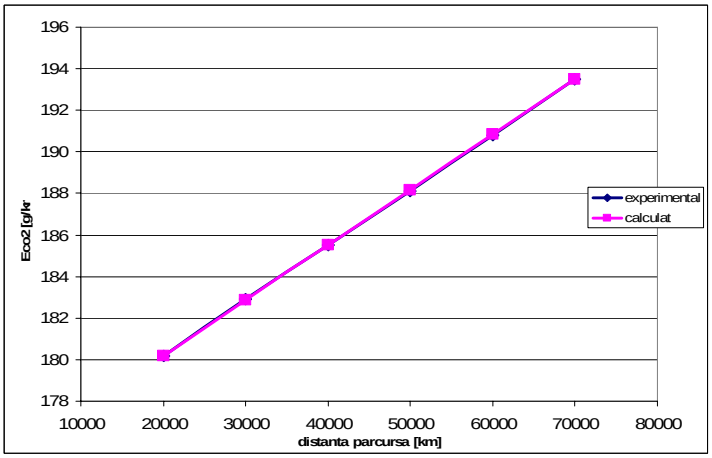



Figure 4. $CO_2$ emissions in correlation with traveled distance

## 4. CONCLUSIONS

Based on own measurements, there were established the evolution the level of smoke degree and particles emissions in relation to the distances covered. Experimental researchs are performed on the smoke opacity measured in relation with the distance traveled by the car equipped with a diesel engine. There are presented graphically and tabular variation for $K_M$ absorption coefficient based on the distance traveled. These allows establishing how the distance traveled values influence this factor.

Using the DEKRA - Germany 2007 software, it could be determinated the evolution of route speciffic fuel consumption, the speciffic and absolute emission of $CO_2$ according with the distance traveled by an automotive car, with an concrete example of calculation.

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# AN EXPERIMENTAL ANALYSIS ABOUT THE FRACTURE OF THE WHEELSET-AXLES OF THE 5100 KW ELECTRIC LOCOMOTIVE

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**ABSTRACT:**
The paper is focused on some experimental analysis performed in the Testing Materials Laboratory belonging to I.C.M. Resita regarding the appearance of cracks in the wheelset-axles of the 5100 kW electric locomotives. Chemical, traction, bending dynamic and torsion tests are performed for different wheelset-axles, different rolling distances and different working conditions which for the "stick-slip" phenomenon occurred.

Keywords:
locomotive, wheelset-axles, mechanical test, crack, stick-slip.

## 1. INTRODUCTION

The proper against skating device of the C.F.R. 5100 kW electric locomotives is not very efficient when a high level difference has to be raised. As an example, when a heavy train is trailed on an important level difference (as it is the Brasov – Predeal railway route), some important oscillations of the wheelset-axles appeared. The main reason is that for difficult traction conditions, the adherence limit is exceeded. The driving torque on the wheels is divided into non-equal parts, so the "stick-slip" phenomenon of the wheelset-axles is present, which mean an alternate torsion and slip state. Because of the elastic assembling of the wheels on the axles, the whole ensemble will oscillate with a proper frequency.

When the phenomenon takes place in the framework of the micro-sliding domain [1],[2] which means in the framework of a perfect adherence, the oscillation are of a high amplitude. The possible consequences is the appearance of a high state of stress in the wheelset-axles. But the final and the most dangerous consequence is represented by the fracture of the wheelset-axles ensemble [3]. This is the reason why the analysis of the wheel set-axles became obviously necessary [4]. It means both a mechanical,chemical analysis and an experimental non-destructive analysis, in order to detect possible crack initiating locations in the volume of the wheelset-axles.

## 2. LABORATORY EXPERIMENTAL ANALYSIS

During the time and according to railway administration regulations, the experimental analysis often avoids the appearance of the wheelset-axles fractures. The main studied wheelset-axles types are presented in table 1:

Tabel 1.

| Nr. | Locomotive type | Number of wheelset on the locomotive | Rolling distance [km] |
|---|---|---|---|
| 1 | 060-EA-006 | 2 | 306.000 |
| 2 | 060-EA-040 | 2 | 481.000 |
| 3 | 060-EA-012 | 2 | 476.000 |
| 4 | 060-EA-024 | 6 | 391.000 |

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Especially for the wheelset-axles number 3 and 4, some detailed chemical, mechanical and metallographic researches were performed, but the conclusion were drawn for all four investigated cases.

### 1.1.Chemical analysis

The chemical analysis of the wheelset-axle materials conduce to the partition of the chemical elements presented in table 2:

Table 2.

| Wheelset nr. | C[%] | Mn[%] | Si[%] | Cr[%] | Ni[%] | Mo[%] | P[%] | S[%] | Cu[%] |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 0,32 | 0,47 | 0,24 | 1,49 | 1,59 | 0,40 | 0,011 | 0,010 | 0,08 |
| 4 | 0,33 | 0,52 | 0,27 | 1,49 | 1,62 | 0,26 | 0,011 | 0,010 | 0,08 |

When compare the above mentioned concentrations with the imposed chemical element concentration of the wheelset-axles belonging to 7350 HP electric locomotive, it is observed that the values are placed into the accepted range by the wheelset-axles producers.

The content of 0.40% Mo on the wheelset-axles number 3, in comparison with 0.30% Mo prescribed content, will not present a non-favourable factor.

### 1.2. Traction test

The standardized traction specimen are in accordance with now-days regulations (it presents a 16 mm diameter on the calibrate circular parts).Tests were performed on an universal (traction-compression) testing machine.

The results are presented in the framework of table 3:

Table 3.

| Wheel set-axles number | Number of specimen | Yield point [MPa] | Ultimate strength [MPa] | Proportional necking [%] |
|---|---|---|---|---|
| 1 | 1 | 730 | 900 | 17,50 |
| 2 | 1 | 700 | 880 | 18,75 |

### 1.3. Dynamic bending test

The dynamic bending test specimens were manufactured both longitudinally and cross-section directionally. It means that a double number of specimens were tested, and results are presented in table 4:

Table 4.

| Wheelset-axles number | Number of the specimen | Longitudinal toughness [MPa m] | Transversal toughness [MPa m] |
|---|---|---|---|
| 3 | 1 | 775 | 425 |
| 3 | 2 | 750 | 337,5 |
| 3 | 3 | 800 | 462,5 |
| 3 | 4 | 675 | 462,5 |
| 3 | Average | 750 | 422 |
| 4 | 1 | 1000 | 500 |
| 4 | 2 | 775 | 450 |
| 4 | 3 | 1050 | 512,5 |
| 4 | 4 | 875 | 525 |
| 4 | Average | 925 | 497 |

### 1.4. Torsion test

The torsion loading represents the main loading which produces the stick-slip phenomenon. The obtained results, presented in table 5, are in accordance with the official prescriptions and regulations of the Railway Romanian Authority (A.F.E.R.):

Table 5.

| Torsion torque [Nm] | Diameter of the specimen [mm] | Yield point [MPa] | Shearing ultimate strength [MPa] |
|---|---|---|---|
| 940 | 20 | 598,7 | 783,4 |
| 980 | 20 | 624,2 | 770,7 |
| 960 | 20 | 611,4 | 777 |
| 920 | 20 | 586 | 764,3 |
| 920 | 20 | 586 | 764,3 |
| 910 | 20 | 579,6 | 757,9 |

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## 3. CONCLUSIONS

- The aspect of the cross-section fracture zone represents the main juridical factor when a wheelset-axles accident takes place. The shiny zone parts (figure 1) represent the fatigue area inside where the cracks grow in time.

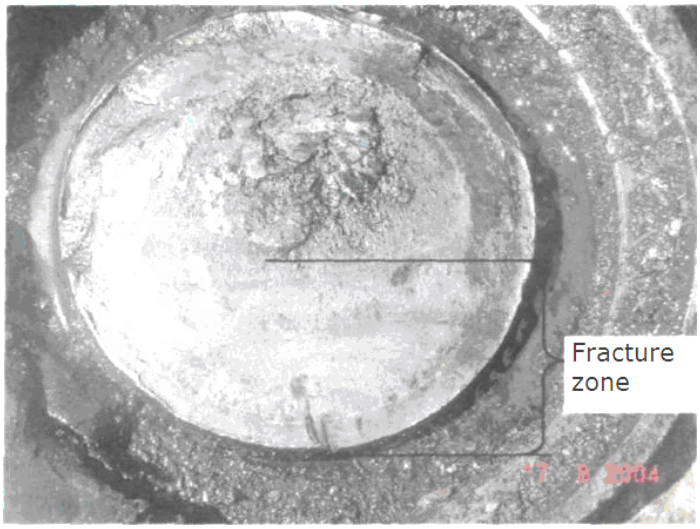



Figure 1. The aspect of the fracture zone in the body of the wheelset



Figure 2. The aspect of the fracture zone in the extremity of the wheelset (lubrication boxes)

- For the wheelset-axles nr.1, the aspect of the crack propagation is represented as two single independent cracks growing on the free wheel.
- For the wheelset-axles nr.2, the crack is developed in a continuous circular direction.
- For the wheelset-axles nr.3, the orientation of the crack is similar, but through the cross-section of the free wheel.
- For the wheelset-axles nr.4, the crack is located under the gear wheel. These are the most dangerous types of cracks. It may be detected only by an ultrasound control. The ultrasonic crack detection is usually performed by using an a lightweight, compact and handy-portable flaw detector designed for use on large workpieces and in high-resolution measurements. The complementary equipment consist in a mobile push-cart on the rail and three touching heads (a normal one and two bending touching heads).The equipment (figure 3) is able to detect fatigue cracks in the rail head, horizontal cracks in the rail head and in the transient area between the rail head and the rail core as well cracks which are initiated from the holes.

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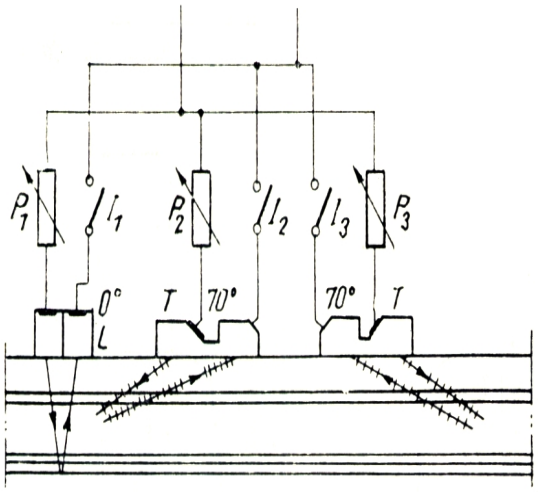



Figure 3. The mobile ultrasonic detection push-cart with three touching heads

The rail profile generates disturbed responses which have to be separated from the faults responses. Anyway, the experimental procedure is able to conduce to: the detection of the location of the cracks, the crack critical length and orientation. It may be calculated: the stress intensity coefficient at the top of the crack, the propagation rate, the estimated life-time of the wheelset for different locations and lengths of the detected cracks.

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# ASPECTS REGARDING THE LIFE-TIME OF WIRES BELONGING TO A STEEL WIRE ROPE

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**Abstract**

The paper presents an analysis regarding the influence of working typical factors about the shallow destruction phenomena between wires in contact. It was studied the influence of contact pressure and the relative displacement between wires concerning the life-time of wire ropes.
There is presented as a conclusion that the life-time of wires is decreasing at the increasing of the average pressure between the wire rope and the wrapping up roll. The destruction phenomenon of wires is increasing when increasing the frequency of the alternant bending process of wire rope around the roll.

**Keywords:**

wire rope, shallow destruction, life-time, contact pressure, fretting corrosion.

## 1. INTRODUCTION

The fretting corrosion belongs to the range of phenomena going to fracture of steel machine parts under different variable forces. The fretting corrosion conduce to decreasing of fatigue limit to (1,5...3) times. The above mentioned phenomena takes place between contact surfaces in a relative motion, when friction forces are acting on small contact areas due to roughness of joining surfaces. In the same time, heat is locally emitted producing punctual welding processes. A transfer of metallic powder between contact surfaces is produced. Because of chemical reactions with the oxygen included in atmosphere, the metallic powder is turning into oxides and nitrides. The degree of wear has high values in case of dry fretting, and small values in case of lubrication [3]. For wire ropes the influence factors about the fretting corrosion are as follows: the contact pressure, the amplitude and the frequency of relative displacement, the state of stress in the common contact area.

The interpretation of the fretting corrosion phenomena is based on the observation that high values of the contact stresses are located in the contact area. These stresses in correlation with relative displacements of contact surfaces are producing fractures of small particles. Taking into account the influence of the emitted heat, because of friction, the oxides are produced going to a wearing effect and facilitating the appearance of the fatigue cracks.

For the steel wire ropes subjected to a tensile test, the fretting corrosion is produced between the component wires as well between the external wires and the wrapping up roll. The favorable effect of lubrification about the life-time of wire ropes is unanimously accepted.

## 2. THE FACTORS OF INFLUENCE CONCERNING THE DESTRUCTION PROCESSES INTO THE CONTACT AREAS

### 2.1. Contact pressure

The contact compression, together with other loadings, conduces to a three-axis state of stress. The final result may be the appearance of the critical state, going to fracture, in layers

as far as a half of the breadth of the contact ellipse [1]. Hertz's formula is usually used in order to calculate the maximum contact pressure between the wire rope and the wrapping up roll.

The relation is valid only for elastic deformations:

$$p_0 = -\frac{3 \cdot P_0}{2\pi \cdot a \cdot b} \qquad [\text{N/mm}^2], \tag{2.1}$$

where: **Po** [N] - pressing on force between bodies in contact;
**a**, **b** [mm]- half-axis of the contact ellipse:

$$a = 1{,}4 \cdot \nu \cdot \sqrt[3]{\frac{P_0}{E \cdot \sum \rho}}, \quad b = 1{,}4 \cdot \nu \cdot \sqrt[3]{\frac{P_0}{E \cdot \sum \rho}} \tag{2.2}$$

**ν = 0,33** - Poisson's ratio;
**E = 2,1.10⁵ N/mm²** - Young's modulus;
$\sum \rho$ - the amount of curvatures of contact surfaces.

The average pressure between wire rope and wrapping up roll is expressed as:

$$p_m = \frac{2 \cdot T}{D \cdot d} \qquad [\text{N/mm}^2], \tag{2.3}$$

where: **T** [N] - traction force;
**D** [mm] - diameter of roll;
**d** [mm] - diameter of wire rope.

The formula may be used for multi-layer wire ropes. The maximum contact pressure between wires may be written as $p_{0\max} = 2\sigma_r$, where **σr** [N/mm²] represent the strength at fracture of wire. When exceeding this value, the momentary destruction is not produced, but a decreasing of the life-time always appears.

### 2.2. The friction between wires

The estimation of friction coefficient at high pressures on the surfaces of wires is very necessary especially for the manufacturing process of wires. The influence of the diameter of wire about the friction coefficient may be neglected. It may be considered that the well known dependence between friction coefficient and perpendicular force remain still valid. As a lubricant very often used for wire ropes, the oil ensure suitable values for the friction coefficient.

### 2.3. The relative displacement of wires

The amplitude of relative displacement between the contact surfaces of wires is due to different values of stretching stresses in wires as well to different deformations of adjacent wires because of the bending process at different diameters [4]. The relative displacement of wires is caused by the diameters of layers, the length of the volute line for a single step having the following formula:

$$L = 2 \cdot \pi \frac{r}{\cos^2 \alpha} \tag{2.4}$$

where: **r** [mm] - the radius of the layer;
**α** - the wrapping up angle of wires in a layer.

There is very difficult to take into account all the above mentioned influence factors for the destruction phenomena of wires. The difficulty is caused by the relative dependence between factors. So, the principle of superposition regarding the effects of the influence factors may not be used. It is of a great practical importance to establish perceptually the decrease of the fatigue limit of wires when the wires are separately leaded in comparison with the same parameter for the wire as a component part of the wire rope.

## 3. THE EXPERIMENTAL ANALYSIS OF THE INFLUENCE OF PRESSURE AND RELATIVE DISPLACEMENT ABOUT LIFE-TIME OF A WIRE ROPE

There are considered the following stresses:

- traction produced by the force **T**, going to the stress in wire rope

$$\sigma_t = \frac{T}{A} \tag{2.5}$$

- primary bending because of the wrapping up around the roll with a diameter **D**, going to the stress in wire rope

$$\sigma_i = \pm E \frac{\delta}{D} \qquad (2.6)$$

δ [mm] - diameter of wire;
**E = 2,1.10⁵ N/mm².**

The fatigue tests conduce to fractures of wires especially in the contact area between the wire rope and the drain of roll. So, this contact zone will be analyzed. For fatigue and life-time tests, loading cycle is characterized by the following parameters:

$\sigma_{max} = \sigma_t$; $\sigma_{min} = \sigma_t - \sigma_i$; $\sigma_{med} = \sigma_t - \sigma_i/2$ and $\sigma_{am} = \sigma_i/2$

For the particular case $\sigma_t = \sigma_i$ a pulsate bending cycle is obtained. Moreover, a pulsate compression cycle will be added having the maximum pressure $p_o$ in the volute zone and **0** in the stretching zone of the wire rope. So, the life-time $N_s$ of wire, which was loaded under a pulsate cycle with $\sigma_{max} = \sigma_t$, may be compared with the life-time $N_c$ of a wire, which was loaded under a similar cycle and an added pulsate pressure (0...$p_o$). Because only the fatigue limit for a symmetrical cycle may be estimated for wires, the Soderberg's diagram is used. The diagram is approximated as a part of an ellipse having the half-axis $\sigma_{-1}$ and $\sigma_c$. Instead of $\sigma_c$ may be used the strength at fracture $\sigma_r$.

So, the following formula will be obtained:

$$\sigma_{-1Nc} = \frac{\sigma_0 \cdot \sigma_r}{\sqrt{4 \cdot \sigma_r^2 - \sigma_0^2}} \quad [N/mm^2], \qquad (2.7)$$

The fatigue tests have been performed [2] in the Laboratory of Strength of Materials from the Mechanical Engineering Faculty of Timisoara. A loading machine Schenk has been used for fatigue tests in the framework of life-times in the proximity of the value N = 10⁶ cycles. The method of loading steps has been preferred in order to estimate the fatigue limit. The principle of the method consists in modifying the level of loading function of the level of stress obtained for the previous test. If the previous specimen has been fractured, the following specimen will be loaded at a smaller level of stress. For the opposite case, it will be used a higher level of stress. The test will continue until the whole range of specimen will be loaded. Results are presented in Table 1.

The advantage of the method consists in grouping the results around an average value. The drawback consists in the impossibility to perform simultaneously different specimens. So, the result of the previous test is necessary.

Table 1

| σ [N/mm²] | fractured wires • | N=10⁶ cycles | | | |
|---|---|---|---|---|---|
| | | **i = σi - σo** | **n** | **i.n** | **i².n** |
| 350 | • | 50 | 1 | 50 | 2500 |
| 340 | **0** • | 40 | 2 | 80 | 3200 |
| 330 | • • • **0** • | 30 | 5 | 150 | 4500 |
| 320 | **0** • • **0 0 0** • | 20 | 7 | 140 | 2800 |
| 310 | **0 0** **00** | 10 | 4 | 40 | 400 |
| 300 | **0** | 0 | 1 | 0 | 0 |
| | | Σ = | 20 | 460 | 13400 |

The fatigue limit of wire may be calculated by using the following formula:

$$\sigma_{-1Ns} = \sigma_1 + \frac{\Sigma(i \cdot n)}{\Sigma n} = 300 + \frac{460}{20} = 323 \quad [N/mm^2], \qquad (2.8)$$

where: $\sigma_1$ - is the reference level of stress, arbitrarily estimated for the smallest value of loading during the test.

The fatigue tests of wire ropes have been performed on a special loading machine designed by the lamented prof.dr.eng. Lazar Boleantu [2]. An usual wire rope **17 - 6x37 -160 S-Z**, STAS 1513-80, with the diameter of a single wire **δ = 0,8 mm** and the area of the cross-section **A = 112 mm²**, has been tested.

There is emphasized in Figures **1** and **2** the life-time of wire rope for three different loading steps characterized by the stress $\sigma_t = T/A$ and by the diameter of roll. For every step, three specimens have been tested. The dispersion of results for a single loading step is located into the area of a rectangle. The hachure indicates the loading step for a fatigue pulsate cycle. It may be observed a relative small difference between the averages values of life-time for the two loading frequencies as well a favorable effect of low loading frequency about the life-time of wire rope.

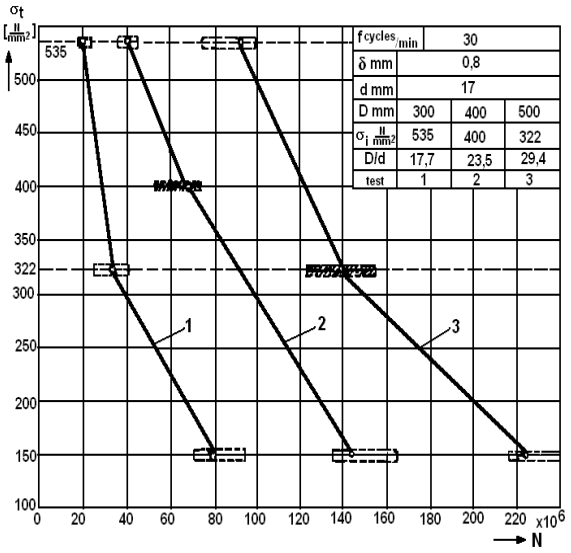



Fig. **1**
Tests performed at frequencies of 30 cycles/min

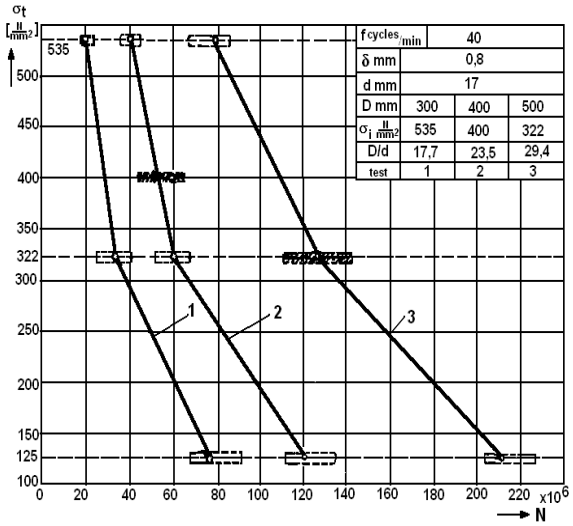



Fig. **2**
Tests performed at frequencies of 40 cycles /min

The decreasing coefficient, regarding the fatigue limit of a wire belonging to a wire rope in comparison with the strength of a single wire for life-time **N = 10⁶ cycles**, has been calculated according to the formula: $c_\sigma = \dfrac{\sigma_{-1Ns}}{\sigma_{-1Nc}}$ (2.9)

Results are presented in Table 2.

| **Test** | **1** | **2** | **3** |
|---|---|---|---|
| **D**[mm] | 300 | 400 | 500 |
| $\sigma_o = \sigma_t = \sigma_i = E\delta/D$ [N/rnm²] | 535 | 400 | 322 |
| $\sigma_r$ [N/mm²] | 1600 | | |
| $\sigma_{-1Nc} = \dfrac{\sigma_0 \cdot \sigma_r}{\sqrt{4\cdot\sigma_r^2 - \sigma_0^2}}$ [N/rnm²] | 266 | 208 | 163 |
| $\sigma_{-1Ns}$ [N/mm²] | 323 | | |
| $c_\sigma = \dfrac{\sigma_{-1Ns}}{\sigma_{-1Nc}}$ | 1,23 | 1,55 | 1,98 |
| $N_s$ [cycles] | $10^6$ | | |
| $N_{cmediu}$ | (19968) 19748 | (68058) 51684 | (138764) 124096 |
| $C_N = N_s / N_c$ | 50 | 14,75 | 7,24 |
| $p_m$ [N/mm²] | 22,4 | 13,2 | 8,55 |
| $p_o$ [N/mm²] | 7850 | 6420 | 5540 |
| $\Delta\varepsilon = \dfrac{2\delta^2}{D(D+2\delta)}$ | $1{,}39.10^{-5}$ | $0{,}8.10^{-5}$ | $0{,}5.10^{-5}$ |

There are presented in Fig. **3** the variations of $c_\sigma$ and $C_N$ for the pulsate testing cycle $\sigma_o = \sigma_t = \sigma_i$, corresponding to the average pressure $p_m$. It may be observed that if $c_\sigma$ is increasing, $C_N$ is decreasing. In the same time, the increasing of $p_m$ has a non-favorable influence about the life-time of wire rope. There is presented in Fig. **4** the variation of $C_N$ function of the average pressure $p_m$ between wire rope and wrapping up roll. The parameter $\Delta\varepsilon$ is representing the relative displacement between the layer of wires in contact with the roll and the internal layer located in the near vicinity, divided by the unit of length. There is ascertained a high value of the increasing slope of $C_N$ when increasing the average pressure $p_m$, for high values of $\Delta\varepsilon$.

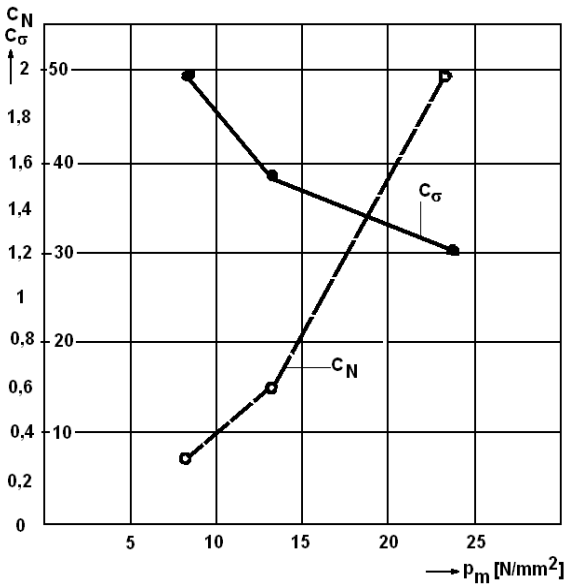



Fig.**3**. The variations of $c_\sigma$ and $C_N$ for the pulsate testing cycle

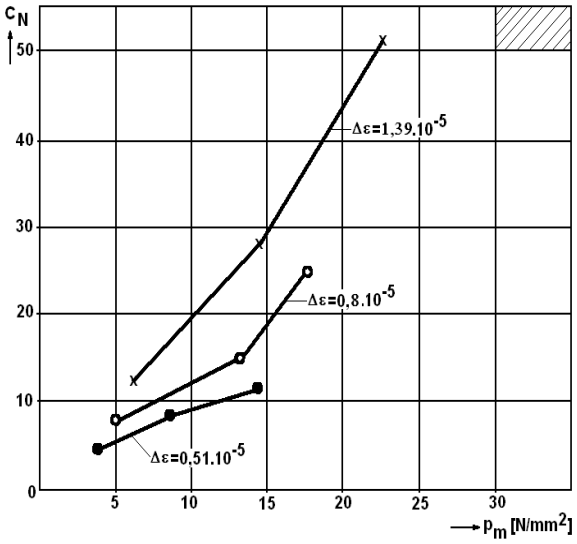



Fig.**4**.The variation of $C_N$ function of the average pressure $p_m$

## 4. CONCLUSIONS

- The life-time of wires belonging to a wire rope is decreasing at increasing of the average pressure between the wrapping up roll and the wire rope. The dependence is valid for bending pulsate loading cycles (Fig. 3), as well for an uneven loading cycle (Fig. 4).
- At constant pressure, the life-time of wire rope is decreasing at increasing of $\Delta\varepsilon$, the relative displacement between the layer of wires in contact with the roll and the internal layer located in the near vicinity (Fig.4). As increase because of the bending loading of wires due to wrapping up and bending of wire rope around the roil.
- Tests performed at frequencies of 30 respectively 40 cycles /minute prove that the destruction process increase when the frequency increase too, going to decreasing the life-time of wire rope. The reason consists in increasing the level of friction force between wire rope and roll because of increasing the angular acceleration. In the same time because of increasing the friction force, there is also increasing the local maximum pressure but is decreasing the elliptical contact surface. Both consequences have a non-favorable influence about the life-time of wires due to increasing the amplitude of contact pressure.
- A strongly increasing of the value of coefficient $C_N$, in case of bending loading cycles, is observed after a comparative analysis between a pulsate cycle (Fig.3) and an uneven cycle (Fig.4). A favorable effect about the life-time of wire ropes is obtained by superposing a compression or a traction stress over a contact compression stress.
- After analyzing the dispersion fields of the number of cycles (the rectangles in Fig.1 and 2) it may be observed the increasing of dispersion when increasing the number of cycles until the appearance of fracture. The explanation consists in the timely cumulative effect of wear. That is because the contact pressure and the bending-traction effects have an

insufficiently importance. The wear is strongly dependent on the friction coefficient between wire rope and wrapping up roll, as well between wires of the same wire rope. So, in order to decrease the level of wear it is necessary to decrease the friction coefficient by using a suitable lubrication. In the same time it is necessary to decrease the starting and the breaking accelerations which have an important influence about the relative sliding between the wire rope and the wrapping up roll.

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# CONSIDERATIONS REGARDING THE TESTING OF ELECTRICAL APPARATUS WITH THE TYPE OF PROTECTION "INCREASED SAFETY"

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**Abstract:**
Increased safety "e" represent a type of protection applied to electrical apparatus in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks in normal service or under specified abnormal conditions.

**Keywords:**
Type of protection, increased safety, type tests

## 1. GENERALITIES

Evaluation and testing of equipments that compose an explosion-proof system, in purpose of certification, is very important considering the existing explosion risk which has to be minimized to ensure peoples health and security, as well as to prevent goods damage and, not in the last instance, to protect the environment.

The type of protection increased safety "e" applies to electrical apparatus with a rated value of supply voltage not exceeding 11 kV r.m.s. a.c. or d.c. Additional measures are applied to ensure that the apparatus does not produce arcs, sparks, or excessive temperatures in normal operation or under specified abnormal conditions.

The principle for the type of protection increased safety is represented by carefully choose of the materials used for construction of such kind of apparatus, assurance of certain clearances and creepage distances in such manner that the probability of a failure to occur and to result an electric arc or spark to be reduced at an acceptable level; as well as to ensure an adequate degree of protection for the apparatus enclosure.

For the certification of electrical apparatus with type of protection increased safety, this should be submitted to type tests and routine tests.

In the type tests category are included the tests to determine the maximum surface temperature (to include the apparatus in a certain temperature class), tests for resistance to impact, dielectric strength test, tests for degree of protection (IP) and, if necessary, tests for thermal endurance to heat and cold, resistance to light, resistance to chemical agents and other tests which are specific for different types of apparatus.

The tests for thermal endurance to heat and cold, determination of surface temperature for luminaries and electric motors; and determination of time $t_E$ for electrical rotating machines now can be done at INCD-INSEMEX. The apparatus needed to run these tests was in part acquired with funds from National Authority for Scientific Research in the Nucleu Program.

### 2.1. Tests for thermal endurance to heat and cold

The thermal endurance to heat shall be determined by submitting the enclosures or parts of enclosures in non-metallic materials, on which the integrity of the type of protection depends, to continuous storage for four weeks at (90 ± 5) % relative humidity at a temperature of (20 ± 2) K above the maximum service temperature, but at least 80 °C.

In case of a maximum service temperature above 75 °C, the period of four weeks specified above shall be replaced by a period of two weeks at (95 ± 2) °C and (90 ± 5) % relative humidity followed by a period of two weeks in an air oven at a temperature of (20 ± 2) K higher than the maximum service temperature.

The thermal endurance to cold shall be determined by submitting the enclosures and parts of enclosures of non-metallic materials, on which the type of protection depends, to storage for 24 h in an ambient temperature corresponding to the minimum service temperature reduced by at least 5 K but at most 10 K.

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Figure1. Control and monitoring panel for climatic chamber Vötsch, type VC 7060

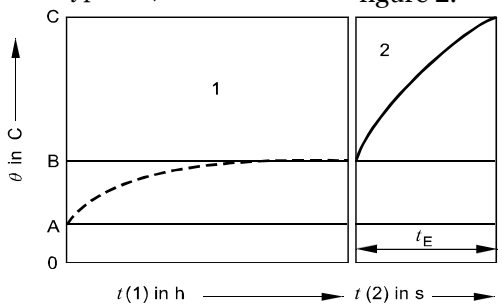
The test rig designed for these tests consists in a climatic chamber Votsch type VC 7060, having a capacity of 0,6 m³, and the temperature can be adjusted in the range -70 ÷ +180 ˚C. The result of test is considered positive if the exposed apparatus shows no deteriorations that affect the type of protection.

**2.2. Test of rotating electrical machines.**

**Determination of time $t_E$**

Time $t_E$ represents the time taken for an a.c. rotor or stator winding, when carrying the initial starting current $I_A$, to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature.

The diagram illustrating determination of time $t_E$ is given in figure 2.




**Key**
*A* Highest permissible ambient temperature
*B* Temperature in rated service
*C* Limiting temperature
*t* Time
*θ* Temperature
1 Temperature rise in rated service
2 Temperature rise during stalled rotor test

Figure 2 – Diagram illustrating the determination of time $t_E$

The temperature rise in stalled motors shall be determined experimentally as follows:

- With the stalled motor initially at ambient temperature, rated voltage and rated frequency shall be applied.
- The stator current measured 5 s after switching on shall be considered to be the starting current $I_A$.
- The temperature rise in the rotor cage (bars and rings) shall be measured by thermocouples and measuring instruments having a small time constant compared with the rate of temperature rise, or by temperature detectors or other means. The highest of the temperatures obtained during these measurements is the one to be considered.
- The average temperature rise of the stator, determined from resistance measurements, is taken as the temperature rise of the winding.
- When the stalled motor test is made at a voltage less than rated voltage, the measured values shall be increased proportionally to the ratio of those voltages, directly for the starting current and according to the square of the temperature rise. Saturation effects, if any, shall be taken into account.

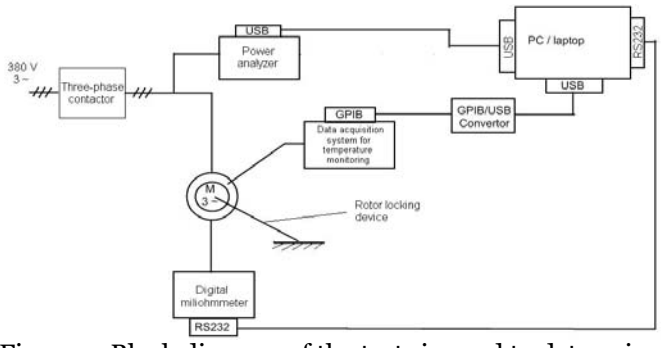



Figure 3. Block diagram of the test rig used to determine time $t_E$

The block diagram for the test rig used to determine time $t_E$ is given in figure 3. To fulfil the test rig the following apparatus was acquired: power analyzer Fluke 435, milliohmmeter Cropico DO5001, data acquisition system Agilent 34970A with thermocouples, laptop Dell Latitude D830.

The role of Fluke 435 power analyzer is to measure and record the important parameters (voltage, current, frequency, power factor, etc.) during the test.

The Cropico DO5001 milliommmeter measure and record the values for the stator winding resistance in cold state and after the test..

The data acquisition system Agilent 34970A with thermocouples is used to measure and monitor temperature during test.

### 2.3. Determination of maximum surface temperature for electrical rotating machines

In order to determine the maximum surface temperature the following apparatus is used: power analyzer Fluke 435, milliohmmeter Cropico DO5001, data acquisition system Agilent 34970A with thermocouples, tachometer Lutron L1236L, laptop Dell Latitude D830.

To determine the maximum surface temperature the following steps should be covered:

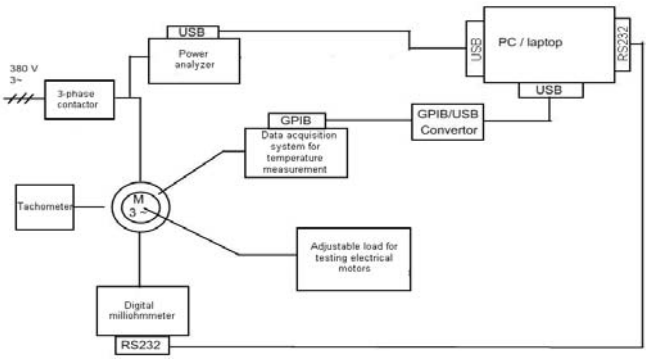



Figure 4. Test rig to determine maximum surface temperature for electrical rotating machines

- build-up experimental mounting according block diagram from figure 4, and connect the electric motor to adjustable load test rig;
- the stator winding resistance is measured and recorded, in „cold" state, with the help of Cropico DO 5001 microohmmeter;
- the thermocouples connected to Agilent 34970A data acquisition system are placed in points considered to be the hottest points during motor running;
- the adjustable load test rig is powered-on and the electric motor is driven on low speed;
- the electric motor is powered-on through a 3-phase contactor;
- the load is adjusted until the motor speed reaches nominal speed (rotation speed is measured with the help of Lutron 1236L tachometer);
- in this configuration, the system will function until the maximum temperature in normal functioning is reached, according SR EN 60079-0 and SR EN 60079-7 (temperature rising is lower than 2 K/ hour);
- after reaching the maximum surface temperature, the motor is powered-off and the adjustable load rig is driven so as to give a quick stop of the motor.
- the stator winding resistance is measured and recorded, with the help of Cropico DO 5001 microohmmeter;

Table 1: Delay time after power-off required to determine temperature in rated service

| Rated power, (kW)/(kVA) | Delay time after power-off, (s) |
|---|---|
| $P \leq 50$ | 30 |
| $50 < P \leq 200$ | 90 |
| $200 < P \leq 5000$ | 120 |

The rotor temperature is measured with thermocouples placed on the rotor through some holes effected in the drive-part shield. Delay time after power-off to determine overtemperature in rated service is presented in table 1.

Temperature and winding resistance recording is made for at least 2 minutes after motor power-off, in reason to set-up the cooling curve for rotor and stator winding.

Data referring to electrical parameters during test (voltage, current, frequency, power factor, etc.) are viewed and recorded through the power analyzer, and transferred to a PC after the test.

The maximum temperature reached in stator winding at rated service is determined with the following formula:

$$\theta_2 = \Delta\theta + \theta_a$$

where

$$\Delta\theta = \frac{R_2 - R_1}{R_1} \times (k + \theta_1) + \theta_1 - \theta_a$$

$R_1$ – winding resistance value in cold state, in Ω;
$R_2$ – winding resistance value in warm state, in Ω;
$\theta_1$ – winding temperature value in cold state, in °C;
$\theta_2$ – winding temperature value after heating test, in °C;
$\theta_a$ - temperature value for the cooling environment (ambient);
k – reciprocal temperature coefficient for resistance at 0 °C for conductive material; k = 235 – for copper; k = 225 for aluminium;
$T_{amb}$ – maximum ambient temperature (generally 40°C);

The maximum surface temperature is determined as the temperature measured in the hottest point of the motor, with the following formula:

$$T_{max} = T_{amb} + \Delta\theta$$

in this case $\Delta\theta$ represents the highest rise of temperature (measured in points where the thermocouples were placed).

### 2.4. Determination of maximum surface temperature for luminaries designed for main supply

In order to determine the maximum surface temperature for luminaries the following apparatus is used: ac power source Kikusui type PCR 1000M, data acquisition system Agilent 34970A with thermocouples, laptop Dell Latitude D830.

To determine the maximum surface temperature of luminaries designed for main supply the following steps should be covered:

- build-up experimental mounting according block diagram from figure 5;
- the thermocouples connected to Agilent 34970A data acquisition system are placed in points considered to be the hottest points during functioning.
- for tubular fluorescent lamps with main supply a diode will be connected in series with the lamp, and the luminaire supplied with a voltage equal to 110% of rated voltage;
- the luminaire is powered-on through Kikusui PCR 1000M ac power supply at voltage and frequency required by standard;
- in this configuration, the all system will function until the maximum temperature in normal functioning is reached (temperature rising is lower than 2 K/ hour). The temperature is monitored by data acquisition system Agilent 34970A with thermocouples;
- when thermal equilibrium is reached the ac power source output of powered-off, and the data corresponding to electrical parameters during test are saved on PC;
- after approximately 1 minute from power-off the ac power source output the temperature recording is stopped and the data is saved on computer;
- the maximum surface temperature is determined with the following formula:

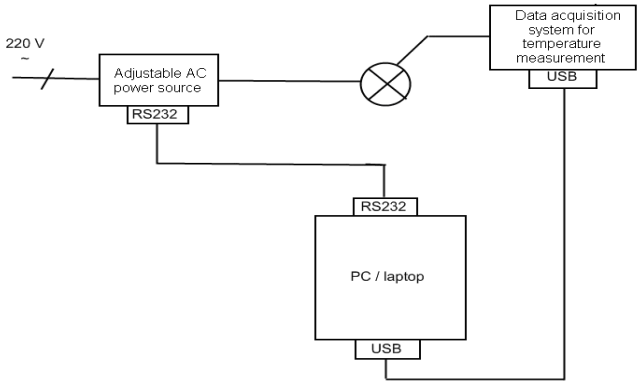



Figure 5. Test rig to determine maximum surface temperature for luminaires designed for main supply

$$t_{max} = t_{inc} + (t_{amb\ max} - t_{amb\ inc})$$

where

$t_{inc}$ – temperature recorded during test (°C) in the hottest spot;
$t_{amb\ max}$ – maximum ambient temperature to which the equipment is designed to work;
$t_{amb\ inc}$ – ambient temperature during test;

- In the end of the test, the temperature should not exceed the temperature specified for the specific temperature class (80 °C for T6, 95°C for T5, 130°C for T4, 195°C for T3). The temperature at the rim of the lamp cap and at the soldering point of the lamp cap shall not exceed the limiting temperature.

## 3. CONCLUSIONS

The purpose of the paper is to underline the new test that can be done at INCD INSEMEX Petrosani for electrical apparatus with increased safety „e" type of protection. These tests are: thermal endurance to heat and cold, determination of surface temperature for luminaries and electric motors; and determination of time $t_E$ for electrical rotating machines. The apparatus needed to run these tests was in part acquired with funds from National Authority for Scientific Research in the Nucleu Program.

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# THEORETICAL AND EXPERIMENTAL ASPECTS REGARDING THE SEALED EFFICIENCY OF DIESEL ENGINES COMBUSTION CHAMBERS

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**Abstract**

In this paper are presented theoretical and experimental aspects accomplished on a diesel engine concerning piston rings dimensioning and verification, hydrodynamic lubrication between piston rings and cylinder and also aspects concerning the elastic pressure. The sealed efficiency of combustion chambers is emphasized through energetic losses and pollution degree for wearing piston rings.

**Key words:**

piston rings, diesel engine, hydrodynamic lubrication, sealed efficiency, elastic pressure

## 1. INTRODUCTION

Along with technical developments, the piston ring, cylinder and piston geometry and construction, together with the corresponding technologies and materials they are made of, were continuously improved. Modern engines are less polluting, operate with higher pressures and temperatures and are more durable. The only fact that has not been changed is the basic function of the piston rings. They provide an adequate compression and reduce the thermal stress of the piston contributing to the exhaustion of a major part of the heat absorbed by it. The piston rings also restrain gases to infiltrate into the crankcase and control the assembly lubrication realizing with cylinder a III group friction connect that provides at the same time the piston assembly direction in its alternative motion.

The selection of piston rings is very important, those being the principal elements of study as they are the ones that together with the piston are executing the translation motion. This is an obligatory condition for hydrodynamic lubrication into the assembly and provides in this way the wear reduction of both elements.

The gases infiltrated behind the lubrication piston ring flow through the exhausted holes of the accumulated oil. Therefore is no longer provided a superior elastic medium pressure in comparison with the one of the compression piston rings. The consumption decreases when the $p_E$ pressure increases as a result of the oil film thickness reduction.

It is estimated that an acceptable consumption can be obtained for a value of film thickness between the piston rings and cylinder less than 2μm. An important influence is exerted by the oval form of the piston coating and by the clearance of the piston into the cylinder.

## 2. THEORETICAL STUDIES ON THE DIMENSIONING AND FUNCTIONAL REQUIREMENTS OF THE PISTON RINGS UP IN THE PISTON RING-CYLINDER

### 2.1. CRITERIA OF FOR CONTROL AND DIMENSIONING PISTON RINGS

The operating requirements of piston rings of any type impose the existence of a adequate maintained in time and at high temperature elasticity, a determined repartition of pressure on the cylinder mirror, its processing in an adequate geometrical form which must provide a sealed position on the operated surface. Besides these basic requirements, a high fiability is necessary. For providing these requirements, the shape of piston rings is a cut ring. The cutting (joint) gives the piston rings elasticity in operation.

At present, for piston rings dimensioning the following objectives must be accomplished:

- The adoption of the medium elastic pressure $p_E$ and pressures distribution;
- The determination of the piston ring basic dimensions, a and h;
- The determination of the piston ring shape in free-state and joint $s_o$, so that to provide the adopted distribution of pressure;
- The verification of tensile stress generated at the piston ring fit and the size of the operating joint;
- The determination of joints from piston ring way;
- The determination of piston rings number.

The study of thermal and lubrication phenomena is very important for the wears and frictions reduction into the piston ring-cylinder connection.

## 2.2. CRITERIA CONCERNING THE DIMENSIONING AND VERIFICATION OF THE PISTON RINGS

The operating requirements of piston rings of any type impose the existence of a adequate maintained in time and at high temperature elasticity, a determined repartition of pressure on the cylinder mirror, its processing in an adequate geometrical form which must provide a sealed position on the operated surface. Besides these basic requirements, a high fiability is necessary. For providing these requirements, the shape of piston rings is a cut ring. The cutting (joint) gives the piston rings elasticity in operation.

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The study of thermal and lubrication phenomena is very important for the wears and frictions reduction into the piston ring-cylinder connection.

### 2.3. Theoretical studies concerning the parabolic shape of piston rings

At present the theoretical and experimental researches on the piston ring-cylinder connection show important progresses on the following directions:

a. The determination of some designing criteria accepted for piston rings and cylinders of internal combustion engines;
b. The elaboration of theoretical models for the lubricated regime;
c. The determination of the influence factors on the wear in the connection and improvement of its elements fiability;
d. The execution of test banks and methodologies for measuring the oil film thickness, friction force, wears and thermal regime in the connection.

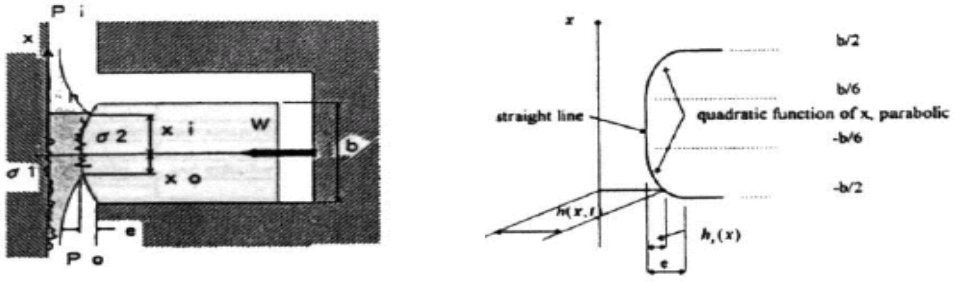



Figure1 The parabolic shape of the piston ring surface

As a general observation, all theoretical studies present the analytical modellation of the piston ring shape as a parabolic one (Fig.1).

## 2.4. CONSIDERATIONS ON THE HYDRODYNAMIC LUBRICATION IN PISTON RING - CYLINDER CONNECTION

As it is known [5], the following conditions are necessary for accomplishing the hydrodynamic regime:
1. The presence of lubricate in the connection;
2. The motion presence on connection surfaces;
3. The presence of a keyway.

If it is taken into account the presence of roughness, it will also appear a fourth condition which shows that for restricting their influence on hydrodynamic flow is necessary that the ratio: $2h_L / (R_{a1} + R_{a2}) > 5$

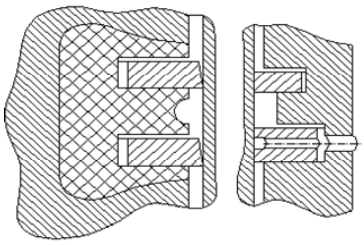



Figure 2 Space buffered of oil accumulation between the piston rings [5]

Where $h_L$ is the lubricate film thickness, and $(R_{a1} + R_{a2}) / 2$ is medium value of elements roughness in the connection.

The latest considerations [5] show that for piston ring-cylinder connection the values bigger than 3 can be acceptable.

A possibility of the consumption reduction $C_{us}$ is the execution of a buffer space of the oil accumulation.

The localization of this space under the first compression piston ring leads to the decrease of the rate of rise of pressure in that area. So, this piston ring is stable on the inferior side and the sealing will be improved. This solution is recommended for small distances between the two piston rings especially when their canals are executed in a piston insertion (Fig.2a).

The buffer space can be executed above the lubricated piston ring by reducing the piston packing leather diameter with no more than 1mm (Fig.2b). So it will be provide a "liquid piston ring" which restrains the oil infiltration to the combustion chamber. It will be obtained a special efficiency that is a sum of many solutions including the forming of piston rings sets to increase the sealing.

## 2.5. ELEMENTS REFERING TO THE WORKING PISTONS RINGS BEHAVIOUR CALCULUS

In reality, modifications from the theoretical free shape appear and therefore the distribution is no longer constant because fixing through heating does not remove completely the material tensions.

The pressure distribution is modified in operation because of two causes:
- The piston rings and cylinder are wearing, changing their contact conditions;
- The piston ring is inserted on the cylinder not only by its elastic force but also by the infiltrate gases behind it.

In this case, the pressure is $p=p_E(1+\gamma)$, where $\gamma=p_s/p_E$. These cases are evaluated through relative wear $u_T/a$ of the piston ring external side and the pressure $p_\tau/p$ between the piston ring and cylinder after a period of time $\tau$. By noting with $\overline{p_\tau}$ the medium pressure after $\tau$, it will be obtained the adjusted pressure:

$$\overline{p_\tau} = p + (\overline{p}_\tau - p_\tau) \quad (1)$$

The construction conditions need for a certain distribution an analytical expression of the piston ring pressure which is due to its own elasticity $p_{E\psi}$ determined by $\psi$ angle (Fig.3).

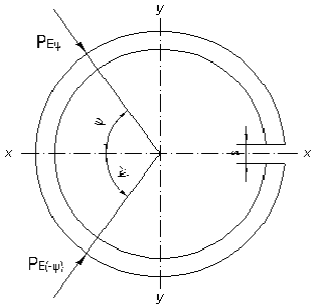



Figure 3 Diagram for the pressure developed by the piston ring

Because $p_{E\psi}$ is a periodic function with $2\pi$ period (the angle $\psi$ variation is between $-\pi$ şi $\pi$), its development is used in Fourrier series, so:

$$p_{E\psi} = p_0 + p_1 \cdot \cos\psi + p_2 \quad (2)$$

$$p_{E\Psi} = p_o + p_1 cos\,\Psi + \ldots + p_n cos n\Psi + q_1 sin\,\Psi + \ldots + q_n sin\, n\Psi \quad (3)$$

where $p_o, p_1 \div p_n, q_1 \div q_n$.are constant.

Related to x-x axis which passes through the middle of the joint, the piston ring load is symmetrical. Therefore $p_{E\psi}$ is an even function - $p_{E\psi} = p_{E(-\psi)}$ so the condition $q_1=q_2=\ldots=q_n=0$ is satisfied.

Under the peripheric pressure action the piston ring is in equilibrium which means that the pressures resultants on the two axis are null. The loading symmetry nullifies the resultant on the y-y axis.

$$- p_{E\Psi} cos(\Pi/2 - \Psi) = p_{E(-\Psi)} cos[-(\Pi/2 - \Psi)] \quad (4)$$

The equilibrium condition on the x-x axis is:

$$\int_0^{\pi} p_{E\psi} \cos\psi d\psi) = 0 \quad (5)$$

Because: $\int_0^{\pi} \cos\psi d\psi) = 0$; $\int_0^{\pi} \cos^2\psi d\psi) = \frac{\pi}{2}$; $\int_0^{\pi} \cos\psi \cos n\psi d\psi) = 0$;

This condition is accomplished if the second term is null meaning $p_1=0$.

The $p_{E\psi}$ pressure is expressed depending on the medium elastic pressure:

$$p_E = \frac{1}{2\pi}\int_0^{2\pi} p_{E\psi} d\psi = \frac{1}{2\pi}\left(p_0 \int_0^{2\pi} d\psi + p_2 \int_0^{2\pi} \cos 2\psi d\psi + \ldots + p_n \int_0^{2\pi} \cos n\psi d\psi\right) \quad (6)$$

Because: $\int_0^{\pi} \cos^2\psi d\psi) = 0$, $p_E=p_o$, is obtained, and the expression of the piston ring developed pressure results as:

$$p_{E\psi} = p_E\left(1 + \sum_{n=2}^{\infty} \nu_n \cos n\psi\right) \quad (7)$$

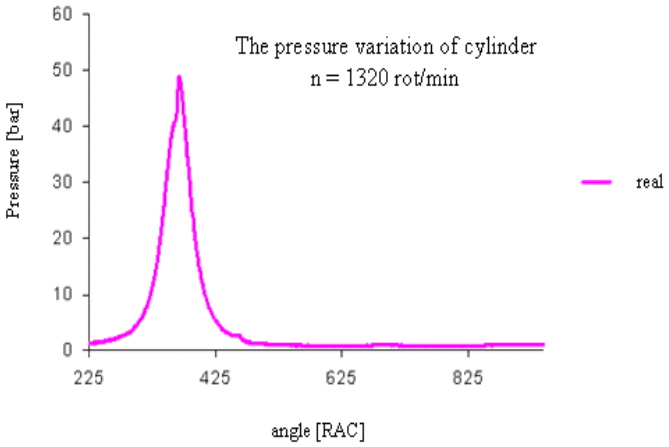



Figure 4 Pressure variations into the cylinder for engine with new piston rings

where $\nu_n = \frac{p_n}{p_E}$

The parenthesis from the relation (7) is the correction coefficient of the medium pressure $p_E$ for variable pressure piston rings.

In practice, a finite number of the sum terms from relation (7) are considered. Because this sum is rapid convergent, the number of terms taking into account up to 2n=10...12 are limited.

For the M511 diesel engine the cylinder pressure variation with new piston is presented in Fig.4.

## 3. EXPERIMENTAL DATA ON THE EVOLUTION IN TIME OF PISTON RINGS PERFORMANCES

Experimental research aims to study the behavior in service of the combustion chamber engine of the diesel engine M-511. There was studied the losses through non-sealing by using a device to vary the pressure in the combustion chamber.

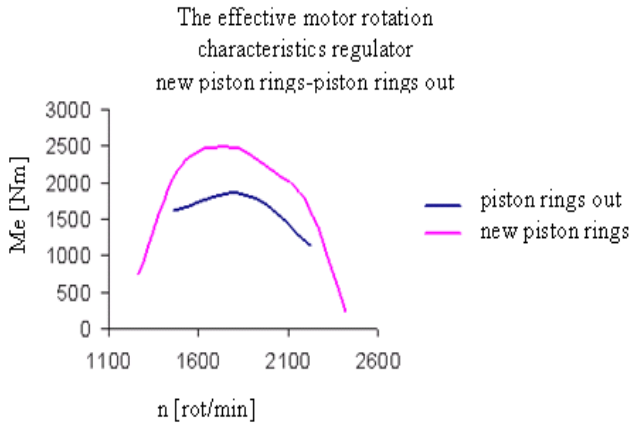



Figure 5 Variation of the effective rotation moment obtained for the new piston rings compared with wearing out ones

The efficiency of sealing the combustion chambers is revealed by energetic losses in the wearing out piston rings. In Fig.5 is presented the variation of the effective rotation moment obtained on the regulator speed characteristics of the engine equipped with new piston rings and wearing out piston rings.

In order to evaluate the evolution of wearing out both in the new and wear out piston rings case there were determined the energetic parameters for engine speed of 2200rpm obtaining on the engine regulator speed characteristics for partial load (Fig.6).

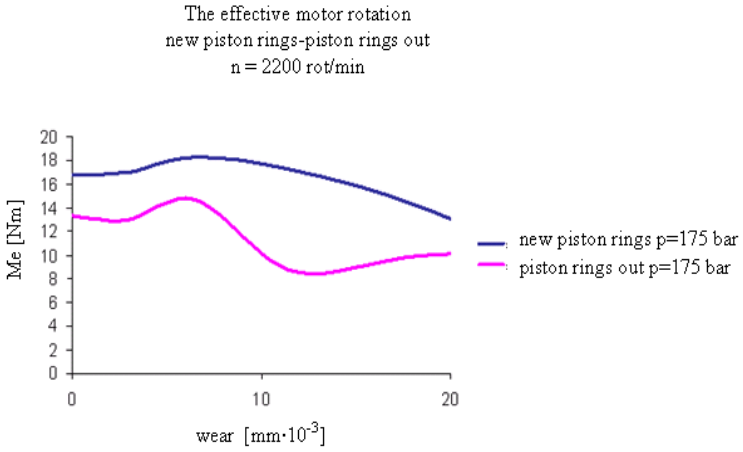



Figure 6 The effective rotation moment, new and wear out piston rings at constant engine speed

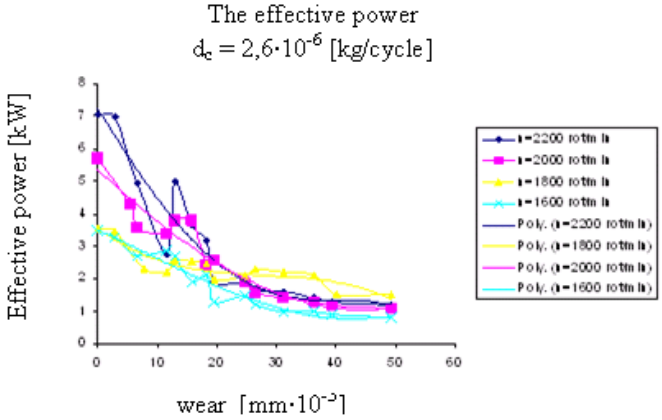



Figure 7 The effective power variation at the same engine speed and cyclical dose depending on wear out

## 4. CONCLUSIONS

The fuel mixture formation in the combustion chamber has a very important role on the combustion consequences and the on the energetic performances, but especially on pollution ones. Because of the losses of the combustion chamber, which are due mostly to the elements of the combustion chambers wear out, a reduction possibility of these effects would be that certain functional parameters to be modified so that the engine performances to be restored.

The effective power variation at the same engine speed and cyclical dose depending on wear is presented in Fig.7.

By knowing the losses evolution due to the wear out of the combustion chamber depending on the engine parameters (speed, power, fuel consumption, smoke degree), there can be made adjustments on the engine functional or constructive parameters in order to compensate these losses.

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# EXPERIMENTAL DETERMINATION OF THE MECHANICAL STRESSES ON THE WARM ROLLING CYLINDERS

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**Abstract**:
The rolling mills cylinders are apply to thermo-mechanical stresses that are variable, complex, with extremely marked influences. Therefore, to intensify the rolling processes we need to observe the durability limits. To this purpose it is necessary to know the type of stress, the materials, and a detailed characterizes evaluation, to determine exploitation timing and to compare with previously established values. The paper presents experimental determinations of the mechanical stresses that take place during plastic deformation in rolling cylinders in exploitation. When being used, the laminating rolls are compared to the thermal tensions that cause thermal fatigue. This fatigue is the main cause for laminating rolls break.

**Keywords**:
experimental, mechanical, stresses, cylinders, fatigue, thermal

## 1. INTRODUCTION

The researches upon the stresses from the hot rolling mill cylinders represent an important scientific theoretical, experimental and economical issue. The calculus of the mechanical tensions which occur inside the laminating rolls are caused by the deformation process during the lamination, and they are the main elements for performing the sizing of the laminating rolls, as well as the main data for the calculus for the sizing of the rolling mill. We believe that the classical methods of rolls' sizing are not appropriate for most of the stages of the rolling process while producing rolls and laminated products.

This observation was remarked in [5] in which at page 489 say: „Although the solicitation of cylinders is a typical case of the variable solicitation, the usual calculus of dimensioning, is based merely on the static solicitation, without bareback is considered the fatigue".

In the book [4] at page 95, the author show: "The resistance of the hot rolling cylinders", with influence of different types tensional in at large, isn't studied" In the works written on this topic, rolling cylinders are calculated at static strains, which are wrongly considered to be constant in time. It is obvious that for the calculus of cylinders body, the determining of diameter based on the static bending moment does not correspond with the real exploitation strain, quite often thermal shocks lead to breakage of cylinders through shearing of caliber bead in the maximal sections. In the classical calculus of the cylinders, the decisive influence of thermal tension – with major effects in the rolling process – is not taken into consideration. Although rolling cylinder strain is a typical case of variable strain, the usual resistance calculus is based only on static strain, without considering the fatigue resistance in sizing the rolls. The replacement of cylinders takes place practically when the diameter is reduced below the minimum limit corresponding to normal wear, [2], [3].

We calculate mathematically the stresses in order to highlight them and to point out the fact that they do not influence the thermal fatigue of the laminating rolls very much, in order to compare them to those stresses caused by thermal influences.

## 2. CALCULATING THE MECHANICAL STRESSES

Nowadays specialized literature refers to the classical calculus methods used for the laminating rolls as, [2], [3], [5]:

- the pane of the rolls is calculated for a static bending;
- the journals of the rolls are calculated for twisting and bending;
- the journal blades are calculated for twisting tensions, meanwhile the blade is calculated for twisting and bending.

Forces acting on cylinders in rolling resistance classical calculation are presented in fig.1.

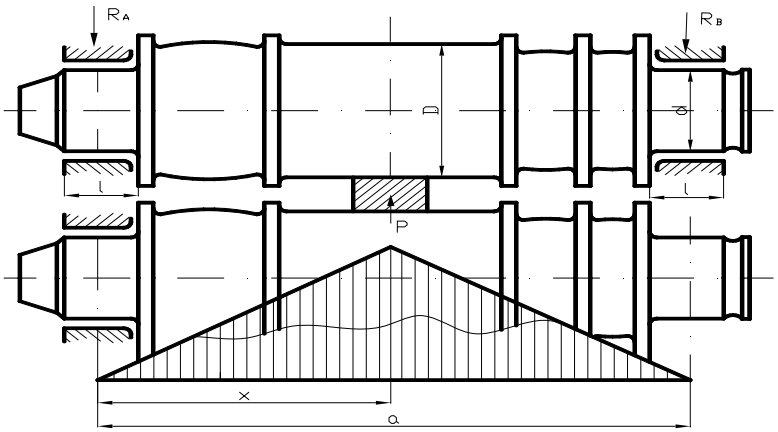



Figure 1. Representation of forces acting on cylinders rolling for the calculation of classical resistance

Nevertheless, we should note that the static stress we have considered for calculating the laminating rolls have not been too accurate as for time constant. The values of these „classic" tensions are determined in order to compare them to other tensions caused by temperature fields, [1].

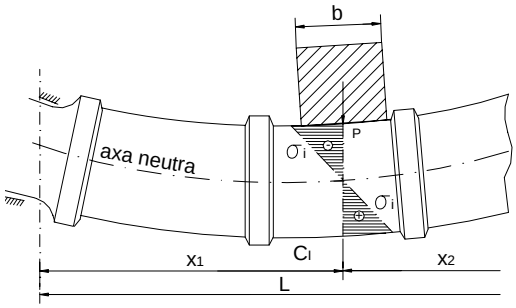



Figure 2. Roll stress caused by rotational bending stress

The bending and twisting stresses inside the pane rolls calibres of the laminating rolls are determined very accurately, avoiding any difficulty, according to current specialized literature, fig.2, [5].

According to fig. 2, bending stresses vary within the roll section, mainly in the compression deformation area, and have negative values. In the opposite side, there are only streching stresses whose values are positive.

Bending stress are determined according to the relation (1).

$$\sigma_i = \frac{M_i}{\frac{I_z}{y}} \alpha_k = \frac{M_i r}{\frac{\pi R^4}{4}} \qquad (1)$$

where: $M_i$ – bending moment who stress the roll during the rolling process, considering that the rolling force is does not vary along length, [5].

$$M_i = P\left[\frac{x_1 x_2}{L} - \frac{b}{8}\right] \qquad (2)$$

where: $x_1$, $x_2$ – the distance between the bearing and the axis of the rolled metal-plate; L – the distance between the axis of the bearings; R – the radius of the roll on the rolling gauge; b – the width of the rolling good corresponding shift of size; $\alpha_k$ – shape factor in case of tension concentration on the rolls already subject to calibration; P – the rolling force obtained after experiments (with an oscillograph); r – the distance from the neutral axis inside the radial section of the roll.

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The pane of the rolls is subject to stress and twisting tensions caused by the rolling process. These tensions are determined according to relation (3).

$$\tau = \frac{\alpha_k M_t}{\frac{I_p}{r}} = \frac{M_t}{\frac{R^4}{2r}} \alpha_k \qquad (3)$$

where: $M_t$ – twisting moment equal to rolling time, [5]: $\Delta h$ – a reduced piece of the section, corresponding to the rolling design; r – the radius from the centre of the roll to the surface. The twisting moment is determining with relation (4):

$$M_t = 0{,}5F\sqrt{R\Delta h} \qquad (4)$$

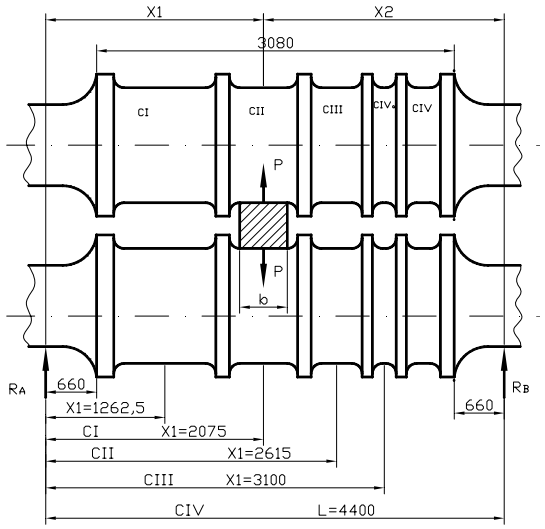



Figure 3. Calculus scheme for the lamination rolls

Twisting and bending tensions are simultaneous inside the roll section. The numerical calculus of these tensions is made for the fibers inside the roll section that correspond to a specific „r" radius.

Contact pressure tensions between the rolling product and the rolls, within the area of deformation, could be determined according to mathematical relations, as well as according to average values of the parameters obtained during the rolling process. In case of a plastic deformation inside the core, we consider that the contact pressure tensions on the surface of the roll gauge are identical to the deformation tensions.

Therefore, we must point out that in case of warm rolling, contact pressure tensions could not be determined according to Hertz Relation, who corresponds only to elastic stress, [2].

If we use the Exelud [2], [3], [4], [5] formula for contact pressure, the tension for the contact pressure is determined according to the relation (5); we use the results of the experiments for specific rolling parameters.

$$\sigma_{pc} = \frac{F_{max}}{B_m\sqrt{R\Delta h}} \qquad (5)$$

where: $F_{max}$ – the highest rolling force; $B_{max}$ – the average width of the rolled goods – the deformation core; $\sqrt{R\Delta h}$ - the length of the contact arc; R – the radius of the rolling gauge; $\Delta h$ – reducing the height of the rolled good during several use.

Fig. 3 describes the mathematical calculus method we have used for determining the twisting, bending, and contact pressure stress within the rolls of the rolling equipment. The rolling gauges are situated on their surface, according to their size, determined by the axis of the bearings. The rolling forces stress the gauges of the 9.2 tonns ingot, according to the rolling scheme for each process during the rolling process. In order to determine the values of the forces, we have used the oscillograph to measure the parameters of the industrial rolling process – we have processed 10 ingots.

The experimental rolling mill is endowed with a plant for the determination of the lamination forces and of the variations of temperature fields in cylinders , which uses the electronic calculus technique, fig.4. The forces of lamination is measured in temporally experimentations of a help installation finded in the endowment rolling mill, in the aim verification of the stress from cylinders in order to subjected to excessive forces, which can produce ruptures or the damage of the rolling mill. In fig.5 presents the montage of tension-meter 1, which takes over half of rolling forces, transmits in bearing holder 3. The tension-meter is located under the axial bearing, lied on the head of the pressure screw 4, in a rigid metallic box, with the steel tie, at the superior cylinder's 5 equilibrate bend, fig.5, [4],[6].

Table 1. The results of the oscillograph analysis for industrial rolling

| No. of stages | Gauge | Rolled good section [mm x mm] | Average rolling time [s] | | $t_{mi}+ t_{ri}$ [s] | Average rolling force $F_m$[kN] |
|---|---|---|---|---|---|---|
| | | | Time $t_{mi}$ | Return time $t_{ri}$ | | |
| 0 | - | 760/830 x 730/800 | - | - | - | - |
| 1 | I | 720 x 730/800 | 0,92 | 2,569 | 3,489 | 8527 |
| 2 | I | 640 x 735/800 | 0,889 | 4,505 | 5,394 | 11021 |
| R | - | 735/805 x 640 | - | - | - | - |
| 3 | I | 700 x655 | 0,928 | 2,099 | 3,027 | 8555 |
| 4 | I | 610 x 680 | 1,174 | 3,030 | 4,204 | 10905 |
| 5 | I | 530 x700 | 1,351 | 2,469 | 3,820 | 11010 |
| 6 | I | 450 x 720 | 1,161 | 6,110 | 7,271 | 10260 |
| R | - | 720 x450 | - | - | - | - |
| 7 | II | 600 x480 | 1,965 | 2,585 | 4,550 | 9582 |
| 8 | II | 500 x505 | 1,614 | 4,812 | 6,426 | 9999 |
| R | - | 505 x 500 | - | - | - | - |
| 9 | I | 390 x 525 | 1,496 | 2,546 | 4,042 | 65543 |
| 10 | I | 330 x 545 | 1,526 | 5,540 | 7,066 | 7621 |
| R | - | 545 x 330 | - | - | - | |
| 11 | IV | 430 x355 | 2,297 | 2,257 | 4,554 | 8410 |
| 12 | IV | 350 x 375 | 4,349 | 6,114 | 10,463 | 8682 |
| R | - | 375 x 350 | - | - | - | |
| 13 | III | 280 x 380 | 2,297 | 11,183 | 13,945 | 6927 |
| The total value of the average rolling cycle of a 9.2 tonns ingot 78,251 s = 1,304 minutes | | | | | | |



Figure 4. The assambly of experimental rolling mill

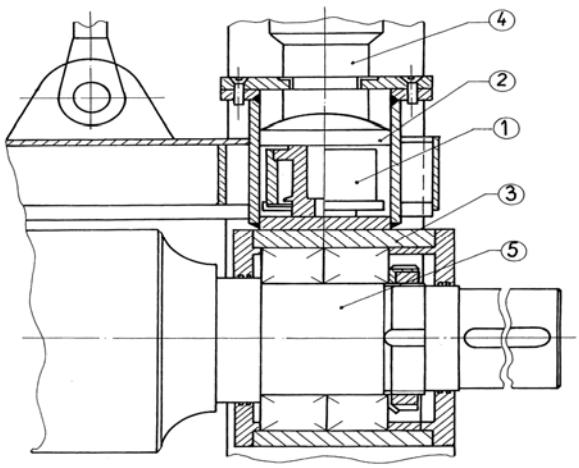



Figure 5.The tensiometer's montage with resistive traductors

The numerical calculus of stress caused by bending stress according with relation (1) is presented in table 2. The numerical calculus of stress caused by bending stress according with relation (3) is presented in table 3.

The process of stresses determination, when tensions are caused by the contact pressure, according to relation (5), corresponds to the result on the contact surface between the rolled good and the rolls. The numerical calculus has been performed according to new characteristic parameters, used for industrial rolling of 9.2 tons ingots – as in table 4.

Determination of stress caused by contact pressure by the relationship (5) corresponds to the effect of surface contact between laminate and cylinders. Calculations made after the parameters resulting from the characteristics of industrial rolling ingots of 9.2 tons are presented in table 5.

Table 2. Calculating the contact bending stresses on the roll surface

| No. of stages | Gauge | Rolled good section [mm x mm] | Gauge radiu R [mm] | Coef $\alpha_k$ | Bending stresses [daN/mm²] | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $\sigma_0$ $\Delta r = 0$ | $\sigma_1$ $\Delta r = 1{,}5$ | $\sigma_2$ $\Delta r = 3$ | $\sigma_3$ $\Delta r = 6$ | $\sigma_4$ $\Delta r = 9$ |
| 0 | - | 760/830 x 730/800 | - | - | - | - | - | - | - |
| 1 | I | 720 x 730/800 | 620 | 1,39 | 5,09 | 5,08 | 5,07 | 5,04 | 5,02 |
| 2 | I | 640 x 735/800 | 620 | 1,39 | 6,91 | 6,57 | 6,55 | 6,52 | 6,49 |
| $R_s$ | - | 735/805 x 640 | - | - | - | - | - | - | - |
| 3 | I | 700 x 655 | 620 | 1,39 | 5,21 | 5,19 | 5,18 | 5,16 | 5,13 |
| 4 | I | 610 x 680 | 620 | 1,39 | 6,63 | 6,61 | 6,59 | 6,56 | 6,53 |
| 5 | I | 530 x 700 | 620 | 1,39 | 6,66 | 6,64 | 6,63 | 6,60 | 6,56 |
| 6 | I | 450 x 720 | 620 | 1,39 | 6,18 | 6,17 | 6,15 | 6,12 | 6,09 |
| $R_s$ | - | 720 x 450 | - | - | - | - | - | - | - |
| 7 | II | 600 x 480 | 592,5 | 1,39 | 8,55 | 8,53 | 8,51 | 8,47 | 8,42 |
| 8 | II | 500 x 505 | 592,5 | 1,39 | 8,55 | 8,53 | 9,51 | 8,47 | 8,42 |
| $R_s$ | - | 505 x 500 | - | - | - | - | - | - | - |
| 9 | I | 390 x 525 | 620 | 1,39 | 4,26 | 4,05 | 4,04 | 4,02 | 4,00 |
| 10 | I | 330 x 545 | 620 | 1,39 | 4,49 | 4,48 | 4,47 | 4,45 | 4,42 |
| $R_s$ | - | 545 x 330 | - | - | - | - | - | - | - |
| 11 | IV | 430 x 355 | 605 | 1,40 | 5,91 | 5,89 | 5,88 | 5,85 | 5,82 |
| 12 | IV | 350 x 375 | 605 | 1,40 | 6,02 | 6,07 | 6,05 | 6,02 | 5,99 |
| $R_s$ | - | 375 x 350 | - | - | - | - | - | - | - |
| 13 | III | 280 x 380 | 600 | 1,40 | 5,80 | 5,78 | 5,77 | 5,74 | 5,71 |

Tabelul 3. Calculation of winding tension for all crossings of a rolling cycle of Lingo 9.2 tonnes at depths $r_i$

| No. of stages | Gauge | Rolled good section [mm x mm] | Gauge radiu R [mm] | Coef $\alpha_k$ | Tensions of twisting [daN/mm²] | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $\tau_0$ $\Delta r = 0$ | $\tau_1$ $\Delta r = 1{,}5$ | $\tau_2$ $\Delta r = 3$ | $\tau_3$ $\Delta r = 6$ | $\tau_4$ $\Delta r = 9$ |
| 0 | - | 760/830 x 730/800 | - | - | - | - | - | - | - |
| 1 | I | 720 x 730/800 | 620 | 1,52 | 1,80 | 1,80 | 1,80 | 1,80 | 1,78 |
| 2 | I | 640 x 735/800 | 620 | 1,52 | 1,99 | 1,98 | 1,98 | 1,97 | 1,96 |
| $R_s$ | - | 735/805 x 640 | - | - | - | - | - | - | - |
| 3 | I | 700 x 655 | 620 | 1,52 | 1,77 | 1,76 | 1,76 | 1,75 | 1,74 |
| 4 | I | 610 x 680 | 620 | 1,52 | 2,09 | 2,08 | 2,08 | 2,07 | 2,06 |
| 5 | I | 530 x 700 | 620 | 1,52 | 1,99 | 1,98 | 1,98 | 1,97 | 1,96 |
| 6 | I | 450 x 720 | 620 | 1,52 | 1,85 | 1,84 | 1,85 | 1,83 | 1,82 |
| $R_s$ | - | 720 x 450 | - | - | - | - | - | - | - |
| 7 | II | 600 x 480 | 592,5 | 1,54 | 2,40 | 2,39 | 2,40 | 2,38 | 2,37 |
| 8 | II | 500 x 505 | 592,5 | 1,54 | 2,29 | 2,28 | 2,28 | 2,27 | 2,25 |
| $R_s$ | - | 505 x 500 | - | - | - | - | - | - | - |
| 9 | I | 390 x 525 | 620 | 1,52 | 1,38 | 1,38 | 1,38 | 1,37 | 1,36 |
| 10 | I | 330 x 545 | 620 | 1,52 | 1,19 | 1,18 | 1,18 | 1,18 | 1,76 |
| $R_s$ | - | 545 x 330 | - | - | - | - | - | - | - |
| 11 | IV | 430 x 355 | 605 | 1,51 | 1,92 | 1,91 | 1,91 | 1,90 | 1,89 |
| 12 | IV | 350 x 375 | 605 | 1,51 | 1,64 | 1,64 | 1,64 | 1,63 | 1,62 |
| $R_s$ | - | 375 x 350 | - | - | - | - | - | - | - |
| 13 | III | 280 x 380 | 600 | 1,55 | 1,47 | 1,46 | 1,46 | 1,45 | 1,44 |

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Table 4. Calculation of pressure stress on the contact surface of rolling cylinders in the area of hole deformation

| No. of stages | Gauge | Rolled good section [mm x mm] | Gauge radius R [mm] | Reduction Δh[mm] | Average width $B_m$[mm] | Tension $\sigma_{pc}$ | |
|---|---|---|---|---|---|---|---|
| | | | | | | $\sqrt{R\Delta h}$ | $\sigma_{pc}$ [daN/mm²] |
| 0 | - | 760/830 x 730/800 | - | - | - | - | - |
| 1 | I | 720 x 730/800 | 620 | 40/110 | 765 | 261,1 | 4,26 |
| 2 | I | 640 x 735/800 | 620 | 80 | 767 | 222,7 | 6,46 |
| R | - | 735/805 x 640 | - | - | - | - | - |
| 3 | I | 700 x655 | 620 | 35/105 | 640 | 255,1 | 5,23 |
| 4 | I | 610 x 680 | 620 | 90 | 655 | 236.2 | 7,04 |
| 5 | I | 530 x700 | 620 | 80 | 682 | 222,7 | 7,24 |
| 6 | I | 450 x 720 | 620 | 80 | 707,5 | 222,7 | 6,51 |
| R | - | 720 x450 | - | - | - | - | - |
| 7 | II | 600 x480 | 592,5 | 120 | 467,5 | 266,6 | 7,68 |
| 8 | II | 500 x505 | 592,5 | 100 | 497,5 | 243,4 | 8,25 |
| R | - | 505 x 500 | - | - | - | - | - |
| 9 | I | 390 x 525 | 620 | 115 | 514 | 267,0 | 4,76 |
| 10 | I | 330 x 545 | 620 | 60 | 536,5 | 192,8 | 7,36 |
| R | - | 545 x 330 | - | - | - | - | - |
| 11 | IV | 430 x355 | 605 | 115 | 342,5 | 263,7 | 9,30 |
| 12 | IV | 350 x 375 | 605 | 80 | 362,5 | 220,0 | 10,88 |
| R | - | 375 x 350 | - | - | - | - | - |
| 13 | III | 280 x 380 | 600 | 95 | 365 | 238,7 | 7,94 |

## 3. RESULTS

According to the analysis of the twisting, bending, and contact pressure tensions we have already highlighted in Tables no. 2,3,4:

- the bending tensions (table 2) are the highest in case of the outside layer and go deep to 15-20 mm underneath the surface of the gauge; the highest values are $\sigma_I$ = 8,55 daN/mm², and they grow smaller as they get closer to the core of the gauge. By the time they reach its axis, they are null.
- the twisting tensions (table 3) produced during the rolling (rolling time) have higher values. The highest value is $\tau_I$ = 2,29 daN/mm² at the surface of the gauge. Thus, these tensions could be ignored. But still, we have to point out the general rule for determining the tensions inside the roll, where they get more and more small; and by the time they reach the axis they are null.
- other tensions caused by stress and contact pressure (table 4) influence only the surface of the gauges, in the area of the deformation core, and their highest value is $\sigma_{pc}$= 10,88 daN/mm².

Generally speaking, we could point out that mechanical tensions we have used for classical resistance calculus for the rolling process have insignificant values. These calculations are not valid in case of real industrial processes. If we consider the thermal tensions, we would be able to come up with a complete study about the genuine industrial process situations, because thermal influences are the main cause for thermal fatigue in case of lamination rolls. Those influences are also valid in case of favorable operation conditions when we use the lamination rolls.

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# THE USAGE OF TYPE SILIUMINIU ALLOYS WITH MAGNESIUM FOR CASTING A VERY LARGE USED PIECES

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**Abstract:**
ATSi7Mg aluminum alloy is subjected to the processes of hardening and aging. The structural transformations are related mechanical properties of the alloy. The prezence of the Mg2Si phase is the main cause of increasing resistance of alloys Al-Si-Mg, but with the presence of stable phase $Mg_2Si$ reduces refractivity of ternary alloys.

## 1. INTRODUCTION

Among the advantages of alloys siluminium $ATSi_{12}$; $ATSi_{10}MnMg$; $ATSi_7Mg$; $ATSi_7MgTi$ is the used in humid atmosphere like maine atmosphere As the concentration of Si growth there is a decrease of the linear thermal expansion coefficient, but to obtain a raft structure raft in the cast [1] [2] [4] [5] [6] (the material is fragile and difficult to process).

For finishing the structure, increase the mechanical resistance and improve mechanical machining by cutting of type AAT siluminium (hipo and eutectic) is added to Na and Cl and salts containing F and Na, S, P, etc.. in the alloy. The hypereutectic alloys have much $Si_I$ in the structure and is difficult to be modified with salts containing Na. A greater effect in modifying these alloys siluminiu hypereutectic is obtained with substances containing S or P [6] [7] [8] [9].

## 2. SYSTEM ALLOYS IN AL-SI + EA (ALLOING ELEMENTS)

System Al-Si alloys + Ea is one of most used in the casting aluminum alloy of great importance pieces because it possess superior mechanical and technological proprieties than other cast aluminum alloys (AAT).

The most typical alloy system Al-Si-Mg is widely used in casting of $ATSi_7Mg$ (6-8% Si, 0.25-0.4% Mg, the rest). This alloy is used both in the hardening state (T4) and after partial aging (T5). Is is used for castings pieces with thin walls and complex shapes used in the condition of medium loaded forces (body pump, etc.). The advantages of alloy ATSi7Mg are: good casting properties (high fluidity, minimum linear contractions) like as $ATSi_{12}$; the tendency of formation of small cracks hot high temperature; good mechanical strength and satisfactory plasticity; compared with ATSi10MnMg not require autoclaves to pressure crystallization; is the possibility to used modifier containing Na as S, P, etc.[2]; Like disadvantages $ATSi_7Mg$ shows: reduced machining by cutting; with increasing concentration of Mg decreases plasticity (mechanical $R_m$ increases and the capability of machining); resistance to corrosion from $HNO_3$ ; reduced refractivity, which may increase with increasing concentration of Si, Mg or Cu.

The hardening basic phase of ternary alloys is $Mg_2Si$ noted as β', the type chemical intermetalic component (determined by normal valence). Possess crystalline elementary cube network and does not form solid solutions α with its constituents, what is characteristic ionic combinations in contrast with benthonic phases type (ex: $Mg_2Al_3$).

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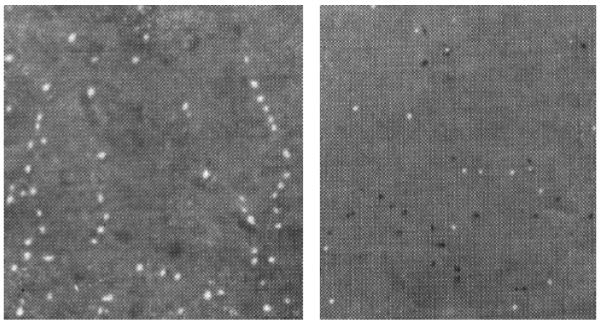



Fig. 1 Structure of alloy $ATSi_7Mg$ (10000:1) aged a-135 °C/15 h and b- a-135 °C/15 h

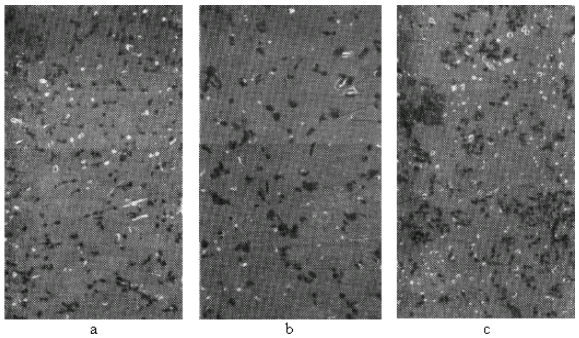



Fig.2 Structure of alloy $ATSi_7Mg$(10000:1) aged a-165 °C in times:a15h b-25h, c-100h

Regarding the influence of Si and Mg on the effect of loss of mechanical resistance of alloys Al + Mg + Si at high temperatures [5], [6], [2], [8] ,it shows that the decomposition of α solid solution of Mg and Si in Al folow the next schedule:

1. Appear in the crystal network of solid solution the Guillet-P zone. There is a change to approaches atoms of Si and Mg and formation of metastabile β' phase; ($Mg_2Si$) - the process is very intense at high temperatures and slow at ambient temperature. Reset of atoms position had place with the distortion is strong crystalline network and consequently there is as result strong growth mechanical resistance of siluminium type alloys at ambient temperature and reducing refractivity of temperature used in aging process (160-1700C and higher).
2. There are a formations of small grains mono-and two-dimensional phase metastabile β'($Mg_2Si$) which possess crystalline hexagonal network. It is believed that the training phase $Mg_2Si$ is the main cause of increasing resistance of alloys Al-Si-Mg, but with the apparition of stable phase $Mg_2Si$ the refractivity ternary alloys will be reduce .This clear happened at heated at 170-180°C retention time of 25h to return treatment.
3. Stable phase $Mg_2Si$ is formed in alloys type siluminium in process to maintain at 185-220°C for several hours and at 300°C for 30 minutes to aging, with strong reduce resistance of alloy.

The alloy aging process at 180-225°C with reduced times of process can provide for ATSi7Mg alloy high strength and low plasticity. Refractivity of these alloys can be strong increased by two ways:

- It strengthens the solid solution α by a complex process of alloying which assure the separation of the granular stable phases crystallized in form of branches
- make an bonding of Si free (elementary) in the stabile component ($Al_8Si_6Mg_3Fe$, $Al_4Si_2Fe$, $Al_5SiFe$ etc.) An example of these components is phase $Mg_2Si$ which is found in most siluminiu alloys ($ATSi_{12}$, $ATSi_7Mg$, etc.)

$Mg_2Si$ phase is formed through a series of transformations that strongly distorts the crystalline network of alloy and increases the mechanical resistance at ambient temperature (due to hardening and aging processes).

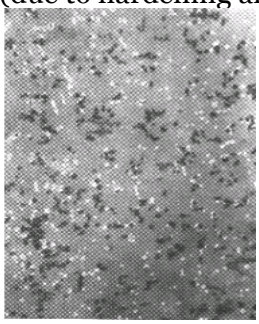


Fig. 3 Structure of alloy $ATSi_7Mg$ (10000:1) aged a-175 °C/10 h

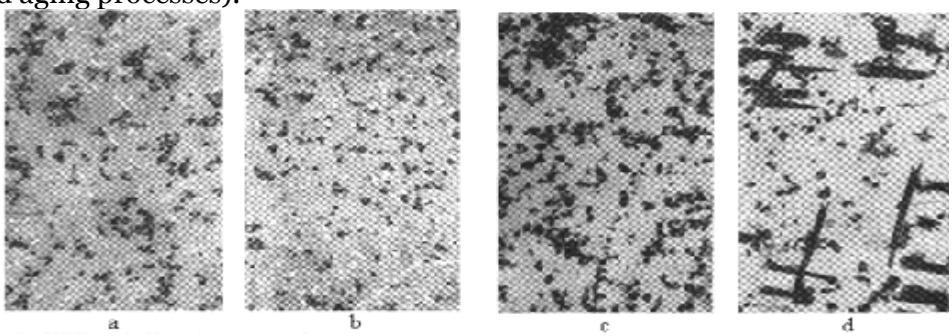



Fig. 4 Structure of alloy $ATSi_7Mg$(10000:1) aged:a-185 °C /15h , b-200 °C /10h, c-300 °C /10h, d-300 °C /100h.

## 3. INTERPRETATIONS

In work [8], [9] it shows that the ternary alloy system Al-Si-Mg, were first observed in aluminum matrix areas which characterize stages of ante-separation. There not was established neither by X-ray observations the differences in areas structure for aging alloys. Despite lack evidence of structural changes, increased of mechanical properties of ternary alloys is a fact. Only at a temperature of 150°C authors [9] in 1958 established that the separation distributed locally of Mg and Si take place.

It is believed (with network vacancies which are formed during the hardening process ) atoms of alloying elements Ea begin to be collected in the chains without any order, after which the atoms slowly sits in an order determined the by network parameter (4.04 Å) and the chain gets the same format with the elementary cell of the matrix. At high temperatures the atoms of Ea formed construction areas least different of the matrix. It shows [9] that this phase β" move gradually in the phase β' rebuilding the crystalline matrix is accompanied by a strong distortion which is the main cause of increasing the mechanical properties of alloys siluminium. But such a tensioned state of the crystalline network helps to reduce refractory of alloys. This is observed as a strong fact, in changing the structure of $\alpha$ solid solution alloy type $ATSi_7Mg$ at 165 ° C in the ageing process where the decomposition of $\alpha$ solid solution takes place relatively quickly.

Figure 1shows the solid solution alloy $ATSi_7Mg$ in which ageing at 135 °C for 15 hours produce formation and deposition of fine dispersed elemental Si [5].In addition to this Si there are deposits in the form round (white points) probably the Guillet areas or how to say „phase" β" .

We say that such products of the decomposing solid solution which is formed as chains in the alloys Al-Mg-Si is characteristic for the initial stage of aging. The structure of $ATSi_7Mg$ aged at 150 °C for 15 h (Figure 1.b) confirms the words [16].

At higher temperatures the return process and the size of elementary high dispersed Si particles and a separation (white point) increase dramatically. (Figure 2). Structure of $\alpha$ solid solution after aging for 15 and 25 h (Figure 2 a, b) at 165 °C has many deposits of Si and formation of β" metastabile phase, and even the stable phase $Mg_2Si$ (fig. 2 c)

From Figures 2 and 3 it is clear that with increasing aging temperature there is the decomposition of solid solution $\alpha$ is very intense and is formed by deposition metastabile phases that increase substantially with aging time. Very intense decomposition α solid solution had place at 175 °C with the maintenance of 10 h.

The figure 4 shows a large amount of fine and small and many particle high dispersed portions of $Si_I$ (primary) that were formed after reset the network. Particles $Mg_2Si$ (in the form of narrow white strips) are shown oriented.

Very suggestive is the alloy $ATSi_7Mg$ old aged at 185 °C for 15 h (Figure 1 a). But I clearly see this in Figure 1 b $\alpha$ solid solution decomposition at the aging temperature of 200 °C, virtually ends after 10h. This produce reduced resistance of alloy $ATSi_7Mg$ at temperature of 200 °C.

## 4. CONCLUSIONS

Technological processes of casting under pressure are widespread in the industry. The process ensures a quality cast alloy type siluminium such as good walls and lack risk of mechanical cracks at hot state and cold state. The proprieties of cast alloys type siluminium can be improved by thermal treatment named artificial aging. There are many ways to make these treatments. These have resulted in changing the structure of alloy, with the apparition $Mg_2Si$ phase (composed intermetalic component). This has an effect to increase mechanical resistance.

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# STUDIES AND TESTS CONCERNING SMELTING CASTING ALLOY OF UNIVERSAL ALUMINIUM

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**Abstract**

The direct consequence use on a major scale a silumin alloy type at casting pieces which working at high temperatures, e.g. thermal engine pistons, is: finding, smelting an alloy that possess good mechanical and technological properties, with preservation of those properties for a long time. The most recommended are Al-Si alloys type, allied with addition agent (Ea) such as Cu, Mg, Mn, B, Ti, Cr, etc. Large used alloys are AT$Si_9Cu_2$MgB and AT$Si_{10}$MgMn but with the shortcoming technology and mechanical properties, has been necessary to find a "universal" cast alloy that has proven to be AT$Si_9Cu_3$MgMnB, which is studied in this paper and responded well to the demands of constructors and technologists requirements of the non-ferrous foundries.

**Key words:**

alloy, aluminium, thermal engine, pistons, casting

## 1. INTRODUCTION

In automotive industry is good to have a cast aluminium alloy (AAT) which correspond to the requirements of foundries technology, to have high mechanical strength both at ambient temperature and at high temperatures (resistance duration), dimensional stability over time, regardless of operating conditions, etc.

For developing (creating) a new alloy (made of AAT), with high technological and mechanical proprieties called UNIVERSAL DESTINATION Alloy, the basis for it had in mind the following considerations [1]....[4]:

1. Si content should be around 8-10%, to ensure high casting properties, which allow casting of PT by any method (in FAF, in shell, with lost models (fusible), centrifugal, under low or high pressure, etc.) without appear casting cracks.
2. Solid solution α must have a high quality of supersaturate in Ea, to allow during the aging process to obtain a high density of ultra-dispersed particles (micro-heterogeneousness) inside s.s.α grains. This allows achieving high flow limits and mechanical resistance.
3. Alloy components -Ea- and inclusion, in the alloy crystallization should not form particles occur on the separation of the s.s.α. [5]...., [7].

Following research [1], [2] developed a new alloy cast in AAT, which possesses a chemical composition (8-11%Si; 3-4%Cu; 0,13-0,35%Mg; 0,1-0,3%Mn; 0,01-0,1B; 0,4%Fe, rest aluminium) and notes ATSi9,5Cu3MgMnB. Alloy has received a fast use at casting the various PT. In figure 1 (2.78) is shown typical PT, cast of this alloy, pieces that once was made by plastic deformation with very high costs.

To note that the proportion of Mg and Cu content in this alloy is other compared to AT$Si_9Cu_2$MgB. That alloy has characteristics of resistance much higher, both at ambient temperature and at higher temperatures. The complex configuration of PT and walls thickness, and the operation of the PT must be considered on load composition of the alloy development. As before, the highest is Si content (but Si<12%), the greater is eutectic quantity, this means that has highest properties of casting and PT hermetically. However,

with increasing Si content of alloy increases the tendency towards abortion gas, therefore PT is formed in a high porosity. For casting the complexity PT (complex configuration), with wall thickness 3-4mm is sufficient for the load to be 9% Si.

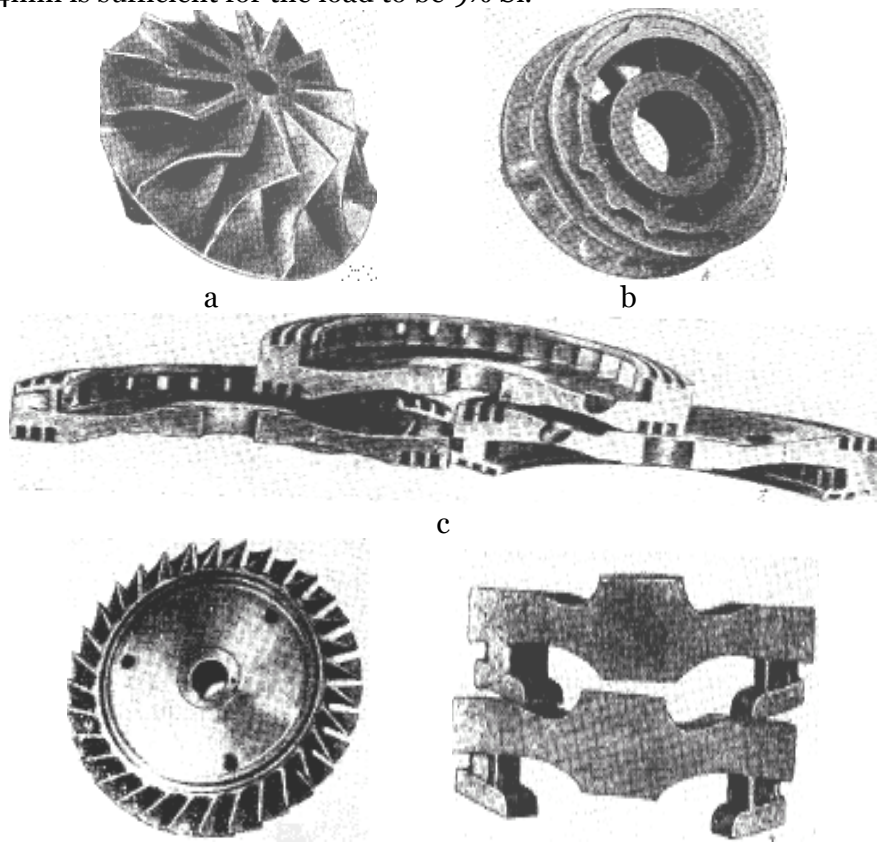


Fig.1 Pieces of great complexity cast of polynar alloy $ATSi_{10}Cu_3MgMnB$:
a- centrifugal; b- precision; c- section of the turbine body; d- Precision; e- Shell (microstructure)

With increasing content of Cu, refractory alloy increases, but plasticity (A) decreases at ambient temperature. If the PT in this alloy is intended to work long time at high temperatures the content that should be at upper limit, and if working at ambient temperature, then at lower limit.

The increasing of Mg content leads to increase refractory alloy, but decreases plasticity at ambient temperature. To increase plasticity, in PT, the content of Mg should be kept at the lower limit, same for Fe content. In this situation the content of Mn should be 0.8% and the content of Fe = 0.2-0.3%.

If PT is accomplished by stamping of semi liquid state, then permitted Fe inclusion even 0.4%. This has a great technical and economic meaning, because in the use of Al load (waste) technical with high content of Fe.

Ti and B are introduced in the alloy as modifier.

## 2. $ATSi_9Cu_5MgMnB$ ALLOY STRUCTURE

The alloy $ATSi_9Cu_3MgMnB$ as you can see possesses a complex chemical composition. Depending on the chemical composition fluctuation, Fe content in the PT and the rate of crystallization, phases of the alloy composition may change strongly. Alloy structure in a cast (especially in parts of the massive and high content of Cu) may have the following phases: α, Si, $Mg_2Si$, $CuAl_2$, AlSiMnFe (figure 2, (2.79)). In case of very slow crystallization (at T ≈ ct, in equilibrium) can form $W(Al_xMg_5Si_4Cu_4)$ phase which is seen in figure 3 (2.80).

Taking into account that in the $ATSi_9Cu_3MgBTi$ alloy can be eutectic with different melting temperatures (because of the complexity phase component, which depends on the rate of crystallization) and also considering the differential thermal analysis (figure 4 (2.81)) for PT is recommended two regimes of hardening:

- heating at 500°C/4h + 515°C/10h followed by cooling in water temperature 20-30°C;
- heating at 490°C/4h + 500°C/4h + 515°C/6h and cooling in water temperature 20-30°C.

The first hardening regime is recommended to PT in the shell or PT with thin walls cast in FAT (when the cooling rate of casting is great -$v_{cr}$>>>0). The second hardening regime is recommended for large size PT with thermal node (joints massifs).

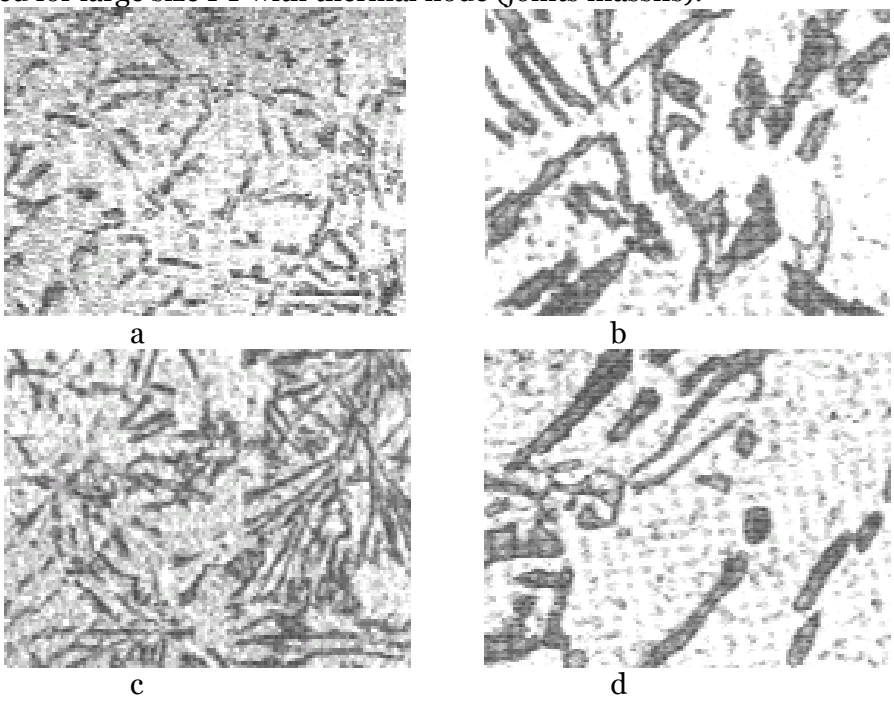



Fig.2 $ATSi_9Cu_3MgMnB$ alloy structure: a- cast (100:1); b- cast (500:1); over TT; c- 100:1; d- 500:1



Fig.3 Type of crystallization phase $W(Al_xMg_5Cu_4Si_4)$ la 500:1

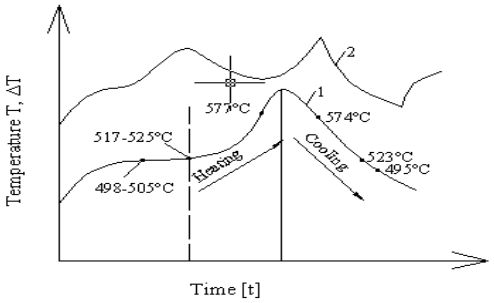



Fig.4 Direct thermal analysis curves (1) and differential (2) of the $ATSi_9Cu_3MgBTi$

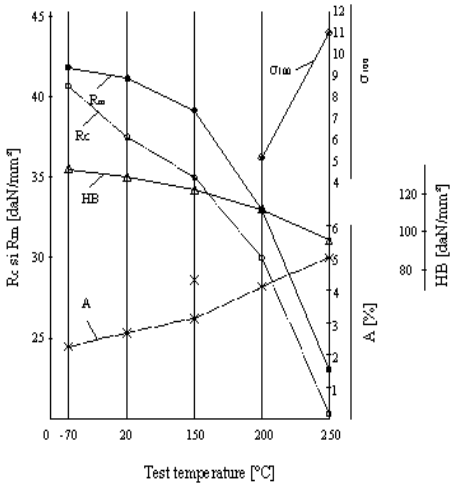


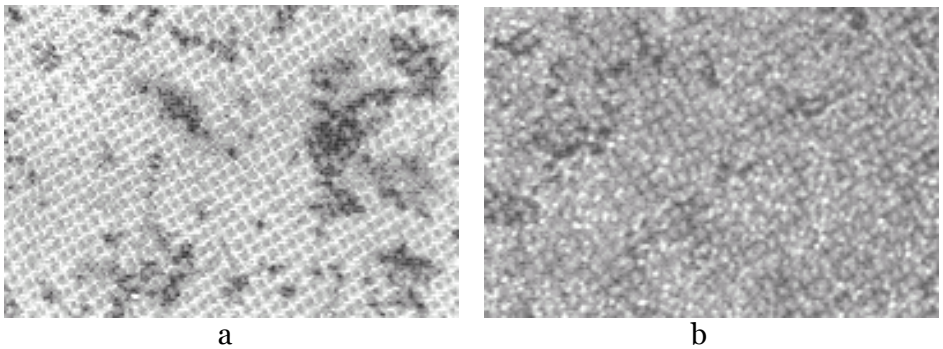

Fig.5 $ATSi_9Cu_3MgMnB$ proprieties determined on sample of Φ12mm cast in shell

Mechanical properties of $ATSi_9Cu_3MgMnB$ hardening after the first regime and the aging after the regime 165°C/22h or 175°C/7h, with air cooling are shown in figure 5 (2.82). At 20°C has HB=120daN/mm² and decrease with test temperature increase.

## 4. CONCLUSIONS

The physical properties of the alloy $ATSi_9Cu_3MgMnB$ practically are the same as those of the alloy $ATSi_9Cu_2MgB$, and the casting of the alloy as $ATSi_{10}MgMn$. The cutting process is better [5], than the two mentioned alloys. The welding is good.

To confirm the correctness of the choice of aging regime is shown in figure 6 (2.83) s.s.α alloy structure ATSi9Cu3MgMnB in hardening state and cast in forms of mixture formation.



a b

Fig. 6 $ATSi_9Cu_3MgMnB$ structure alloy in hardening state after casting in: a- FAT and b- shell (10000:1)

Note that the cooling was the first stage of aging, this mean that, they have managed to form ZGP and agglomerations of Si ultra-dispersed particles what were separately from s.s.α. In comparing these pictures, you can see that ZGP density in solid solution alloy $ATSi_9Cu_3MgMnB$, cast in FT, is much reduced, comparative to s.s.α of the alloy cast in shell. This can be explained by the fact that: supersaturate degree of s.s.α in the last sample, in all probability, is higher, and the degree of distortion $R_{cr}$ of s.s.α also higher, which accelerates the process of form ZGP, and ultra-dispersed particle of elementary Si.

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# MEASURING THE PRESSION FIELD IN AN INVERTED AIR FILTER

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**Abstract:**
This article presents a concept regarding the design of an efficient air filter for internal combustion engines, and more precisely: the super-absorbing air filter. The collection effect is being described by measuring the pressure fields with a digital manometer under air flow action.

**Keywords:**
air filter, internal combustion engine, pressure fields

## 1. INTRODUCTION

The correct filtration of the air that circulates inside the cylinders of the internal combustion engine is essential for preserving the good functioning of the engine over time. The obstruction of the admission of various impurities from the atmospheric air significantly lowers the wearing out of the moving parts of the engine.

Unfortunately, in addition to its air filtration function, the air filter displays a significant gas-dynamic resistance of the absorbed air. If the air filter is not periodically cleaned and the car circulates frequently in a dusty area, both the absorption pressure $p_a$ and the filling coefficient $\eta_V$ are dramatically decreased.

There are currently on the market several constructive variants of air filters, which differ according to the filtering principle:

- filters with filtering cell,
- inertia filters,
- combined filters.

These air filters have the following *disadvantages*:

- the presence of the filtering element inside the box induces an enhanced gas-dynamic resistance of the absorbed air (generating the phenomenon of insufficient absorption);
- storage of impurities inside the filter affects the self - cleaning feature of the filtering element;
- the filtering element can not be visualized and it has to be dismantled for the impurity level to be checked;
- incapacity of the air filter to significantly increase the speed of the absorbed air;
- incapacity of the air filter to cool the absorbed air;
- impossibility of the air filter to create a slight effect of overfeeding during the functioning of the engine.

## 2. THE INVERTED SUPER ABSORBING FILTER

The inverted super absorbing filter consists of a cylindrical filtering element, bordered at its anterior part by an internal diffuser fused to a joint cylinder. At its posterior part, the cylindrical filtering element is embedded concentric-axially (2/3 of its length) in a mono-block complex, which consists of an external diffuser for air collection, followed by a direction-invertor (figure 1).



Figure 1. The inverted super absorbing filter

For an optimum air collection and absorption yield, the inverted super absorbing filter is set along the geometrical axis of the car.

Due to its geometry, the external diffuser (figure 2) with direction-invertor (figure 3) ensures a very good collection, causing the inversion of the absorbed air flux by 180°, which is thus directed through the filtering element towards the internal diffuser (towards the exit of the filter).

The external diffuser with direction-invertor covers the filtering element (for 2/3 of its length) up to a very precise distance from the exterior of the element, which ensures the collection and inversion of the air flux. Cooling radiators are located on the outside of the direction-invertor.

### 2.1. The external diffuser for air collection with direction-invertor

The cooling radiators consist of external wings, which cover 80% of the external surface of the direction-invertor. They maintain a low temperature of the direction-invertor and generate, consequently, a thermal equilibrium between the surface of the wall and the absorbed air. As a result, the temperature of the air is significantly decreased before it enters the air filter.

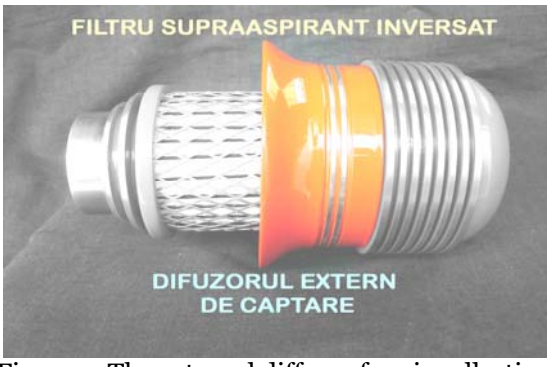



Figure 2. The external diffuser for air collection

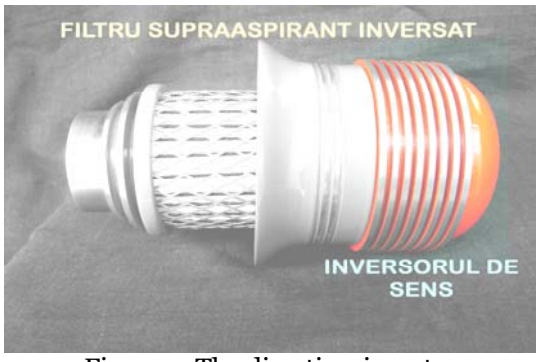



Figure 3. The direction-invertor

### 2.2. The filtering element

The filtering element (figure 4) has a cylindrical shape. It consists of a micron size cardboard, which forms the lateral surface of the filtering element (in a radial section, the micron size cardboard has a W shape).




Figure 4. The filtering element




Figure 5. The internal diffuser and joint cylinder

The cardboard ensures a micron size filtration and is covered on the outside with a millimetric sieve, which allows a rough millimeter size filtration of the air. The micron size cardboard and the millimetric sieve are fixed at the two open ends by silicone rings, for an optimum sealing and concentric – symmetrical alignment with both the internal diffuser of the anterior part and the mono-block complex of the posterior part.

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### 2.3. The internal diffuser for air acceleration

The internal diffuser for air acceleration has a taper shape and ensures the connection between the contact surface and the joint cylinder (figure 5). Due to its constructive geometry, the internal diffuser has the capacity of increasing the speed of the absorbed air. Taper-shaped cooling radiators are located on the outside of the internal diffuser. Because of their taper shape, they redirect the air flux towards the external diffuser, which allows a concentrated flow of the air and a minimum gas-dynamic resistance. They maintain a low temperature of the diffuser and generate, consequently, a thermal equilibrium between the surface of the wall and the absorbed air. As a result, the temperature of the air is significantly decreased before it leaves the inverted filter.

The purpose of the joint cylinder is to link the air filter to the admission gallery of the engine.

The internal diffuser for air acceleration, the filtering element and the mono-block complex (the external diffuser for air collection with direction-invertor) have varying dimensions according to the swept volume of the engine, so that the bigger the swept volume, the larger the dimensions of the diffuser and vice-versa.

The inverted super absorbing filter improves the filling coefficient and is useful for engines that employ air filters set in the opposite direction of the flow of the absorbed air (filters set up at the rear of the Bugatti, Ferrari, Lamborghini engines).

### 2.4. Conclusion regarding the inverted super absorbing filter

The inverted super absorbing filter has the following *advantages*:

- being in direct contact with the air, the filtering element ensures a minimal gas- dynamic resistance of the absorbed air, increasing therefore the level of absorption and collection of the air, and consequently boosting the air filling coefficient of the engine cylinders;
- possibility of self-cleaning of the filtering element;
- the level of impurities on the filter can be readily evaluated: the filtering element can be easily visualized without previously dismantling the filter;
- the speed of the absorbed air both at the entrance and the exit of the filter is considerably increased;
- significant capacity of the air filter to cool the absorbed air;
- the air filter creates a slight effect of overfeeding during the functioning of the engine, which is proportional with the speed of the car;
- this air filter fulfils new tasks, in addition to its classical function of air filtration: increases the degree of absorption and collection, the speed of the absorbed air, cools down the absorbed air and inverts the air flux by 180°

## 3. DESCRIPTION OF THE EXPERIMENTAL SETUP

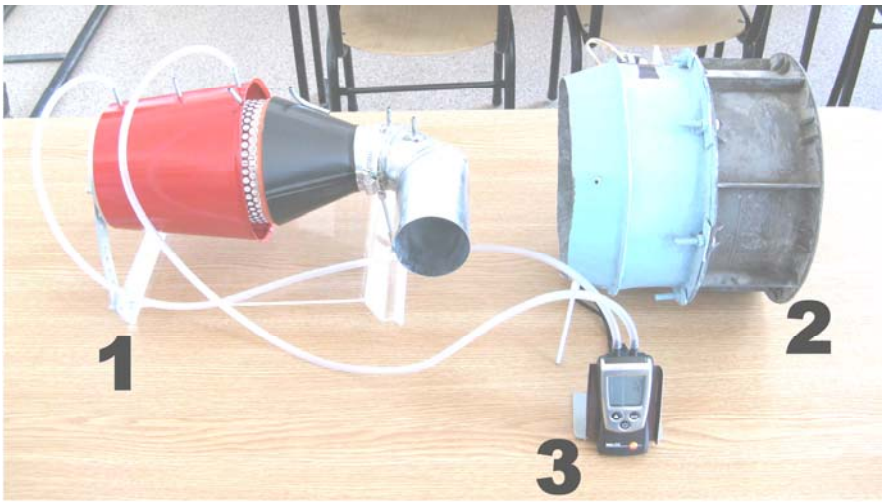



Figure 6. General view of the experimental setup:
1- inverted super-absorbing filter; 2- constant flow ventilator;
3- digital manometer

### 3.1. The inverted super-absorbing filter

The inverted super-absorbing filter consists of a cylindrical filtering element (C), bordered internally by a diffuser (D) fused to a joint cylinder (E). The cylindrical filtering element is embedded concentric-axially (90 % of its length) in an external air collector (A), bordered at its posterior part by an internal cone (B) (Figure 7).




Figure 7. Inverted super-absorbing filter. Constituting elements

For an optimum air collection and absorption yield, the inverted super aspirant filter is set longitudinally with respect to the geometrical axis of the car.

### 3.2. The external axial collector with the internal cone

Due to its geometry, the axial external collector A with the internal cone B (Figure 7, 8 and 9) ensures a very good air collection. It causes the inversion of the absorbed air flux by 180°, which is therefore directed through the filtering element towards the internal diffuser (towards the exit of the filter).




Figure 8. The external axial collector with the internal cone (longitudinal view)




Figure 9. The external axial collector with the internal cone (radial view)

The axial external collector with internal cone covers the filtering element (for 90 % of its length) up to a very precise distance from the exterior of the element, which allows an optimal collection and inversion of the air flux. There are 4 pressure plugs on the outside of the axial external collector and 3 pressure plugs around the internal cone.

### 3.3. The cylindrical filtering element

The filtering element is cylindrically shaped (Figure 10). It consists of a piece of cardboard with micron-size pores, which forms the lateral surface of the filtering element (in a radial section, the cardboard piece has a W shape).




Figure 10. The filtering element

The cardboard ensures a micron-size filtration and is covered on the outside with a sieve with millimetre-size pores, which allows a rough millimeter-size filtration of the air. The cardboard and the sieve are fixed at their open ends by silicone rings, for an optimum sealing and concentric – symmetrical alignment with both the internal diffuser at the anterior part and the mono-block complex at the posterior part.

### 3.4. The internal diffuser for air speed acceleration.

The internal diffuser for air acceleration D (figure 11) has a taper shape and ensures the connection between the filtering element C and the joint cylinder E (Fig. 7). Due to its geometry, the internal diffuser has the property of increasing the speed of the expelled air. Its taper shape directs the air flux towards the external axial collector, which allows a concentrated air flow and a minimum gas-dynamic resistance.




Figure 11. The internal diffuser

## 4. MEASURING METHODOLOGY

The static pressure is measured in the external axial collector via the pressure plugs 1, 2, 3, 4, inside the filtering element (at ½ its length) via plug 5, at the entrance of the internal diffuser via plug 6 and inside the joint cylinder via plug 7 (figure 12). All these pressure plugs were designed perpendicular to the air flow.

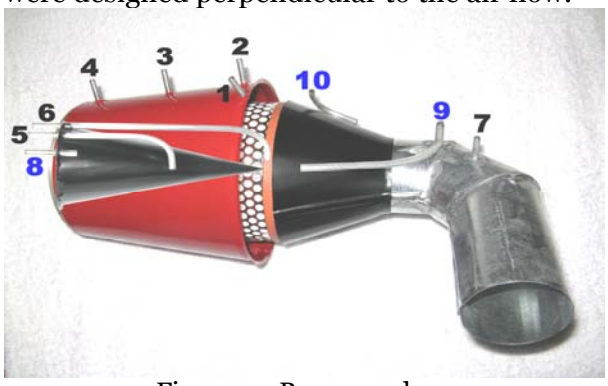



Figure 12. Pressure plugs




Figure 13. The digital manometer TESTO 510



Figure14. Filter with the internal cone



Figure15. Filter without the internal cone

The dynamic pressure is measured at the basis of the internal cone via plug 8, at the exit of the internal diffuser via plug 9 and at the external surface of the internal diffuser via plug 10 (figure 12). These pressure plugs were designed axial to the air flow.

The measurements were performed with the digital manometer TESTO 510 (0-100hPa) described in Figure 13. Pressure measurements relative to the atmospheric pressure were carried out at each pressure plug, at various distances

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## 5. ANALYSIS OF RESULTS AND CONCLUSIONS

A significantly higher collection yield is observed in the presence of the internal cone (figure 14, Tabel 1) compared to when the internal cone is missing (Figure 15 and Tabel 2). The following graphs show the effect of the presence or absence of the cone on the pressure fields recorded at various distances from the ventilator: 0, 20, 40 cm.

Table 1. Static Pressure values (with internal cone)

| distance | Plug 1 | Plug 2 | Plug 3 | Plug 4 | Plug 5 | Plug 6 | Plug 7 |
|---|---|---|---|---|---|---|---|
| 0 | 44 | 28 | 33 | 50 | 26 | 14 | 8 |
| 5 | 38 | 25 | 30 | 42 | 22 | 11 | 7 |
| 10 | 33 | 23 | 28 | 36 | 20 | 11 | 10 |
| 15 | 31 | 23 | 28 | 34 | 21 | 13 | 10 |
| 20 | 32 | 26 | 30 | 37 | 22 | 13 | 13 |
| 30 | 32 | 26 | 33 | 39 | 27 | 20 | 14 |
| 40 | 32 | 27 | 34 | 40 | 28 | 20 | 16 |
| 50 | 29 | 24 | 29 | 32 | 23 | 17 | 14 |

Table 2. Static Pressure values (without internal cone)

| distance | Plug 1 | Plug 2 | Plug 3 | Plug 4 | Plug 5 | Plug 6 | Plug 7 |
|---|---|---|---|---|---|---|---|
| 0 | 39 | 26 | 35 | 50 | 20 | 8 | 3.5 |
| 5 | 30 | 19 | 25 | 36 | 15 | 4.5 | 2 |
| 10 | 20 | 15 | 20 | 29 | 13.5 | 3 | 1 |
| 15 | 16 | 13 | 19 | 21 | 13 | 3 | 1 |
| 20 | 17 | 14 | 19 | 22 | 11.5 | 2 | 1 |
| 30 | 15 | 13 | 18 | 22 | 12 | 2 | 2 |
| 40 | 15 | 13 | 19 | 22 | 12 | 3 | 2 |

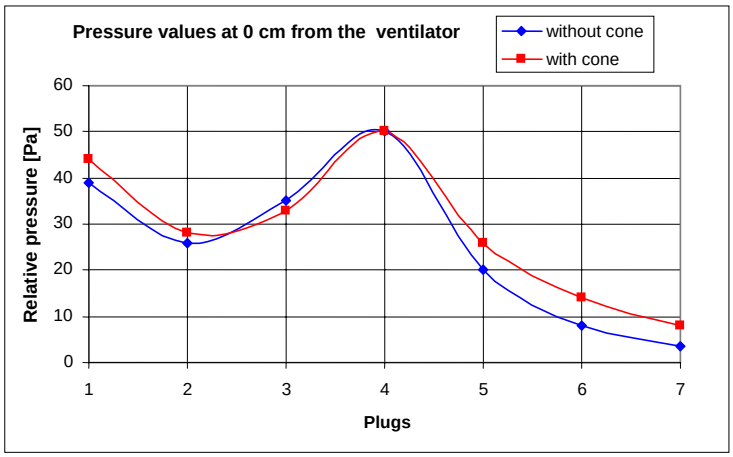



Figure 16. Comparative pressure values in the filter at 0 cm form the ventilator

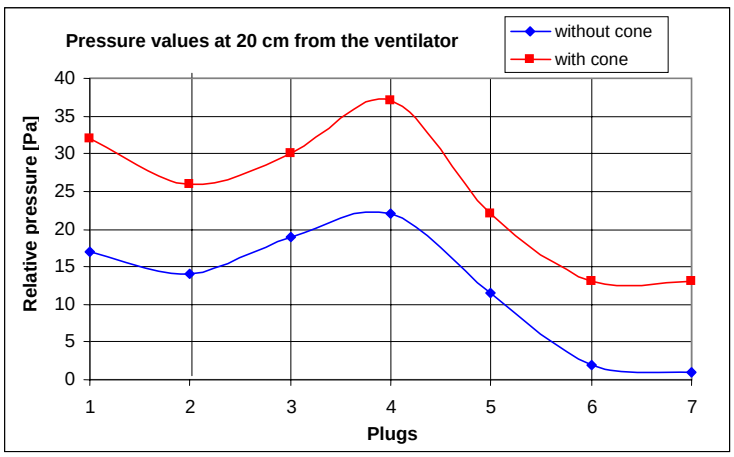



Figure 17. Comparative pressure values in the filter at 20 cm form the ventilator

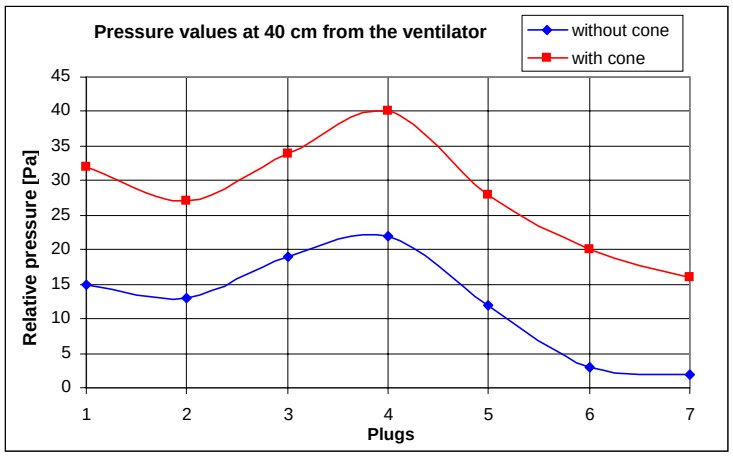



Figure 18. Comparative pressure values in the filter at 40 cm form the ventilator

The following graphs display the relative pressure fields measured at each plug vs the distance between the filter and the ventilator:

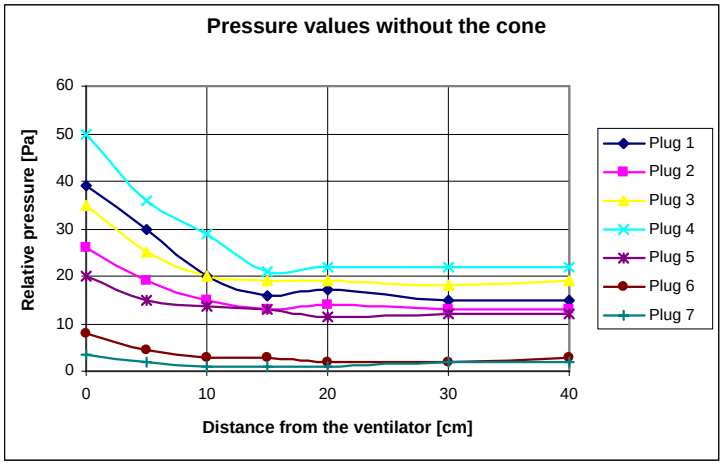



Figure 19. Relative pressure in the filter in the absence of the cone

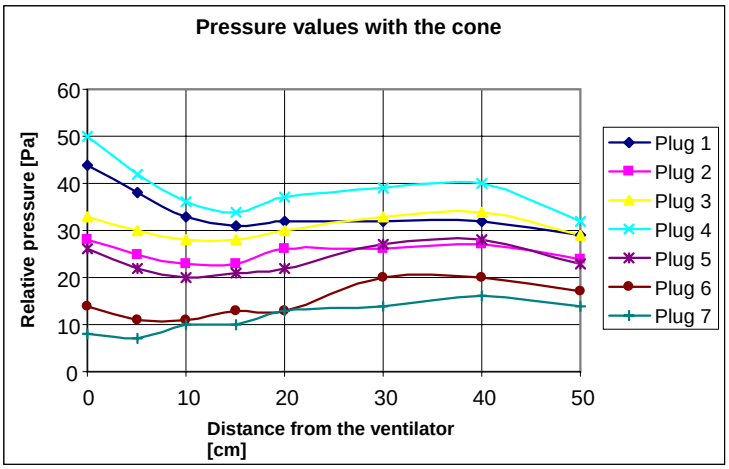



Figure 20. Relative pressure in the filter in the presence of the cone

The inverted super-absorbing filter improves the filling coefficient and is useful for engines that employ air filters set in the opposite direction of the flow of the absorbed air (filters set up at the rear of the Bugatti, Ferrari, Lamborghini engines).

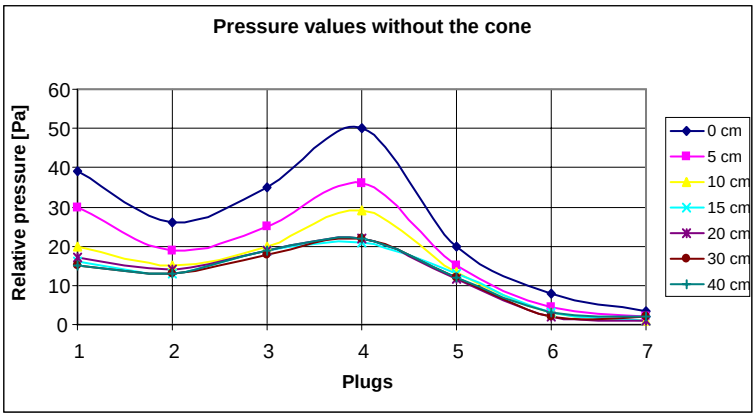



Figure 21. Comparative pressure values in the filter at various distances form the ventilator in the absence of the cone

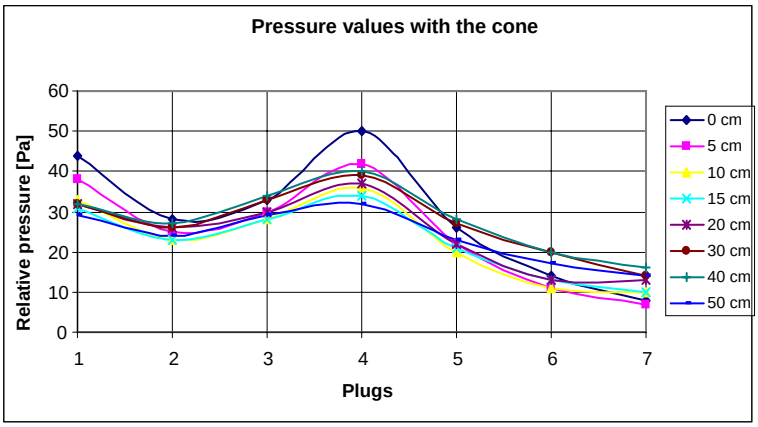



Figure 22. Comparative pressure values in the filter at various distances form the ventilator in the presence of the cone

## 6. CONCLUSIONS REGARDING THE INVERTED SUPER-ABSORBING FILTER

The inverted super aspirant filter has the following advantages:

- being in direct contact with the air, the filtering element ensures a minimal gas-dynamic resistance of the absorbed air, increasing therefore the level of absorption and collection of the air;
- possibility of self-cleaning of the filtering element;
- the level of impurities on the filter can be readily evaluated: the filtering element can be easily visualized without having to dismantle the filter;
- the speed of the absorbed air both at the entrance and the exit of the filter is considerably increased;
- the air filter creates a slight effect of overfeeding during the functioning of the engine, which is proportional with the speed of the car;
- this air filter fulfils new tasks, in addition to its classical function of air filtration: increases the degree of absorption and collection, the speed of the absorbed air, cools down the absorbed air and inverts the air flux by 180°.

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# LABORATORY MEASUREMENTS OF LIGHT-DUTY VEHICLE POLLUTION AND FUEL CONSUMPTION

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**Abstract:**
The present paper present a method used in simple applications in order to determine the fuel consumption of a light-duty vehicle starting from the exhaust gases quantity and depending the testing cycle type. Are covered the EU, US and Japanese cycles and are presented the mesurements done on a twin-roll dynamometer.

**Keywords:**
fuel consumption, dynotest, driving cycles, carbon balance method

## 1. INTRODUCTION

Many countries have regulations on the measurement of exhaust gas emissions of passenger cars and light trucks. Pollution regulations define measurement conditions and the limit values for emissions of the following pollutants: carbon monoxide (CO), unburnt hydrocarbons (HC), nitrogen oxides (NOX), and particulate matter for diesel engines (compression-ignition engines). "Fuel consumption" regulations define the measurement conditions for both consumption and carbon dioxide (CO2) emissions for passenger cars.

These measurements are taken on chassis dynamometers that can simulate different regulatory driving cycles: urban and extra-urban cycles in most countries and also motorway cycles, especially in the United States. Trucks, earth-moving vehicles and farm vehicles do not have to comply with any regulations on pollution or fuel consumption once fully assembled. Only their engines are subjected to laboratory pollution measurements with upper limits on the following emissions: CO, HC, NOX, particulate matter and exhaust fumes. As these engine measurements do not include tyre rolling resistance, we will not investigate them any further in this document. However, just as for passenger cars, progress in truck engine, vehicle and tyre design is helping lower pollution levels.

## 2. TEST PRINCIPLES

The vehicle is set up on a chassis dynamometer which simulates the resistance to forward movement experienced when driving on roads. During the test, the exhaust gases are collected then analyzed to determine:

- for pollution measurements: the mass of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOX) and, for diesel engines, particulate matter. The results are given in g/km.
- for fuel consumption measurements: the mass of carbon monoxide (CO), total hydrocarbons (THC) and carbon dioxide (CO2) in g/km. Fuel consumption is then calculated using the "carbon balance method".

## 3. POLLUTION AND FUEL CONSUMPTION MEASUREMENTS

- Speed (tolerance of ± 2 km/h with respect to the theoretical speed)
- Time (tolerance of ± 1s)

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- Braking effort
- Temperature in the test chamber (between 20 and 30 °C)
- Air humidity
- Engine tuning: as per manufacturer's specifications
- No heating, lighting or air-conditioning
- Fuel: reference fuel as defined by the Directive
- Vehicle: run in for at least 3,000 km and kept at between 20 and 30 °C for at least 6 hours before the test.

**Pollution measurements**

- Size: the widest size specified as original equipment by the automobile manufacturer. If more than 3 sizes are certified, it is choosed the second widest. The model is not indicated in the test report.
- Run in at the same time as the vehicle or with between 50 and 90 % of original tread depth.
- Tyre pressure specified by the manufacturer, as used for the preliminary road test to adjust the dynamometer. Important: May be raised by up to 50 % if the measurements are recorded on a twin-roll dynamometer.

**Measured parameters:**

- Mass of CO, HC, $NO_X$, and, for diesel engines, particulate matter.

**Fuel consumption measurements**

- One of the tyres specified as original equipment by the automobile manufacturer. Tyre pressure as recommended for the load and speed, adjusted if necessary to test bed operation.

**Measured parameters:**

- Mass of CO, THC, CO2.

**Calculated parameters:**

- Fuel consumption in l/100 km.

## 4. DYNAMOMETER ADJUSTMENT

The dynamometer must be able to reproduce all the forces to which a running vehicle is subjected:

- rolling resistance forces,
- inertial forces,
- internal frictional forces,
- aerodynamic forces.

The dynamometer is calibrated either using data obtained from a road coastdown test or from calibration tables stipulated in the Directive.

**Dynamometers**

There are two types of dynamometer: single-roll and twin-roll.

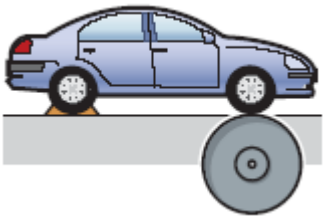


Figure 1. Car on a single - roll dynamometer



Figure 2. Car on a twin - roll dynamometer

**Note:** Tyre deformation is greater on a single-roll dynamometer than on a road, and still greater on a twin-roll dynamometer. Dynamometer-generated rolling resistance is greater than road-generated rolling resistance. At a normal tyre pressure, the deformation inflicted by a twin-roll dynamometer could even damage the tyre. European Directives therefore allow the tyre to be inflated up to an extra 50 % for twin-roll dynamometer tests.

## 5. DETERMINING FUEL CONSUMPTION BY THE CARBON BALANCE METHOD

The **carbon balance method** may be used to calculate fuel consumption from the quantity of carbon found in the exhaust gases collected.

Even with the complex chemical transformations taking place in an internal combustion engine, the relationship between fuel consumption and carbon emissions can be stated relatively simply:

- The main four fuels currently used are made almost exclusively of saturated hydrocarbons (alkanes). Saturated hydrocarbons are composed of carbon (C) and hydrogen (H) only, in known proportions.
- When combustion takes place, all the carbon from the fuel is emitted in the exhaust gases, combined with oxygen from the air in the form of carbon dioxide ($CO_2$), carbon monoxide (CO) or as unburnt hydrocarbons (HC, also referred to as VOC – Volatile Organic Compounds).

The calculation formulae are given in the following relations:

**Fuel consumption calculation** (according to Directive 1999/100/EC):

*Petrol Vehicles :*

$$C = \frac{0{,}1154}{\rho} \cdot [(0{,}866 \cdot THC) + (0{,}429 \cdot CO) + (0{,}273 \cdot CO_2)] \quad (1)$$

*Diesel Vehicles :*

$$C = \frac{0{,}1155}{\rho} \cdot [(0{,}866 \cdot THC) + (0{,}429 \cdot CO) + (0{,}273 \cdot CO_2)] \quad (2)$$

*Liquefied petroleum gas (LPG) vehicles :*

$$C_{norm} = \frac{0{,}1212}{0{,}538} \cdot [(0{,}825 \cdot THC) + (0{,}429 \cdot CO) + (0{,}273 \cdot CO_2)] \quad (3)$$

*Natural gas vehicles (NGV) :*

$$C_{norm} = \frac{0{,}1136}{0{,}654} \cdot [(0{,}749 \cdot THC) + (0{,}429 \cdot CO) + (0{,}273 \cdot CO_2)] \quad (4)$$

where:

C - fuel consumption in litres per 100 km (for petrol, LPG or diesel) or in cubic metres per 100 km for NGV

THC - total hydrocarbon emissions measured, in g/km

CO - carbon monoxide emissions measured, in g/km

$CO_2$ - carbon dioxide emissions measured, in g/km

ρ - test fuel density measured at 15 °C. A reference fuel density is used for LPG and natural gas.

## 6. CARBON AND CO2 EMISSIONS PER LITRE OF FUEL CONSUMED

Even if the exact amount of $CO_2$ produced by one litre of fuel depends on various factors such as temperature, ambient pressure and fuel quality, the following may be considered typical values:

- 1 litre of petrol used produces 2.35 kg of $CO_2$, i.e. 0.64 kg of carbon;
- 1 litre of diesel used produces 2.66 kg of $CO_2$, i.e. 0.72 kg of carbon.

### E.U. DRIVING CYCLE

The European regulatory driving cycle is the same for both fuel consumption and pollution measurements. Automobile manufacturers thus take both sets of measurements during a single test. The cycle simulates 4.052 km of urban driving (part ONE) and 6.955 km of extra-urban driving (part TWO – driving on expressways and bypasses).

Specifications:

Maximum speed: 120 km/h
Average speed for part one: 18.7 km/h
Average speed for part two: 62.6 km/h
Total simulated distance: 11.007 km
Total duration: 19 min 40 s

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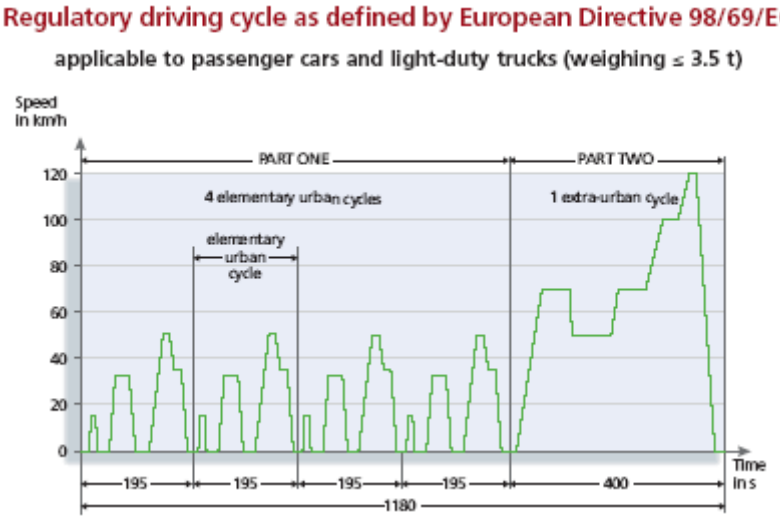



Figure 3. EU driving cycle

- Part ONE comprises four "elementary urban cycles", each made up of 15 successive phases (idling, acceleration, steady speed, deceleration, idling, etc.).

The urban cycle was drawn up in 1958 after following a Renault Dauphine car in Paris. It therefore represents a very slow urban cycle.

- Part TWO comprises one extra-urban cycle made up of 13 phases.
- Exhaust gases are collected continuously throughout the cycle.

## U.S. DRIVING CYCLES

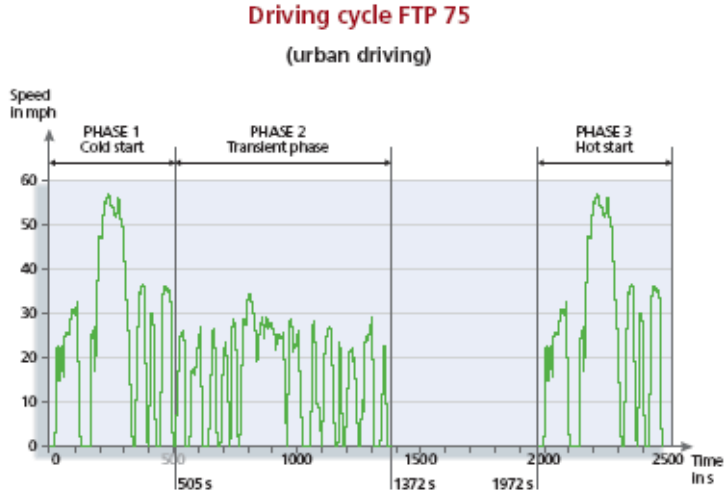



Figure 4. US driving cycle

Specifications:

Average speed: 21.2 mph (34.1 km/h)
Maximum speed: 56.7 mph (91.2 km/h)
Total rolling time: 31 min 17 s (1,877 s)
Stopping time: 10 minutes
Distance travelled: 11.04 miles (17.8 km)
Weighting factors: PHASE 1 = 0.43
PHASE 2 = 1
PHASE 3 = 0.57

There are three American regulatory driving cycles used in the certification of passenger cars and lightduty trucks with respect to pollutant emissions:

- **FTP 75**: cycle simulating urban driving from a cold start followed by a hot-start urban cycle;
- **SFTP-US06**: "aggressive" motorway driving;

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- **SFTP SC03**: urban driving with air-conditioning on (not shown here).

**Fuel consumption** measurements are based on the **FTP 75** cycle and the normal motorway driving cycle **HWFET**.

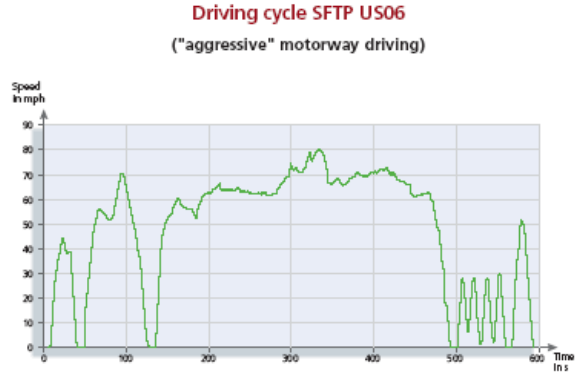



Figure 5. US driving cycle – aggressive motorway driving

Specifications:

Average speed: 48.4 mph (77.9 km/h)
Maximum speed: 80.3 mph (129.2 km/h)
Total rolling time: 9 min 56 s (596 s)
Distance travelled: 8.01 miles (12.9 km)




Figure 6. US driving cycle – normal motorway driving

Specifications:

Average speed: 48.3 mph (77.7 km/h)
Maximum speed: 60 mph (96 km/h)
Total rolling time: 12 min 45 s (765 s)
Distance travelled: 10.26 miles (16.5 km)

## JAPANESE DRIVING CYCLES

There are currently two Japanese regulatory driving cycles:

- One hot-start cycle known as 10-15 mode for measuring the pollution and fuel consumption of passenger cars and light trucks.
- One cold-start cycle known as 11 mode applied in addition to 10-15 mode for measuring the pollution of petrol-driven passenger cars and lightduty trucks. 10-15 mode simulates urban driving (three "10-mode" elementary cycles) followed by peri-urban driving (one "15-mode" elementary cycle). It is a hot-start cycle, with the measurements only beginning after 15 minutes of rolling at 60 km/h, a measurement during idling then a further 5 minutes' rolling at 60 km/h and finally a "15-mode" elementary cycle, which means a total warm-up time of more than 20 minutes. Measurement results are given in g/km.

11 mode simulates another urban trip, this time from a cold start. Measurement results are given in g/test.

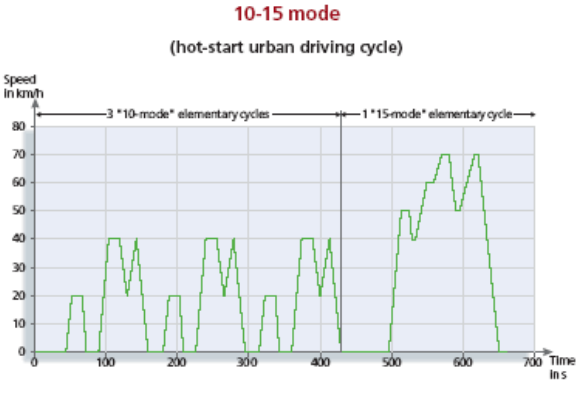



Figure 7. 10-15 mode Japanese cycle

Specifications:

Average speed: 22.7 km/h
Maximum speed: 70 km/h
Total rolling time: 11 min (660 s)
Distance travelled: 4.16 km

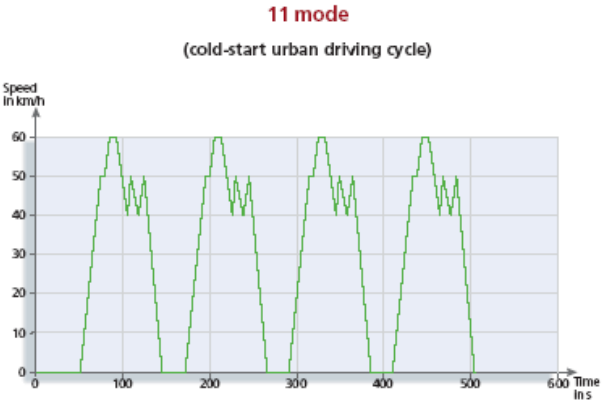



Figure 8. 11 mode Japanese cycle

Specifications:

Average speed: 29.1 km/h
Maximum speed: 60 km/h
Total rolling time: 8 min 25 s (505 s)
Distance travelled: 4.084 km

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## 7. PRACTICAL APPLICATION

On the MAHA LPS 3000 dynamometer is loaded the correspondent driving cycle (figure 9) and when all the mesurement devices are set and the exhaust gas analyser are ready, the mesurement is started and datas are saved in tables and displayed as graphics (figure10).

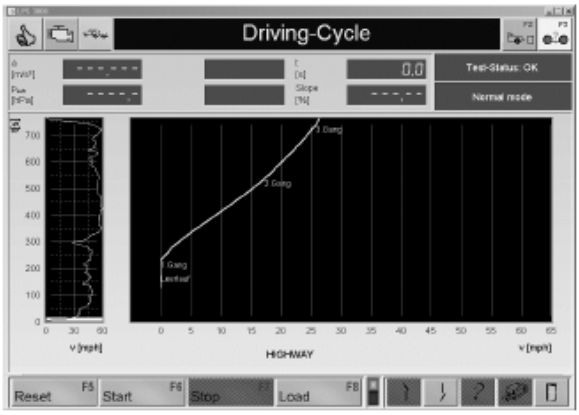



Figure 9. Loading the corresponding driving cycle for light-duty vehicle

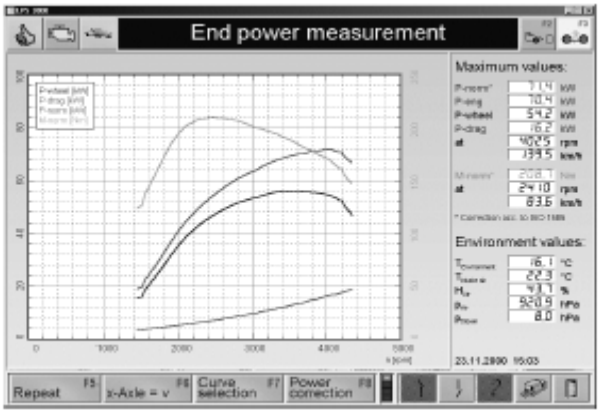



Figure 10. Graphics for analyzing the performances of the vehicle's engine

Applying the formulas 1 – 4, depending the engine's type, we have the values for fuel consumption, values that could be compared with official datas from car manufacturer, or could be used for analyzing the working of the engine.

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# MODALITIES OF REDUCING THE LEAKAGE FLOW IN MECHANICAL SEALING

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**Abstract**

The paper presents the connection between the contact pressure on the sliding ring, the size of the interstice and the pressure of the sealed fluid determined experimentally as well as the modalities of reducing the flow discharge.

**Keywords**

Leakage, unsealing, flow discharge

## 1. GENERAL CONSIDERATIONS

In the case of the mechanical seals, the sealing is obtained by a small interstice between two rings with front contact surfaces, which are in relative motion (figure 1).

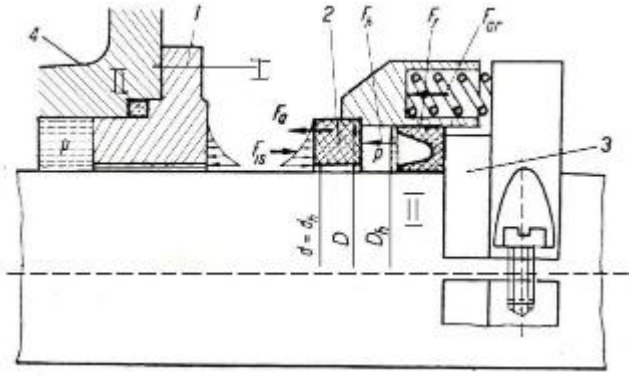



Figure 1

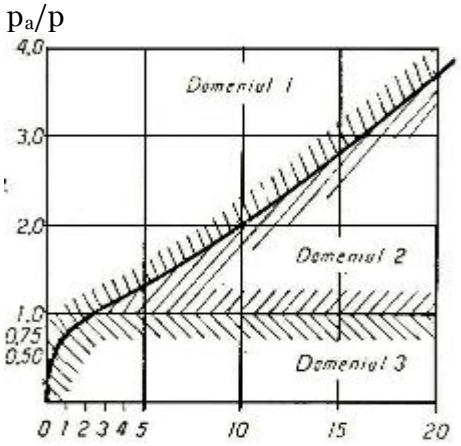



Figure 2

Experimentally it has been observed that there is a connection between the contact pressure on the sliding ring $p_a$, size of the interstice $k$ and the pressure of the sealed fluid $p$ (figure 2).

In the field noted 1 there is no pressure forming in the interstice $p_{is} \approx 0$ and $p^2_a = p_{ar} + k_p$. The interstice contains fluid that is leaking through the contact surface irregularities. There is a limit lubrication discharging rapidly to a dry friction that can lead to rapid wear.

Fluid losses marked Q are given with the help of the empirical equation:

$$Q = \pi d(p - p_e \pm p_z) 60 S h^2 / p^2_a \quad (1)$$

where:

- d - Entrance diameter of the fluid in the interstice
- p – The pressure of the sealed fluid
- $p_e$ – external pressure
- $p_z$ - pressure due to centrifugal force
- S – Interstice specific coefficient
- h – Interstice size
- $p_a$ - axial contact pressing

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It can be noted that the fluid loss through leakages is largely influenced by the size of the interstice and by the contact pressure.

Seals in this area are characterized by a stable operation, low pressure in the interstice and loss of fluid through minimal leakage.

In the field noted 2 there is a pressure $p_{is}$ in the interstice that can grow to the amount of fluid pressure p. The interstice is a friction joint with a low coefficient of friction. Loss of fluid can be calculated quite precisely with the equation noted 1.

In the field noted 3, the seal has the most favorable conditions for friction in the interstice, but at the same time also the greatest loss through leakage.

In the interstice it is established a laminar leakage; the losses by leakage of fluid can be calculated by the relationship:

$$Q = \pi(p-p_e \pm p_z)d_m * h^3/12\eta b \qquad (2)$$

where: $d_m$ - average diameter of the ring

$\eta$ – dynamic viscosity of the fluid

## 2. LOSS OF FLUID THROUGH UNSEALING

### 2.1 Parameters that determine the loss of fluid

Mechanical sealing behavior is influenced by:

- relationship between the acting surface of the fluid and the frontal contact surface $k = A_h/A$;
- relative speed of sliding between the contact surfaces and the sealed fluid pressure
- the couple of materials of the two sliding rings in contact;
- the sealed medium, its lubrication and cooling properties, its chemical behavior, the content of impurities;
- the shape of the interstitial of the surfaces in contact, influenced by the nature of mechanical and thermal strains that appear during operation;
- roughness of the surfaces in contact their deviation from the geometrical shape;
- friction, vibrations, pressure shocks, continuous working or with stops, the ability of heat dissipation, lubrication direction in relation with the direction of the centrifugal forces;
- Temperature of the sealed medium and contact surfaces and their evolution in time.

### 2.2 Ways of reducing the flow discharge

The ratio of surfaces $h = A_h / A$ may range from positive, over unitary or sub unitary, or even negative.

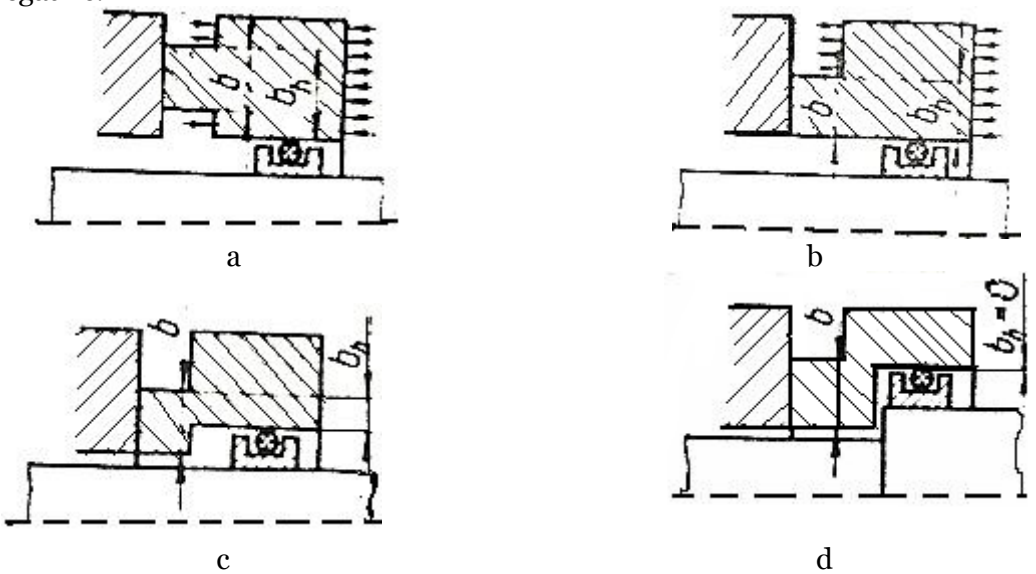



Figure 3

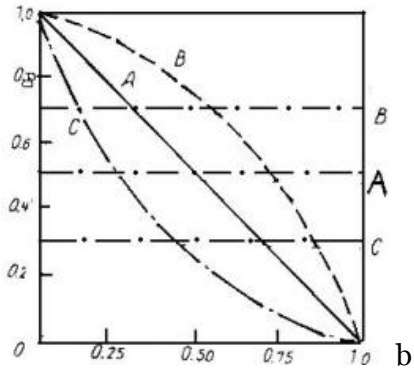
a) k>1 loaded sealing or unbalanced
b) k=1 balanced sealing or unloaded
c) k<1 balanced sealing or unloaded
d) k=0

The "loaded" seals situate in fields of operation 1 and 2 with minimum loss through the interstice.

In the unloaded constructions the pressing on contact surfaces is made by the spring force.

Experimental research [2] showed that pressure in the interstice is dependent on the ratio k and viscosity (figure 4). For joint studies with low viscosity (propane or butane), the seal must be designed with a value k = 0.7 in order not to lose contact between sealing surfaces $r_e$, while for water a value k=0.58÷0.6 is enough. For high viscosity mediums (oils) k = 0.3÷0.4. Normally, mechanical sealing show radial plane surfaces, with the great manufacturing advantage of simplicity.

p/ $p_1$,A




b

Figure 4

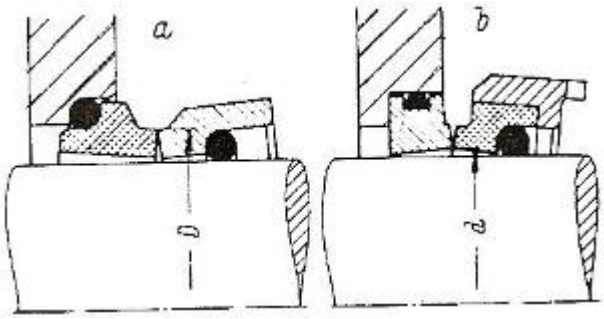
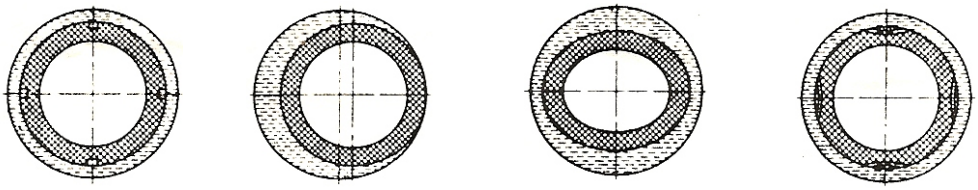



Figure 5

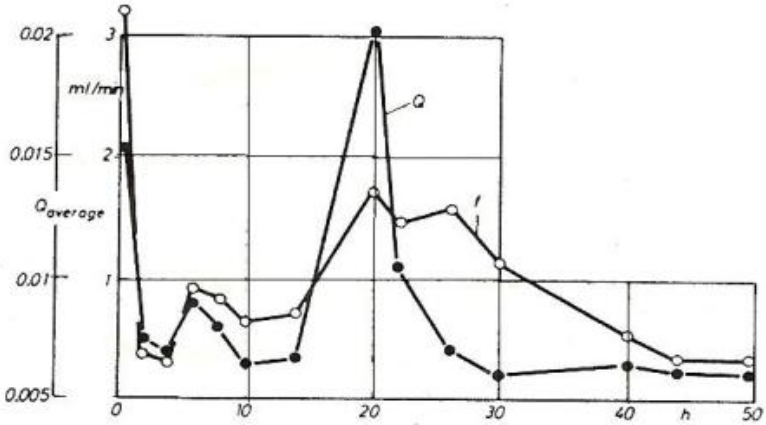
The configuration of the area may suffer modifications due to heat or wear, applied torsion moment, radial or axial forces; the rings deform and the interstice becomes convex, concave or tilted with peripheral contact, internal or external (figure 5). If the operating conditions remain constant, by choosing a suitable couple of materials in contact, wear can gradually restore the parallelism to the ring surfaces, if time and contact pressure is convenient. Besides geometry, the roughness of the rings surfaces in contact has a considerable influence on losses. If the roughness rises losses do to unsealing rise also.

As in the friction-wear process appear strong heating in the area of contact thus leading to deformations of the interface, results that in heavy operating conditions in particular (pressures, high speeds) in order to reduce the flow out of sealing constructive measures are necessary to diminish wear.



a b c d

Figure 6




Time

Figure 7

Figure 6 presents the construction of sealing surfaces in contact with frontal circular channels eccentric friction surfaces, elliptical rings, circular ring channels, with effect on the hydrodynamic lubricating film between sliding surfaces.

Figure 7 presents the interdependence between the flow loss Q and the coefficient of friction for a high pressure seal with frontal sealing surfaces with radial channel.

## 3. CONCLUSIONS

The geometry of a mechanical sealing interstice, its roughness, can be changed depending on working conditions. In turn they influence the force pressing the two rings, the pressure of the interstice, losses through leakage of the fluid and even the friction conditions.

Leak flow rate may thus rise even when constant operating conditions are present. In mechanical sealing the condition that the lubricant has no pressure in the interstice (see fig.2 in area X) is very important to ensure the stability of operation and minimum loses due to fluid leakage.

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# THERMO ELASTIC INSTABILITY WITHIN A CLASS IV FRICITON JOINT

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**Abstract**

With a class IV couple of friction joint there are conditions when the disturbances of the pressures on the interface increase, decrease or remain unchanged. When the two materials of the joint are identical a relative stability is formed regarding this phenomenon, while a good heat-conducting material coupled with a heat insulator, depending on certain characteristics of sliding speed, creates instability. Equation of this paper specifies the threshold for instability.

**Keywords:**

Thermo elastic instability; Solutions; Temperature wave

## 1. INTRODUCTION

With a class IV friction joint (annular joint), which is the primary sealing of a frontal sealing, may appear situations in which pressure disturbances within the interface decrease, increase, or remain constant. These in turn are influenced by the properties of the materials in contact, coefficient of friction and relative sliding velocity.

The increase of the pressure disturbances in the interface leads to an increase in contact pressure and the local temperature. Adjacent to the zones with low pressure the surfaces can detach leading to important losses by leakage.

Materials of the same type making the joint tend to a relative stability when speaking of this phenomenon, while a joint composed of a good heat conductor material and a insulator will always show characteristics of relative sliding speed, from which instability appears.

The sliding contact at relatively high speeds is associated with a macroscopic instability, so that on a flat and uniform contact area will appear disturbances of local pressure.

This leads to negative effects upon the contact area from the point of view of heating and wear.

The simplified configuration of the primary sealing (class IV friction joint) is presented in Fig. 1. For such geometry, if the pressure is uniform in the interface, the temperature slowly rises until it hits a nominal value determined by the operating parameters.

If instead the uniform distribution of the pressure is disturbed even sparsely (which can be expressed as a Fourier series or waves along the contact surface) the disturbance may diminish, may remain unchanged or may rise. Thus, the stability of the pressure distribution can be investigated according to the behavior of waves of initial disturbance.

The problem is assumed to be ideal linear, with a linear heat transfer, thermal expansion and elastic displacement so that:

- the solution found is for the pressure wave produced at the surface of the semi-infinite ring extremity when there is a temperature wave of constant amplitude moving with constant speed;
- there is a relationship between the pressure wave and the heat produced by friction, generated at the limiting value, where it is assumed that another plate slides over and takes over the pressure distribution.

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As an additional restriction of harmful waves it is assumed that there is no disruption at the extremities of the distance corresponding to the circumference of the tube (fig 1).

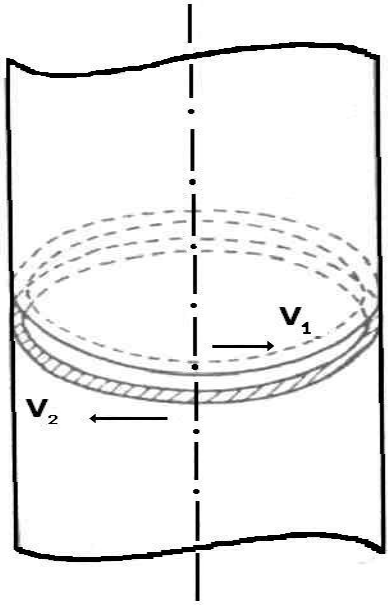



Figure 1

This implies that the harmonic components of the disturbance, complete one or more numbers of cycles over the specified length.

The combination of properties of materials in contact and operating conditions which satisfy the entire set of conditions will be considered to define the circumstances of a specified wavelength disturbance, without diminution or amplification.

## 2. SOLUTIONS FOR A TEMPERATURE WAVE WITH CONSTANT MOVEMENT

If referred to one of the plates marked with 1, the edge temperature perturbation can be expressed:

$$T = T_o * \sin \omega(x-vt) \quad (1)$$

where:

- $T_o$ is the constant for temperature
- $\omega = 2n\pi/L$ the measure of wave number
- x – is measured along the contact surface
- v - Instantaneous transverse velocity of the wave along the contact surface

Heat transfer equation:

$$\delta^2T/\delta x^2 + \delta^2T/\delta y^2 - (\delta T/\delta t)/k = 0 \quad (2)$$

$$-\infty \le x \le \infty$$

$$0 \le y \le \infty$$

with T=0 when $y \to \infty$; y is measured perpendicular to the contact surface

Solution for body number 1:

$$T_1 = T_o e^{-b_1 y_1} \sin(\omega x - \omega v_1 t + a_1 y) \quad (3)$$

where:

$$b_1 = \{\omega^2/2 + \omega/2 [\omega 2 + (v_1/k_1)^2]^{1/2}\}^{1/2} \quad (4)$$

$$a_1 = \{-(\omega^2/2) + \omega/2 [\omega^2 + (v_1/k_1)^2]^{1/2}\}^{1/2} \quad (5)$$

where:

- k – material diffusion capability
- K - material conductivity
- p - pressure
- $c_p$ – specific heat

The heat flow ($q_1$) is given by the equation:

$$q = -K(\delta T/\delta y)_{y1=o} = -KT [a_1 \cos(\omega x - \omega v_1 t) - b_1 \sin(\omega x - \omega v_1 t)] \quad (6)$$

Surface temperature will be:

$$T = T_o \sin \omega t \quad (7)$$

and

$$q_1 = K_1 T_o (b_1 \sin \omega x - a_1 \cos \omega x) \quad (8)$$

For the second body (which moves in the opposite direction relatively to the temperature wave with the speed $v_2$):

$$T_2 = T_o e^{-b_1 y_1} \sin(\omega x - \omega v_2 t - a_2 t) \quad (9)$$

Where $a_2$ and $b_2$ correspond to the (4) and (5) equations with the correct changes for indices. Thus:

$$q_2 = -K_2 (\delta T_2/\delta y_2)_{y2->o} = K_2 T_o [a_2 \cos(\omega x - \omega v_2 t) - b_2 \sin(\omega x + \omega v_2 t)] \quad (10)$$

If the wave is stationary and plate is moving relative to it:

$$q_2 = K_2 T_o (b_2 \sin \omega x + a_2 \cos \omega x) \quad (11)$$

and

$$q = q_1 + q_2 = T_o [(K_1 b_1 + K_2 b_2) \sin \omega x + (K_2 a_2 - K_1 a_1) \cos \omega x] \quad (12)$$

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## 3. STATE OF THERMO ELASTIC STRESS IN A PLATE SUBJECTED TO A WAVE OF TEMPERATURE THAT MOVES UNIFORMLY

The thermo elastic equation of a plate depending on the potential of displacement Ψ is:

$$\delta^2 \Psi / \delta x^2 + \delta^2 \Psi / \delta y^2 = (1+ \nu_o)\alpha T_o e^{-by} \sin(\omega x + ay - \omega vt) \quad (13)$$

where: α - coefficient of thermal expansion

$\nu_o$ – Poisson's coefficient

The speed **v** of the surface on the direction of y is zero ($v_{y->o}$) and $\Psi \to o$ when $y \to \infty$, $\delta \Psi / \delta y \equiv v$, resulting in:

$$\Psi_1 = (Ae^{-\omega y})(C \cos\omega x + D \sin\omega x) + (k_1/v\omega)(1+\nu_1)\, \alpha_1 T_o e^{-b_1 y} \cos(\omega x + a_1 y) \quad (14)$$

Coefficients C and D are evaluated to meet the condition on the limit. Results that the surface pressure $p_1'$ will be:

$$p_1' = E_1 \alpha_1 T_o k_1 [-(\omega - b_1)\cos\omega x + a_1 \sin\omega x]/v_1 \quad (15)$$

A similar equation can be written for the body numbered 2. At the moment of contact between the two bodies each surface will suffer a displacement equal and contrary till the equalization of tensions:

$p_1'' = E\omega\delta/2$ with $\delta = \delta_o \sin\omega x \leftarrow$ thermal layer thickness

As a result:

$$p = -E_1\omega\delta/2 = p_1' + p'' \quad (16)$$

$$p = E_1\omega\delta/2 = p_2' + p'' \quad (17)$$

Given the fact that *p* must be identical for the two bodies (according to the law of balance) δ can be eliminated

$$p = E_1E_2T_o\{[\alpha_2k_2(\omega-b_2)/v_2 - \alpha_1k_1(\omega-b_1)/v_1]\cos\omega x + [\alpha_2k_2a_2/v_2 + \alpha_1k_1a_1/v_1]\sin\omega x\}/(E_1+E_2) \quad (18)$$

According to the principles of equilibrium, the heat generated by friction must be equal to the heat from the interface if:

$$mp(v_1 + v_2) = q \quad (19)$$

$$(K_1b_1+K_2b_2)\sin\omega x + (K_2b_2-K_1b_1)\cos\omega x = (v_1 + v_2)\mu E_1E_2\{[\alpha_2k_2(\omega-b_2)/v_2 - \alpha_1k_1(\omega-b_1)/v_1]\cos\omega x + [\alpha_2k_2a_2/v_2+\alpha_1k_1a_1/v_1]\sin\omega x\}/(E_1+E_2) \quad (20)$$

To satisfy the equation (2):

$$K_1b_1+K_2b_2 = (v_1 + v_2)\mu E_1E_2[\alpha_2k_2a_2/v_2+\alpha_1k_1a_1/v_1]/(E_1+E_2) \quad (21)$$

$$K_2b_2-K_1b_1 = (v_1 + v_2)\mu E_1E_2[\alpha_2k_2a_2(\omega-b_2)/v_2 - \alpha_1k_1a_1(\omega-b_1)/v_1]/(E_1+E_2) \quad (22)$$

So for bodies of the same material: $v_1 = v_2 = v/2$, and equation (21) reduces to:

$$\mu E\alpha ka/bK = 1 = \mu E\alpha ka\{[1+[1+(v/k\omega)^2]^{1/2}]/[1+[1+(v/k\omega)^2]^{1/2}]\}^{1/2}/K \quad (23)$$

and for two bodies of which, one is good conduit for heat and other heat isolated:

$k_1 \to o$, $K \to o$, $v_2 \to o$, and $v_1 \to v$. If $v>1$, $a_1 \to \omega(v_1/2k_1\omega)^{1/2}$

$a_2 \to v_2 2k_2$; $b1 \to \omega(v_1/2k_1\omega)^{1/2}$; $b_2 \to \omega[1+(c_2/k_2\,\omega)^2/8]$

and equation (21) reduces to:

$$v_1 = v = 2K_2\,\omega(E_1+E_2)/\mu E_1E_2\alpha_2 \quad (24)$$

## 4. CONCLUSIONS

The equations from above serve to provide the terms depending on which the pressure disturbance in a frontal sealing interface increases. In this case load concentrations occur in small portions of the contact surfaces, resulting in damage or separation of the rings.

For materials of the same type, instability occurs only at a high coefficient of friction. Initial size of the uniform load has little influence on the general temperature which may alter the properties of the materials. Role of slip velocity is also small.

In case the material has different properties from the point of view of transfer of heat produced by friction will be taken from the heat-conducting body and the limit between stability and instability depends on the relative sliding velocity.

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# STUDY REGARDING MASS REPARTITION TO ROAD VEHICLE WITH MULTIPLE DESTINATIONS

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**ABSTRACT**

This paper presents a study regarding to distribution of mass road vehicles for multiple destination: for freight transport and people transport. Category of this road vehicle is N1 with the maximum mass allowance 3500 kg. Main producers of this categories of road vehicle achieve common platforms, subsequently has transformed to the final type destination. The distribution of mass road vehicles on the axes is different because the mass center of freight is different after transformation.
Some aspects of this new situation which appear to modification of freight are presented in the case of vehicle from category N1.

## 1. INTRODUCTION

The study realized in this paper is the road freight vehicle type "lightly truck" (figure 1) with next principal parameters:

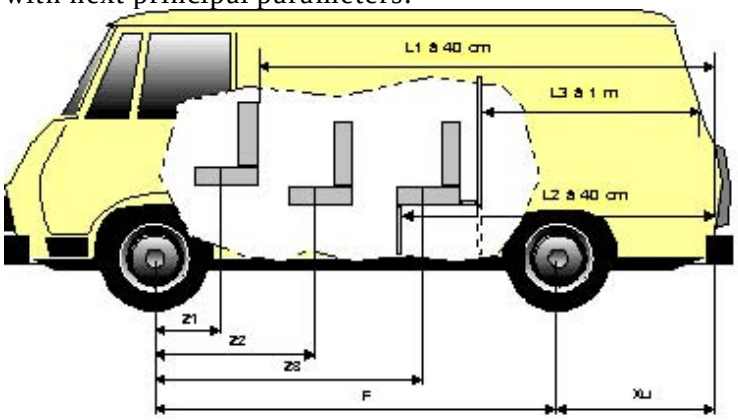



Figure 1 Parameters of road vehicle

L1-measured in meter: The length of space charge before transformation (this data can be measured or can be take from producers of road vehicle);
L2-measured in meter: The length of space charge measured to +40 centimeter height regard to floor vehicle;
L3- measured in meter: The length of space charge measured to +1 meter height regard to floor vehicle;
F-measured in meter (wheel base)
Xu-rear overhang
Z1-measured in meter: distance from mass center of front seats and rear axe
Z2- measured in meter: distance from mass center second line of seats and rear axes
Z2- measured in meter: distance from mass center third line of seats and rear axe
Yc- measured in meter: distance from mass center of load and rear axe
FZ(1,2 and 3)- measured in meter: distance from mass center of seats and rear axes
PTAC-measured in kilo: admissible maximum mass (for category N1 is 3500kg)
PV- measured in kilo: own vehicle mass (without driver, a fuel tank is 90% full)
PV1- measured in kilo: own vehicle mass to front axes E1
PV2- measured in kilo: own vehicle mass to front axes E2
POM- measured in kilo: own vehicle mass in driving conditions (European Directive CE 98/14
POM=PV+75*0,1M (M-mass of 100 % fuel from fuel tank)
CM- measured in kilo: mass of load
CMAR- measured in kilo: load distribution on the rear axes
CMAV- measured in kilo: load distribution on the front axes
E1- measured in kilo: maximum load to front axes
E2- measured in kilo: maximum load to rear axes
C.U.- measured in kilo: real load (=PTAC)
N-number of the seats including driver seat

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## 2. THE STUDY

### 2.1. Condition imposed

- For vehicle with admissible maximum mass (for category N1 is 3500kg), and the seat number is N<=7 and the body structure is tip BB VAN , after classification from European Directive98/14/CE ( for vehicle with multiple destination, people transport with luggage or freight transport in the same compartment) it is necessary to verify the ratio of luggage mass and people mass following relation:

PTAC-(POM+(N1)x68)>(N1)x68

- For other cases if the people mass including the driver is less with 60% from real load C.U. then:

75xN=...<(PTAC-PV)x0,6

- For the cases if the vehicle is with two line of seats, PTAC must be more 2400 kg

### 2.2 Dimensional Checking and design description

- L3 must be more or equal then 1meter
- If the vehicle has just one line of seats L2 must be more or equal then 0,5xL1+0,3
- If the vehicle has two line of seats L2 must be more or equal then 0,4xL1
- If Yc value is negative it is necessary a certification from producer to accept this value and it must be included into condition the maximum load on front axes
- It is forbidden to separated the first line of seats with the second line of seats
- The space for passengers must be separated from the space of freight with rigid closure with a resistance of 800KN/$m^3$
- If the vehicle has more than two line of seats is necessary to assembled the stuck window

## 3. MASS DISTRIBUTION ON AXES

### 3.1. Driver and passengers

1. first line of seats
Driver mass and passengers:P1=75 kg x passengers number
P1=...kg
Z1=...m
F-Z1=...m
P1AV=(P1x(F-Z1))/F=...kg
P1AR=(P1xZ1)/F=...kg
2. second line of seats
mass passengers:P2=75 kg x passengers number
P2=...kg
Z2=....m
F-Z2=...m
P2AV = (P2 x (F- Z2))/F =...kg
P2AR = (P2 x Z2)/F = ... kg
3. third line of seats (optional)
mass passengers:P3=75 kg x passengers number
P3 = ... kg
Z3 = ... m
F- Z3 = ... m
P3AV = (P3 x (F- Z3))/F = ... kg
P3AV=...F
P3AR = (P3 x Z3)/F = ... kg
3.2. Load mass
CM=PTAC-(PV+P1+P2+P3)
CM=...kg
CMAV=(CMxYc)/F=...kg
CMAR=(CMx(F-YC)/F=...kg

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3.3. Calculation with passengers

| | Total | Front | Rear |
|---|---|---|---|
| Vehicle mass | PV= | PV1 | PV2 |
| Driver and passengers AV (first line of seats) | P1= | P1AV= | P1AR= |
| Passengers on second line of seats | P2= | P2AV= | P2AR= |
| Passengers on third line of seats | P3= | P3AV= | P3AR= |
| Load | CM1= | CM1AV= | CM1AR= |
| Maximum load | PTC1= | E1= | E2= |
| Maximum authorized load | PTAC= | | |

3.4. Calculation without passengers

| | | | |
|---|---|---|---|
| Vehicle mass | PV= | PV1 | PV2 |
| Driver (1) | P1= 75kg | P1AV= | P1AR= |
| Load | CM2= | CM2AV= | CM2AR= |
| Maximum load | PTC1= | E1= | E2= |
| Maximum authorized load | PTAC= | | |

Calculation condition:
1. CMAR= maximum load on axes: E2-PV2-P1AR
Calculation:CM=(CMARxF)/(F-Yc)
CM=PTAC-PV-75kg
E1 must be more of minimum mass authorized
CMAV>minimum mass authorized-PV1-P1AV
If the condition is not achieved:
CMAV= minimum mass authorized-PV1-P1AV
CM=(CMAVxF)/Yc

## 4. ANALISES, APROCHES

For the example of repartition of mass it was made a calculation for a vehicle CITROEN JUMPER L3H2 with extra four seats.
PTAC=3500 kg (maximum authorized mass)
E1 max=1850 kg
E2 max=2000 kg
F=4,078 m
L1,L2,L3=3.68,2.79,2.655 m
Xu=0.959 mm
Z1=0.95 m
Z2=1.755 m
Z3=0 -
Yc=(L2/2)-Xu=0.436 m
PVconst=2050 kg
E1 const=1290 kg
E2 const=760
Cab mass=145 kg
E1 cabine=38 kg
E2 cabine=107 kg



Figure 2 - Example before transformation

PV transf=PVconst+cabine=2195 kg
E1 transf=E1const+E1cabine=1328 kg
E2 transf=E2const+E2cabine=867 kg
Tank fuel mass=70 litres
POM = PVtransf +75 –
(0,1*70*0.9)=2263.7 kg with petrol
N=5 passengers number

Condition

1. PTAC<=3500kg and maximum of number passengers is 7

PTAC-(POM+(N-1)*68)>(N-1)*68

The results :964,3kg>272kg

Repartition of load

Driver and passengers

*P1=75kg*3 passengers ( including the driver)

*P2= 75 * 3 passagers

*P3= 75* 0 passagers

* P1AV= [ P1* (F-Z1) ] / F
* P1AR= [ P1* Z1 ] / F

*P2 AV= [P2 * (F-Z2) ] / F
*P2 AR= [ P2 * Z2 ] / F

*P3 AV= [P3 * (F-Z2) ] / F
*P3 AR= [ P2 * Z2 ] / F

The results:

| | |
|---|---|
| P1= | 150 |
| P1AV= | 115,06 |
| P1AR= | 34,94 |
| P2= | 225 |
| P2AV= | 128,17 |
| P2AR= | 96,83 |
| P3= | 0 |
| P3AV= | 0 |
| P3AR= | 0 |

The results:

| | |
|---|---|
| CM= | 930 |
| CMAV= | 99,4 |
| CMAR= | 830,6 |

Calculation with passenger

* PTC1= Pvtransf+P1+P2+P3+CM
* E1= E1transf+P1AV+P2AV+P3AV+CM1AV
* E2= E2transf+P1AR+P2AR+P3AR+CM1AR

Driver and load

* CM= PTAC – ( PV+P1+P2+P3)
* CMAV= [ CM* Yc ] / F
* CMAR= [CM* (F-Yc) ] / F

| | |
|---|---|
| PTC1 max. laod | 3500 |
| PTAC | 3500 |
| E1= | 1670,63 |
| E1max | 1850 |
| E2= | 1829,37 |
| E2max | 2080 |

## 5. CONCLUSIONS

The results obtained can lead to the following conclusion:

- it is necessary to make a repartition of mass to vehicle with multiple destinations for safety driving condition;
- the method can be used for the increased the degree of safety for the vehicle with multiple destination from N1 category;
- some aspects can be used to vehicle with special destination (ambulance, etc.)

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# METALLOGRAFIC ASPECTS OF THE ELEMENTS MAKING UP A STEAM BOILER

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**Abstract**:
OLT 35K steel is part of the non-allied steel category, used for the achievement of tubes that work at high temperature. Specimen has been taken from this tube type, placed in a steam boiler, from which strip drive test-bars were manufactured. Afterwards, they were tried on driving, at ambiant and high temperature, close to the ones used in operation, so as to determine the mechanical features of the material, after a certain period of use. Conclusions made, concerning the influence of temperature on how the OLT 35K steel deals with high temperature, can be taken from the results and, in this way, you can estimate the remaining life-length of both that material and implicitly that of the source equipment.

**Keywords**:
high temperature, thermal resistant steel, mechanical testing, life-length, mechanical feature

## 1.GENERAL APPRECIATION

In the context of the present economy, the technological process must be done with high efficiency of transformation. Nowadays, this efficiency can be grown only by high pressure and temperature of the technological process, this being the reason for which the development of a steel scale is required, and especially the ones with low allied degree, as they are less expensive.

In the same time, decisions on the material are essential in all fields of industrial practice, because any technical activity has to finally result in a resistance structure or a functional device. And, each new technological process brings about the development of a new material as the achievement of structures and/or device is being conditioned by their existance and usage.

Choosing the right steel, in point of the required features, the aquisition price and the manufacture price, as well as in reserve, has always been a priority in the eyes of designers and industry manufacturers.

*Work Temperature* is an element considered more and more interesting because, in a special way, you can assert that the new technological development depends, in many sectors, on the manner you deal with *how materials behave at high temperature.*

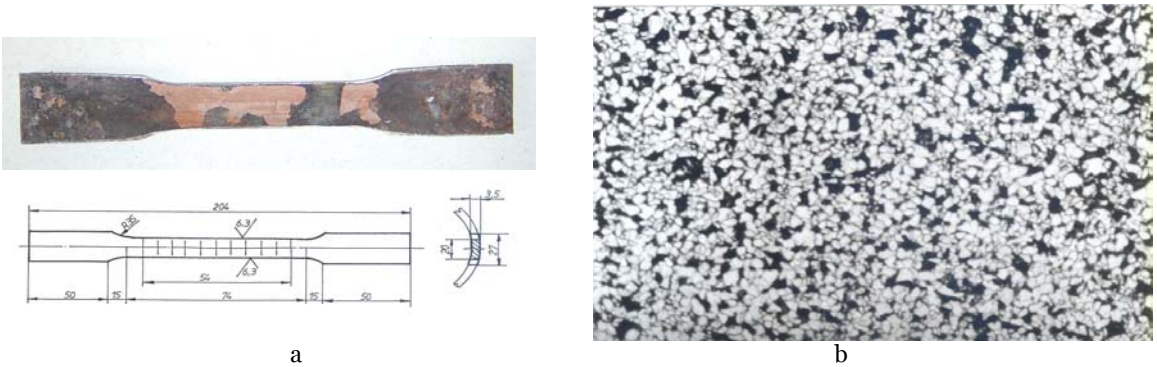
The reliability and quality of the elements wich work at high temperature and pressure is part of the reliability of electrical and thermic energy production units. The working of these units at best parameters is very important because if not the social and economic implications can be huge.

Choosing and using the right steel, in point of the required mechanical features, for a special field of usage, cannot be made without knowing the real behavior of the material, which relies on theoretical and **experimental research**.

The mechanical features of metals, obtained by testing made with bars, liable to different requirements that are close to the conditions of operation of the elements strength, allow the quality check of their material, fixing the maximum limits of requirements, being essential elements that stand at the discretion of that technologist's designer.

## 2. TEST-BARS USED IN TESTING

Test-bars, generally having the shape and size of those found in testing at ambiant temperature, are used in mechanical experiment at high temperature. Because test-bars are heated in different precincts, it is necessary that the shape and size of the holding extremity is built in such a way to allow their assembly in the holding jaws of the testing machineries. There are situations when, between the extremities of the test-bars and the ones of the holding jaws, some prolonged rods made from metals resistent at high temperature, have to be assembled.



a b

Figure.1. The shape and size of test-bars used in testing: a) test-bar drawn from focus; b) the metalographical structure resulted from the chemical analysis

Ring-shaped transversal samples have been drawn for metalographical analysis, looking at emphasizing the morphology of transformation stages from the material, and establishing the seed size, likely oxidation or decarburization phenomena and other structure faults.

For the OLT 35K tube material, drawn from the focus and shown in fig.1.b, and after the optical microscope study, it seemed that it offered a ferrite-perlite structure, with a 7-8 outline of real seed, proceeding from SR ISO 643-93, and the tube walls had not have a decarburized structure.

After the metalographical analysis, it is found that the tested material is part of the adherent standard, but stating that small size of molybdenum can be detected. Analysing this fact, in accordance with [2], we can state that, in small amounts, molybdenum is fighting against the reversible return brittleness. Disolved in ferrite and forming carbides, molybdenum improves the resistance features and to a certain extent, the plasticity features of annealed or normalized steel, just like the case at study. Molybdenum also improves the usage resistance and stops the sliding process, by forming carbides, ascertaining a sensitive growth in the steel resistance at high temperature.

Therefore, molybdenum is the ally element that provides the mechanical resistance of steel used at high temperature.

## 3. TESTING

OLT 35K steel – STAS 8184-80 is part of the non-allied steel category, used for manufacturing tubes that work at high temperature. Steel is elaborated in electrical ovens, Martin ovens, in converters with oxygen spraying or other equivalent methods.

The chemical make-up of the used material (drawn from focus), for the experimental testing, is shown in table 1. The mechanical features guaranteed on the delivered products as tubular, established on longitudinal drawn test-tubes, under ambiant testing atmosphere, are given in table 2.

Table 1. The chemical make-up of the OLT 35K steel, drawn from focus

| Material | C [%] | Mn [%] | Si [%] | S [%] | P [%] | Cr [%] | Ni [%] | Cu [%] | Mo [%] |
|---|---|---|---|---|---|---|---|---|---|
| Focus – OLT 35K | 0,15 | 0,76 | 0,34 | 0,011 | - | 0,19 | 0,20 | 0,17 | 0,01 |
| STAS 8184-80 | Max. 0,17 | Min. 0,45 | 0,15... 0,35 | Max. 0,045 | Max. 0,040 | Max. 0,30 | Max. 0,30 | Max. 0,30 | - |

Table 2. The guaranteed mechanical features for OLT 35K steel

| Steel type | Breaking resistance $R_m$[N/mm²] | The conventional running limit $R_{p0,2}$, [N/mm²], min. | After breaking percentage elongation A, [%], min | The narrowing value of the section Z, [%], min. | Impact value KCU 300/2 min. |
|---|---|---|---|---|---|
| OLT 35K | 350...450 | 230 | 26 | 60 | 60 |

Table 3. The driving mechanical features of the OLT 35K steel

| Testing temperature [°C] | Breaking force $F_{max}$ [N] | Breaking resistance $R_m$[N/mm²] | After breaking percentage elongation A[%] | The narrowing value of the section Z [%] |
|---|---|---|---|---|
| 20°C | 34435 | 491,92 | 90,00 | 37,85 |
| 100°C | 33800 | 482,85 | 85,00 | 44,07 |
| 200°C | 27350 | 390,71 | 72,22 | 55,00 |
| 300°C | 34900 | 498,57 | 71,29 | 33,60 |
| 400°C | 34200 | 502,85 | 64,81 | 29,57 |
| 500°C | 39380 | 562,57 | 78,70 | 33,14 |

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In the field of high temperature, driving testing has been made on a universal machinery by adjusting a genuine conception of heating precincts, [1] .

Figure 2. a÷f shows the F-Δl curves, obtained for a share of the tested tubes, and the values of the resulted mechanical features are synthesized in table 3.

The testing made for establishing the mechanical driving features have taken place between +20°C...+500°C. The values shown in chart 3 represent the average of the mechanical features obtained in sets og 3 bars, tested at each level of temperature. Variation diagrams of the driving mechanical features were outlined by using these values, depending on the testing temperature. Therefore, in fig.3, it is shown the $R_m$ feature variation, and in fig.4 that of *A* and *Z* feature.

Fig.5 shows a share of OLT 35K bars, drawn from the focus and tested at temperatures of: +20°C, +100°C, +200°C, +300°C, +400°C and +500°C.

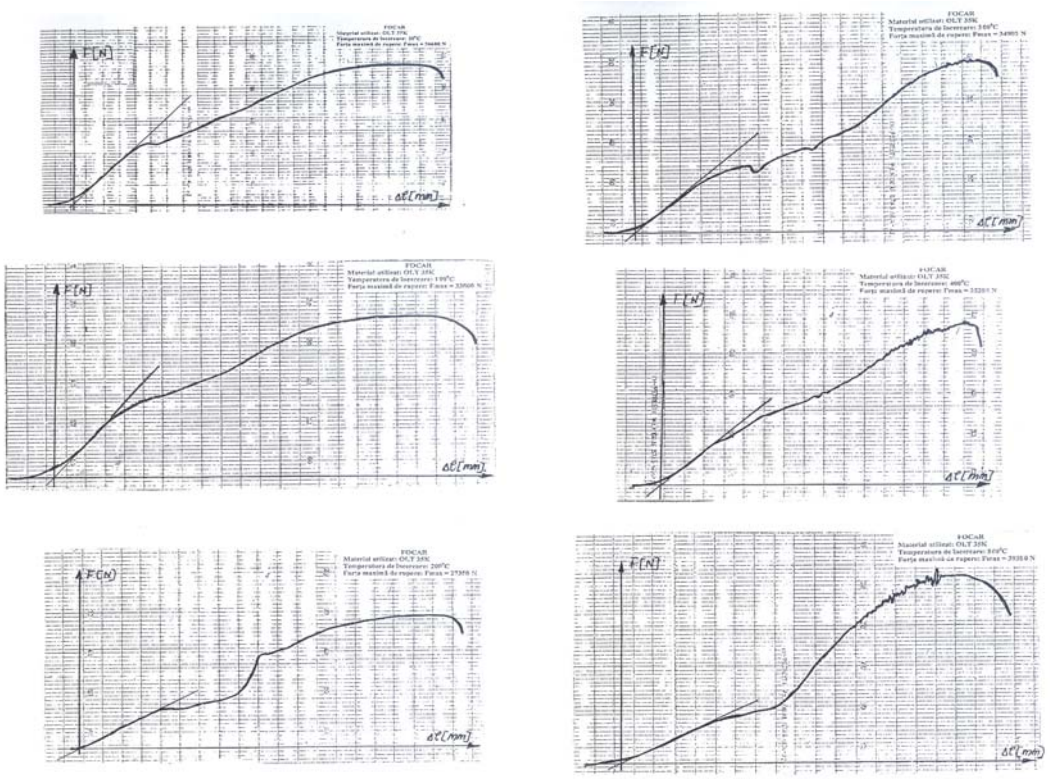


Fig.2. a÷f. F-Δl diagrams, at different temperature, obtained for OLT 35K, focus

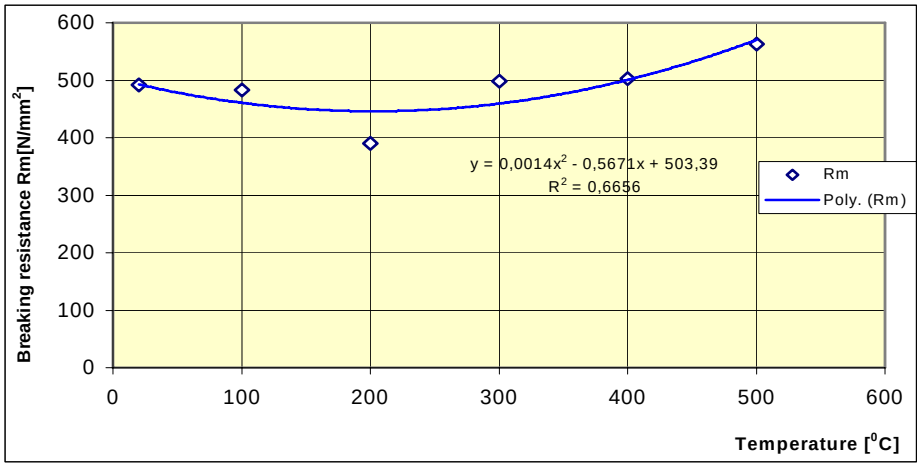



Fig. 3. Variation of characteristics $R_m$ for steel OLT 35K, by temperature

Looking at the dates, you can find out that while the temperature gets high, the breaking resistance $R_m$ and the after breaking percentage elongation gets lower, the first one reaching the temperature of 200°C and the second, 300°C. This could be explained by the fact that steel has lost some of its initial plasticity and resistance features, and still the breaking resistance experimentally established did not decline below the standard required values, for ambiant temperature, by working in the focus of a steam boiler.

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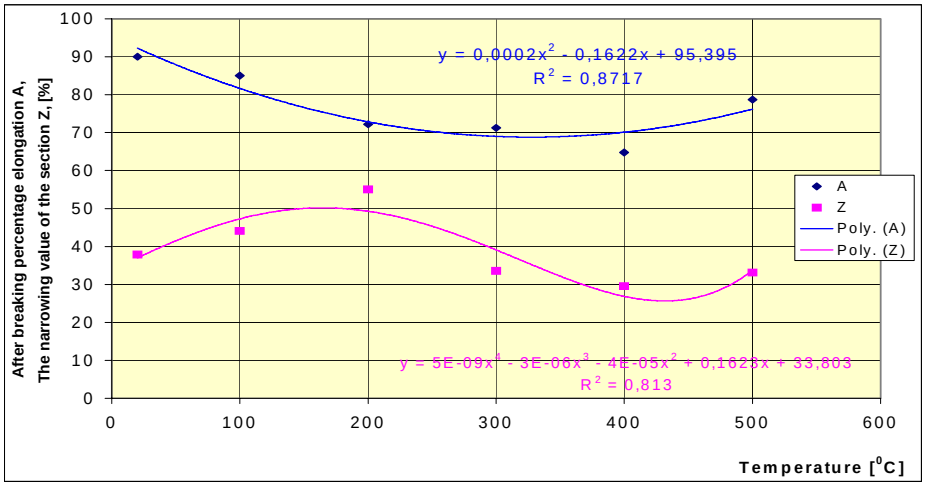



Fig.4. Variation after breaking percentage elongation A and The narrowing value of the section Z, for steel OLT 35K, by temperature

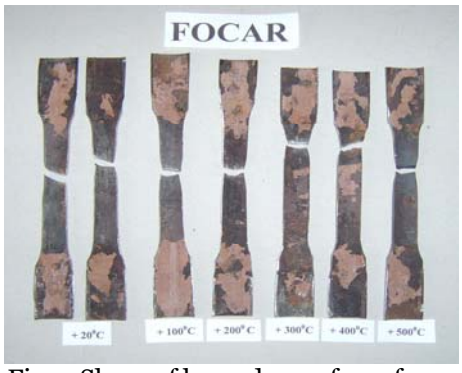



Fig.5. Share of bars, drawn from focus and tested at different temperature

The after breaking percentage elongation is valued between 90%, at temperature of 20°C (maximum) and 64,81%, at temperature of 400°C.

The narrowing value of the section is maximum valued at 55%, for the temperature of 200°C and minimum at 29,57%, for the temperature of 400°C.

Analysing the appeaance of the broken test-bars surface, you can say that temperature influences the critical tangen tension value from the sliding layouts and especially the diffusion process of carbon, so that at a temperature between 250...300°C, the diffusion speed of carbon atoms is great, which makes the dislocation movement possible (in accordance with Ludes lines), that are taking place in the material.

## 4. CONCLUSIONS

Following the metalographical analysis and the testing, it can be concluded that materials still offer great mechanical resistance features, as in the structure of the analysed steel there is a sufficient quantity of perlite and ferrite and fine granulation, which gives an important reason for continuing their exploitation.

A primordial objective to all thermal-electrical power stations is to extend the func'ional length of the elements that work at high pressure and temperature. This extent of the functional length cannot be done in any way, without knowing the real behavior of the material, but only by both strict use of the safety conditions and maintaining the best functioning parameters.

Avoiding the appearance of damage requires a good knowledge of mechanical, phisical, chemical, metalographical and any type of features, in as many conditions as possible, close to the ones in exploitation, which means knowing the real behavior of the material, knowledge that is based on theoretical research and experimental testing.

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# REGISTRATION AND PROCESSING OF FUNCTIONAL PARAMETERS VALUES FOR INTERNAL COMBUSTION ENGINES

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University Politehnica of Timişoara, Engineering Faculty of Hunedoara, ROMANIA

**Abstract:**
The article represents a study regarding the creation of a correlation between the functional parameters of the internal combustion engines, both diesel and petrol ones, with the help of the MATLAB mathematic software. The values of these parameters were registered with the help of the mega macs 55 equipment, in real time, the motor vehicles running in urban traffic.

**Keywords:**
internal combustion engine, correlations, mathematic software, intelligent diagnosis, OBD

## 1. INTRODUCTION

The best results in tracking down defects immediately after their appearance can be reached if the motor car systems performance is permanently supervised, which involves the development of certain on board diagnosis techniques and equipment. Their evolution has been and is closely linked to the evolution of motor car construction. Thus, the appearance of microprocessor-operated systems has enabled a considerable increase in the number of objectives monitored and the number of registered and analyzed parameters.

The OBD (On Board Diagnostic) system monitors the engine performances and evacuation emissions, including the self-test sensors during vehicle running, to make sure it works. The board computer can identify a problem before it is tracked down by the vehicle driver, warning him/her about the failure by displaying a bright light. Most bright witnesses will display “Check Engine," “Service Engine Soon" or an engine symbol.

As soon as the OBD detects a problem, a failure code (error) is registered in the motor vehicle computer. When the vehicle is placed on an OBD l/M checking tester, this code will help the technician track down and repair the defect.

OBD-II is a new standard introduced in the second half of the ‘90, insuring the engine and chassis, equipment accessories and car installation control almost entirely. OBD II is an extensive set of standards used by SAE, and adopted by EPA and CARB (California Air Resource Board).

Certain motor vehicle models equipped with OBD-II are not 100% compatible. There are three basic OBD-II protocols used, each with minor variations of the communication model between the board computer and scanning outrigger.

Based on the OBD-II protocols, and connecting a mega macs 55 tester, the main functional parameters were registered for two types of engines. These values were transferred to the MATLAB mathematic software, with whose help different correlations were created.

## 2. ENGINE TESTING

The study was conducted on two different engines, petrol and diesel, and the data were obtained with the help of the mega macs 55 equipment from Gutmann company.

The diagnosis of the engine management was made in urban traffic, the equipment being connected through the OBD coupling to the engine command central unit. The data prevailed are displayed in the form of the data shown in the pictures below.

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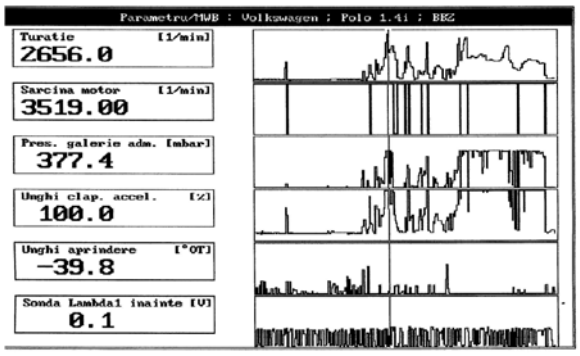



Figure 1. VW Polo, 1.4i engine

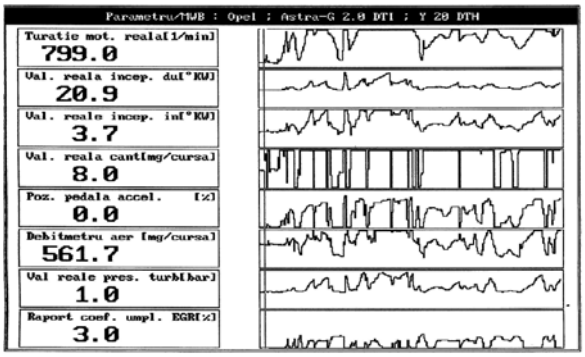


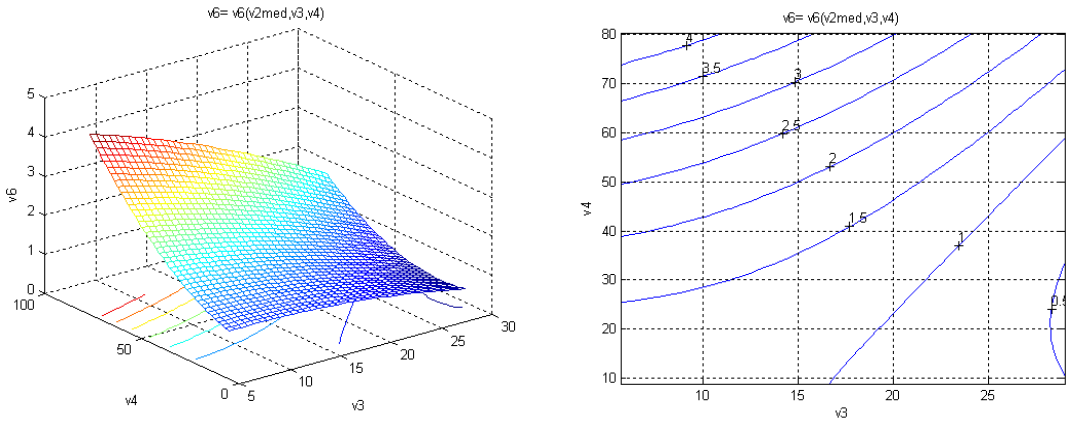

Figure 2. Opel Astra 2.0 DTI engine

As it can be observed, the system allows the registration of the engine functional parameters in graphic form, and by moving the cursor along the abscissa, in the left side of the display one can see the actual values of these parameters at a certain point in time.

## 3. PROCESSING OF EXPERIMENTAL DATA

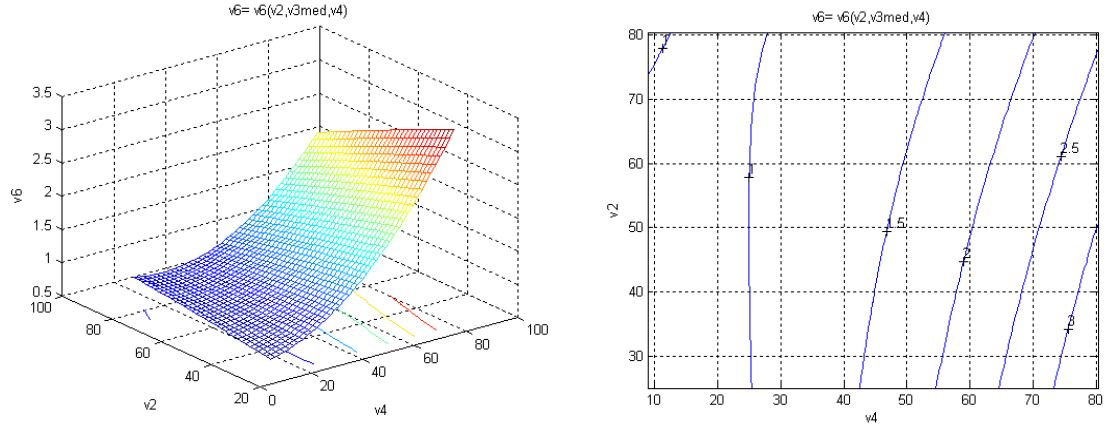
Following the measurements made in traffic, in a 15 minute interval, the data were introduced in a specialized processing program, thus a series of correlations being made, from which conclusions can be drawn referring to engine running in different revolutions and charges specific to urban traffic.

The study was conducted on the diesel engine fitted on the Opel Astra model and on the VW Polo 1.4i petrol engine.



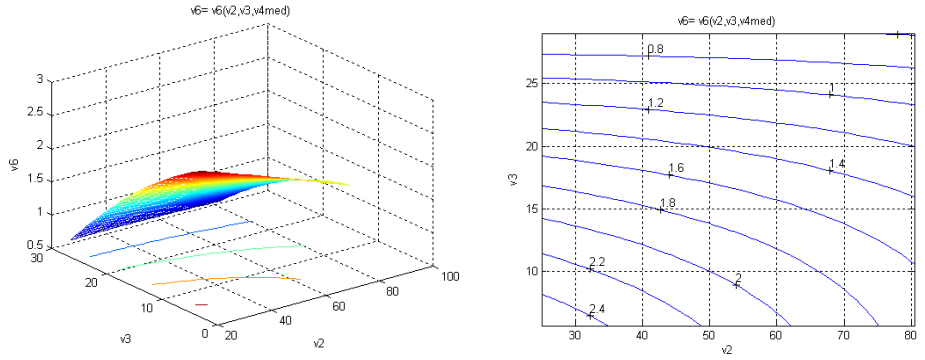

a. b.

Figure 3. Real value of the oversupply pressure (v6) function of the real quantity injected (v3) and the acceleration lever position (v4) for the Opel Astra engine



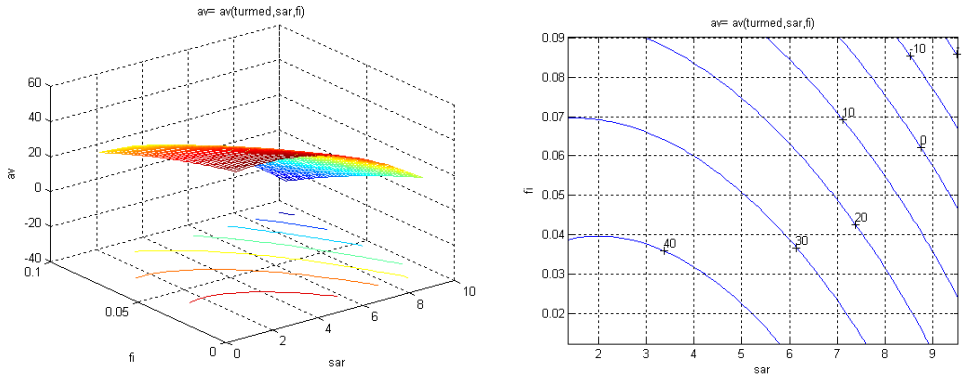

a. b.

Figure 4. Real value of the oversupply pressure (v6) function of the real advance in the injection (v2) and the acceleration lever position (v4) for the Opel Astra engine



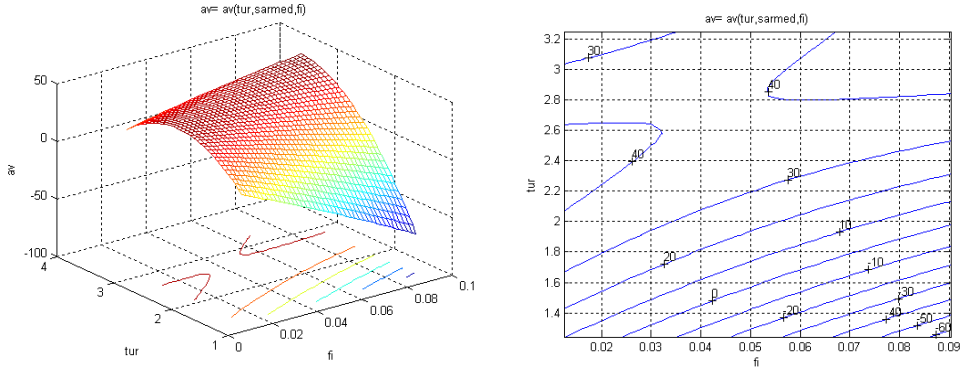

a. b.

Figure 5. Real value of the oversupply pressure (v6) function of the real advance in the injection (v2) and the real quantity injected (v3) for the Opel Astra engine



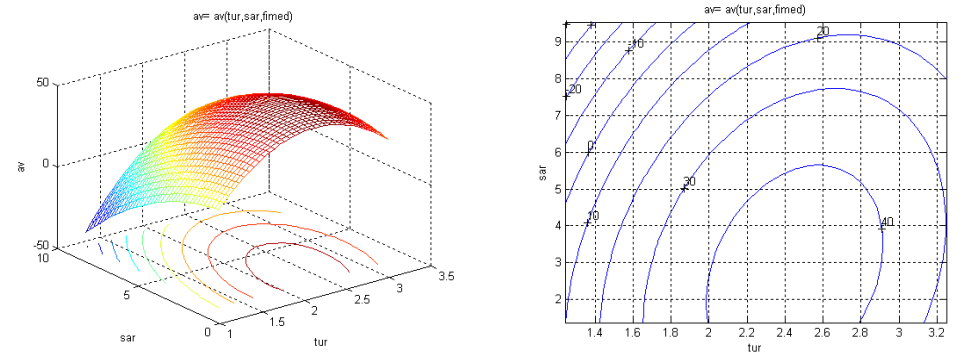

a. b.

Figure 6. Value of the advance function of load and the acceleration choke opening angle for the VW Polo 1.4i engine




a. b.

Figure 7. Value of the advance function of revolution and the acceleration choke opening angle for the VW Polo 1.4i engine




a. b.

Figure 8. Value of the advance function of revolution and load for the VW Polo 1.4i engine

## 4. ANALYSIS OF RESULTS AND CONCLUSIONS

The registration system of the engine functional parameters allows only the sequence visualization of the prevailed data, based on which conclusions can be drawn regarding the functioning of different components.

Once these data are introduced in a specialized processing program, they can offer global information regarding the correlations which the command electronic unit makes during engine running between the different components that interact with one another.

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# STUDY ON THE VARIATION OF CONVENTIONAL FLOW LIMIT DEPENDING ON THE MAIN ALLOY ELEMENTS FOR THERMORESISTANT STEEL

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**Abstract**:
The paper presents the results of the research made under laboratory experimental testing, on OLT45K steel, intended to the manufacturing of tubes, used at high temperature in the make-up of thermal-energetic installation. Mechanical driving testing has been made at the temperature of 450°C, on shares of test-bars drawn out of a number of 50 charges, with a view to achieving the optimization of the chemical composition of this steel type. The optimization, under experimental dates, suggests alternatives of combinations among the main elements of the chemical composition, so as the steel can be elaborated with superior mechanical features at high temperature. The obtained results have a large feasibility area, and can be also endorsed for other steel types and mechanical features for which the optimization is viewed, therefore being very useful to technologists, in the process of achieving a certain type of steel.

**Keywords**:
high temperature, thermal resistant steel, mechanical testing, life-length, mechanical feature.

## 1. GENERAL APPRECIATION

Generally, any research elaboration implies some stages: gathering the dates, their modeling and the decisional working out. The informational pattern-making follows 3 steps: manual, mechanical and automatic.

Its results have to be presented in a shape which makes them utilizable by the beneficiary, no matter the pattern-making method.

A new and important problem, raised in the study of multidimensional reparations, concerns the bound among the analysed variables and through them, among the phenomena they represent, known as **correlation**. It includes two fundamental problems: the first consists in describing the medium variation law of a variable depending on another (or other) variable(s), known as the **problem of regression** and settled under the regression function, and the irrespective of the linked variable measures.

Estimating and sizing the thermal-electric power station pipes is extremely detailed and expensive, regarding the use of the finite element programmes, as it is very hard to specify all the testing which the pipe system is to be requested, during the estimated life length. Extreme situations and possible exploitation accidents are also hard to estimate.

This is the reason of choosing as a subject of the paper the making of multiple correlations, II figure, which offers information on the influence of two of the chemical composition elements on the technical running limit at the temperature guaranteed by the metal manufacturer. From the graphical representation and knowledge of the outline values, we can establish the desired value of the mechanical feature, for any content of an element found in the chemical composition. We can also establish the best variation fields of these elements, varying with the desired values of the studies parameter.

## 2. EXPERIMENTAL DATES

The numerical studies had as starting point the driving experimental testing at heat, made on shares of test-bars drawn out of a number of 50 charges of OLT 45K steel, endorsed into an electrical oven equipped with a spring, whose chemical composition is presented in [1] paper.

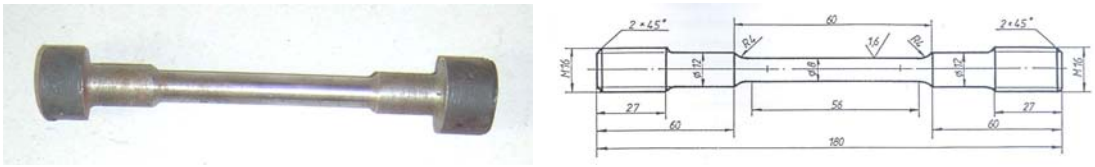


Fig.1 The shape and size of test-bars used in testing

Three test-bars have been tried for each charge, their shape and size being shown in fig.1.

## 3. ESTABLISHING THE NUMERICAL STUDIES

By using the experimental dates obtained after laboratory testing, it went forward to establishing some graph correlations, using MATLAB 5.0 programme. Files with experimental dates and those obtained by the rolling of the used programmes, can be found in [1] paper. The numerical results, obtained by rolling the programme are sizable, for which they are not presented in the paper. Then, the graphs obtained by mathematical pattern-making of the results.

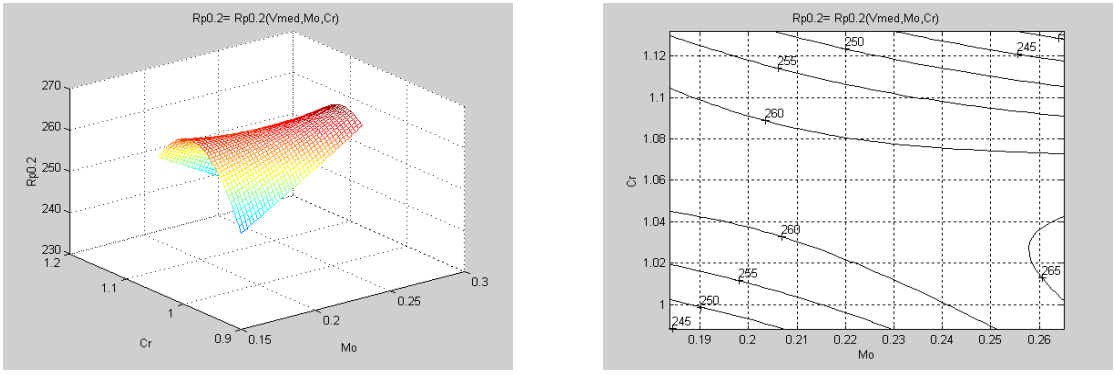



Fig.2 The variation of the technical running limit $R_{p0,2/450}$, containing manganese and silicium, taking into consideration the medium percentage of carbon

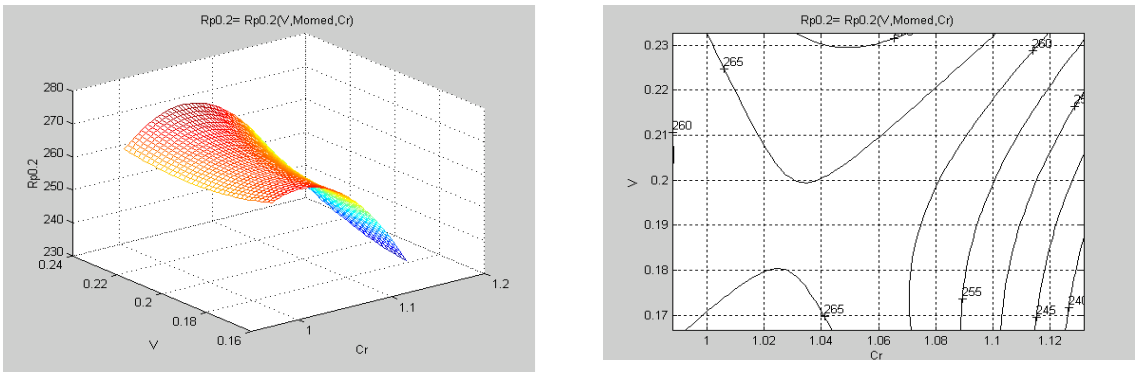



Fig.3 The variation of the technical running limit $R_{p0,2/450}$, containing carbon and silicium, taking into consideration the medium percentage of manganese

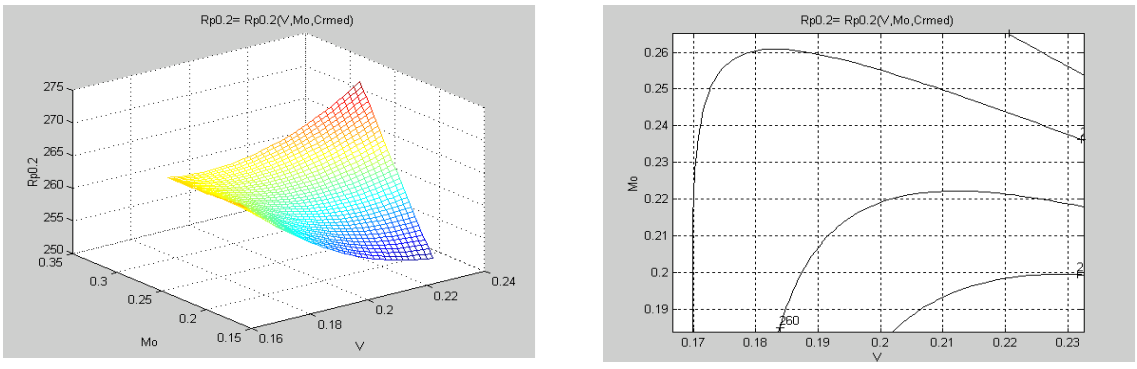



Fig.4 The variation of the technical running limit $R_{p0,2/450}$, containing manganese and carbon, taking into consideration the medium percentage of silicium

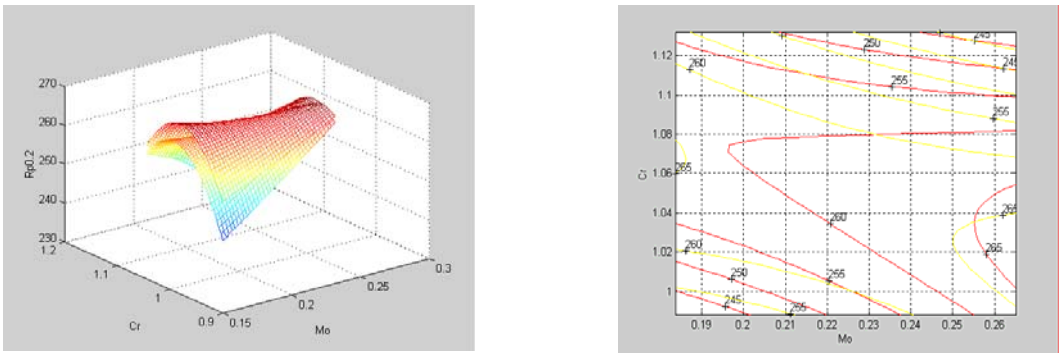



Fig.5 The delimitation of the best field for the technical running limit $R_{p0,2/450}$, depending on the manganese and silicium content, taking into consideration the medium percentage of carbon

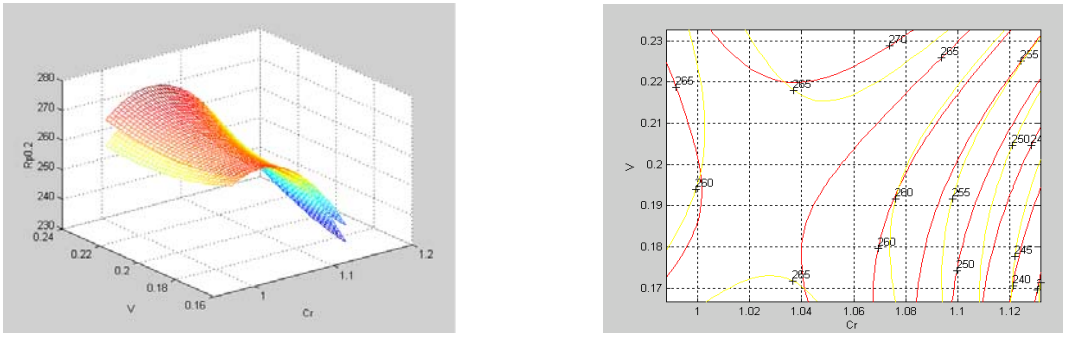



Fig.6 The delimitation of the best field for the technical running limit $R_{p0,2/450}$, depending on the carbon and silicium content, taking into consideration the medium percentage of manganese

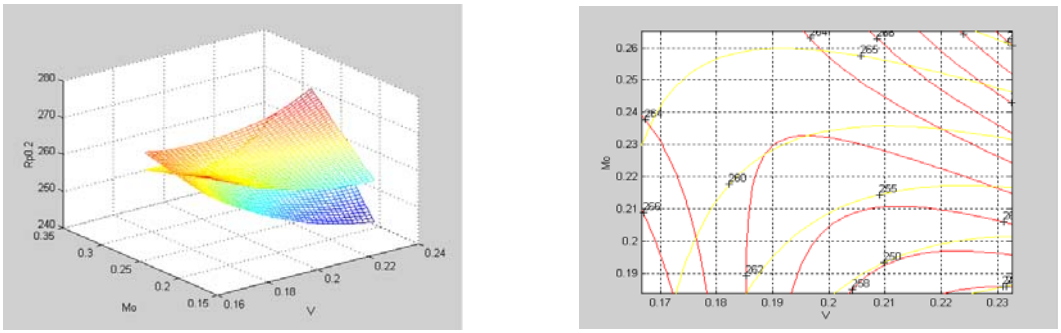



Fig.7 The delimitation of the best field for the technical running limit $R_{p0,2/450}$, depending on the carbon and manganese content, taking into consideration the medium percentage of silicium

Because of the huge size of dates found in such a processing of experimental dates, we stopped, focusing on the mechanical feature $R_{p0,2/450}$, which must be guaranteed by the metal manufacturer, for the analysed steel.

The most important feature of this steel category at high temperature is the conventional running limit at heat. This is the reason why the study has been made for establishing combinations of the best chemical composition and through the working process, for the steel to have superior mechanical features. Therefore, the obtained results follow the way of the conventional running limit for combinations of three main elements of the chemical composition. Through the multidimensional numerical pattern-making of the experimental dates, it was tried the finding of a modeling of the dependent variable, considering the independent variables x, y, z as:

$$u = C_1 \cdot x^2 + C_2 \cdot y^2 + C_3 \cdot z^2 + C_4 \cdot x \cdot y + C_5 \cdot y \cdot z + C_6 \cdot z \cdot x + C_7 \cdot x + C_8 \cdot y + C_9 \cdot z + C_{10} \quad [1]$$

The variation limits of the variable are:

[%C] = 0,16...0,23; [%Mn] = 0,51...0,83; [%Si] = 0,16...0,35; $Rp_{0,2/450}$ = 169...255.

The medium values and the medium square deviation of the variables are:

[%C]:0,18563...0,01886; [%Mn]:0,66375...0,09545; [%Si]:0,235...0,047697; [$Rp_{0,2/450}$]: 08,95...17,193

The correlation coefficient is valued: rf = 0,65599451703118,

and the deviation from the regression area is: sf = 12,97668845383391

The maximum established on the 50 charges sample is given by:

$$R_{p0.2} = 19828{,}0654 \cdot [\%C]^2 - 268{,}3624 \cdot [\%Mn]^2 + 571{,}8135 \cdot [\%Si]^2 + \\ - 2984{,}07 \cdot [\%C] \cdot [\%Mn] + 148{,}8591 \cdot [\%Mn] \cdot [\%Si] + 1182{,}9936 \cdot [\%Si] \cdot [\%C] + \\ - 5668{,}4577 \cdot [\%C] + 962{,}9562 \cdot [\%Mn] - 672{,}8277 \cdot [\%Si] + 472{,}3753 \quad [2]$$

These 4 dimensional surfaces allow a *saddle point* of coordinates:

[%C] = 0,19417; [%Mn] = 0,79343; [%Si] = 0,2842; Rp0,2/450 =208,473.

The existence of the saddle point is very important as it assures a stability of the feature close to this point, being it preferable or avoidable. In this case, it is preferable. The behavior of these hyper surfaces close to the saddle point can only be studied as tabular, which means ascribing values on concentric spheres of the studied point to the independent variable. Because of the fact that this surface cannot be represented in 4 dimensional spaces, it has been chosen the successive replacement of each independent variable, with its medium value, and obtaining the following equations:

$$R_{p0.2}C_{med} = -268{,}3624 \cdot [\%Mn]^2 + 571{,}8135 \cdot [\%Si]^2 + 148{,}8591 \cdot [\%Mn] \cdot [\%Si] + \\ + 409{,}0382 \cdot [\%Mn] + 453{,}2345 \cdot [\%Si] + 103{,}3764 \quad [3]$$

$$R_{p0.2}Mn_{med} = 571{,}8135 \cdot [\%Si]^2 + 19828{,}0654 \cdot [\%C]^2 + 1182{,}9936 \cdot [\%Si] \cdot [\%C] - \\ - 574{,}0225 \cdot [\%Si] - 7649{,}1341 \cdot [\%C] + 993{,}3067 \quad [4]$$

$$R_{p0.2}Si_{med} = 19828{,}0654 \cdot [\%C]^2 - 268{,}3624 \cdot [\%Mn]^2 - 2984{,}07 \cdot [\%C] \cdot [\%Mn] - \\ - 5390{,}4542 \cdot [\%C] + 997{,}938 \cdot [\%Mn] + 345{,}8392 \quad [5]$$

These surfaces which belong to the 3 dimensional spaces can be represented and therefore interpreted by technologists. The surfaces are shown in fig.2, fig.3, fig.4, fig.5, fig.6 and fig.7. For a more exact analysis, the corresponding level curves have been shown next to these. The knowledge of the level curves allow the establishing of the two independent variable values, so as $R_{po,2/450}$ can be obtained, within the limits required or imposed by the beneficiary.

By looking at the graphs shown in fig.2, and considering %C an average, you can estimate that maximum values of $R_{po,2/450}$ feature can be obtained for 0,50% Mn and 0,14% Si, values which are close to the inferior limit of the composition imposed by standard. From fig.3, considering % Mn an average, you can say that maximum values of $R_{po,2/450}$ (230 N/mm2) features can be obtained for C concentrations within the 0,12 – 0,14% limits and Si within the 0,15 – 0,18% limits, subfields which are close to the inferior limit of the composition imposed by standard. From the graphs shown in fig.4, and considering % Si an average, you can estimate that while the C and Mn grow, the $R_{po,2/450}$ conventional running limit grows as well. The diagrams in fig.5, fig.6 and fig.7 show the limits of the maximum field, where the metallurgic engineer can choose the element percent of the chemical composition, in order to obtain steel having the desired features of the manufacturer. Knowledge of the level curves for these maximum fields allows the correlation of the two independent variable (the contents of the chemical element) so that $R_{po,2/T}$ can be obtained within the limits asked by the beneficiary.

## CONCLUSIONS

These results allow the establishing of the best C, Mn, Si contents from the chemical composition of 12VMoCr10, so that, by the end of the elaboration, steel can possess certain imposed mechanical features.

The analysis has been done for 3 elements of the chemical composition, being able to enlarge it for both other elements, depending on the desired chemical composition and other types of steel.

Taking into consideration that the way in which one charge is done has a deep importance on the mechanical features of the steel, knowledge of these correlations is really significant for the engineer, because he is the one to estimate the values of the imposed parameter, depending on the chemical composition which allows him the adjustment of the chemical composition during the elaboration, in order to obtain the features desired by the beneficiary.

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# APPLICATION OF THE SQUIRREL CAGE ASYNCHRONOUS MACHINE WORKING AS SINGLE PHASE GENERATOR IN MICROHYDRO POWER PLANTS

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Department of Electrical Engineering and Industrial Informatics, ROMANIA

**Abstract**:
Today the hidroenergy potential of Romania is used only in proportion of 60 %. There are in work several project concerning the arrangement of several water flows (Jiu, Strei, Bistrita, Mures). This will increase the overall percent up to 70 % in 2020.
However it remains an important percent of usable potential which can be integrated by technology upgrade or building of new power plants.
The asynchronous generator is a more efficient solution for small installed power and especially where the electric consumers are single phase and the electrical grid is isolated from the main grid.

**Keywords**:
asynchronous machine, single phase generator, mathematical model

## 1. INTRODUCTION

Power is the vital input for economic development for any developing country. Technologies being at its zenith, many methods for the generation of power have been developed. Owing to the perpetual increase in energy needs it is difficult to meet the growing demand by exploiting energy from the limited conventional sources such as coal, oil, gas, etc. In consequence a greater emphasis is now being given to the harnessing of energy from non conventional energy sources such as wind, micro and mini hydro and solar [1].

As a result of increasing environmental concern, more and more electricity is generated from renewable energy. The main advantage of electricity generation from renewable sources is the absence of harmful emission and the infinite availability of the prime mover that is converted to electricity [2].

With continuing energy crises, utilities in poor country's are finding it increasingly difficult to establish rural area electrification. The cost of supplying electrical power through grid to such areas is becoming excessively high to the large investments in transmission lines losses. Far these reasons the stand-alone decentralized power generating stations using non-conventional energy sources like wind, micro and mini hydro are being considered for electrifying rural and remote areas [1].

Taking into account its simplicity of use and its modest cost comparated to a synchronous machine, the asynchronous machine is as susceptible to function in generating in power stations of production of the electric energy. In this case, the slip is negative and the rotor turns in the direction of the spinning field pattern at a slightly higher speed. The generator provides the active power to the utility, but the reactive power necessary to its supply is provided by the utility. An isolated operation of the induction generator is possible. The convert of renewable energy is mainly equipped by both asynchronous generators and capacitors of self- excitation [3].

In many papers is investigated the ability of some dynamic self- asynchronous generator models to predict the output voltage depending of the variation of turbine speed (figure 1).

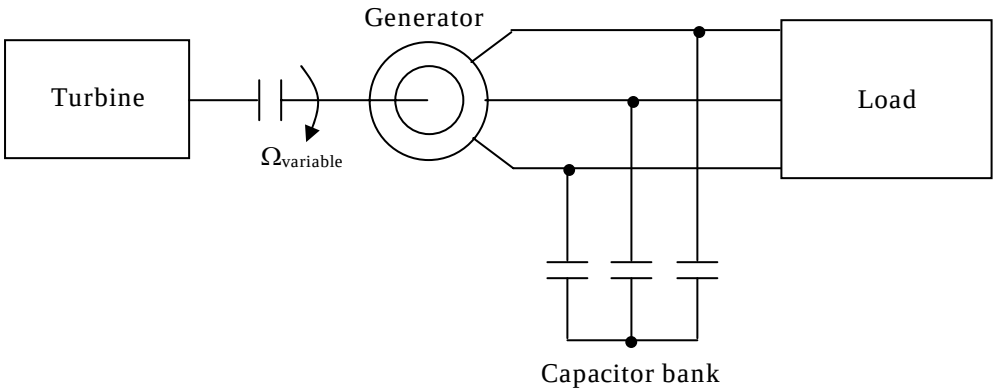



Figure 1 Self-excited asynchronous generator

Low-power generators (say up to 10 kW) invariably feed a single-phase supply system. Since it has been found that a normal single-phase asynchronous motor cannot be effectively used as self-excited generator, a specially designed two-winding single-phase has been proposed in [4]. Since this requires modified manufacturing procedures, and hence is expensive, the alternative of using off the shelf three-phase load asynchronous motor as an self-excited asynchronous generator to feed single-phase load appears attractive. This requires a suitable balancing system to achieve balanced wending currents and to obtain maximum output with minimum losses [5].

Large numbers of exploitable small hydro sites exist in several countries with capacities ranging from 5 to 50 kW, mostly needing to feed single-phase loads. The use of three-phase asynchronous motors as self-excited asynchronous generator to feed such loads makes practical sense. The present paper provides theoretical support to such promising technologies.

## 2. STATEMENT OF THE PROBLEM

When the rotor speed of asynchronous machine is greater than the synchronous speed of air gap revolving field, then the same asynchronous machine can be act as asynchronous generator.

As a generator asynchronous machine has severe limitation. Because it lacks a separate DC field current, an asynchronous generator needs AC excitation current. The self excitation phenomenon using external capacitors is well known. If an appropriate capacitor is connected across the terminals of an externally driver asynchronous machine as shown in figure 1, an emf is induced in the machine wending to the excitation provided by the capacitor[1],[6].

Induced voltage and current will continue to rise until the VAR supplied by the capacitors is balanced by the VAR demanded by the machine, a condition that is essentially divided by on saturation of the magnetic circuit.

Let us consider that the machine has an initial residual flux (or same means are provided to inject an initial current into the stator windings), and the rotor is propelled by some external mechanical power source, such as on fuel engine, hydraulic turbine, etc. If external capacitors of adequate values are connected to the stator windings, self excitation occurs. The magnitude of the generated voltage will depend among other things on the capacitance value, the load current, and the load power factor. Considering steady state operation it is possible to observe three regions clearly differentiated: a) a stable zone corresponding to operation in the saturated region of the magnetic core; b) an unstable zone, corresponding to operation on the linear region of the magnetic core; and c) a region of no-generation. In the first case the linear curve of the excitation capacitors intersect the care magnetizing curve at a well defined point. In the second case, the intersection is not well defined, far it occurs at an infinite number of points. In the third case, the only intersection occurs at the origin as is shown in figure 2 [6].

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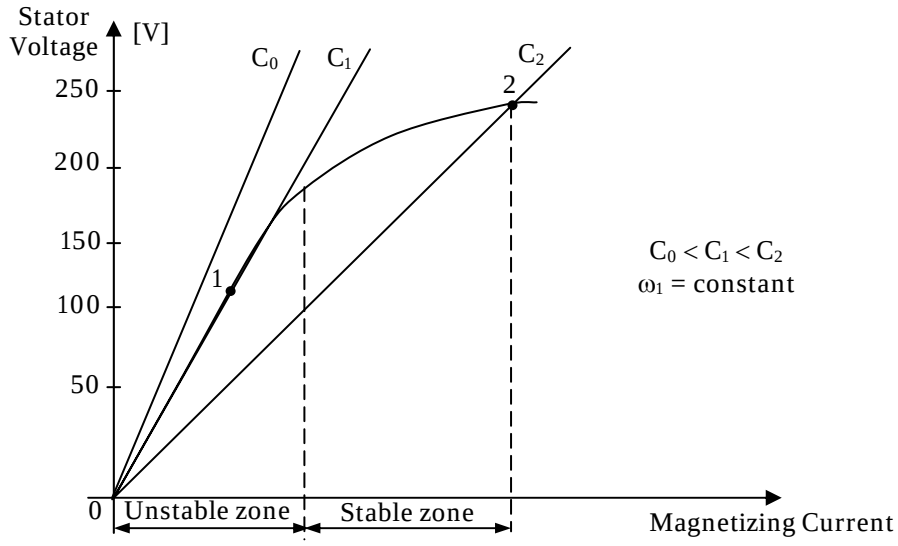



Figure 2 Magnetizing characteristic of a self-excited asynchronous generator

Let us assume that the machine is actually operating at point 1 in figure 2. If a capacitor of value $C_2$ is connected, the new generated voltage will be determined by the machine characteristic curve, and will evolve from point 1 to point 2 with a definite time constant. Conversely, if the capacitor is reduced from a value $C_1$ at point 1 to a value $C_0$, smaller that $C_1$, the magnetizing current will not be compensated by an identical but leading current component. In this case, the machine will first try to save the situation by dropping some of its magnetizing current in order to reach another stable operating point along its magnetizing curve. This results in a lower air gap voltage and a consequently lower flux; the slip will increase and finally the machine will stop generating (intersection an origin in figure 2). Fortunately, the time constants involved in either situation (voltage increase or decrease) are lower than the generation period, this fact allows corrective commutation actions to be taken to keep the average leading current around its required value [6].

## 3. EXCITATION REQUIREMENTS OF SELF-EXCITED ASYNCHRONOUS GENERATOR (SEAG)

The minimum capacitance ($C_m$) for the excitation of asynchronous generator is obtained from no load test. On no load, the capacitor current ($I_c$) must be equal to the magnetizing current ($I_m$), under stabile operating:

$$I_m = I_c \tag{1}$$

$$\frac{U}{X_m} = \frac{U}{X_c} \tag{2}$$

$$X_c = X_m \tag{3}$$

where

$$X_c = \frac{1}{2\pi f \cdot C} \tag{4}$$

From no-load test we calculated the magnetizing reactance $X_m$ by applying the rated voltage of the machine and find out the magnetizing current ($I_m$). The value of minimum capacitance C for self-excitation is

$$C_m = \frac{1}{2\pi f} \cdot \frac{I_{mphase}}{U_{phase}} \tag{5}$$

The most serious problem with an asynchronous generator is that its voltage varies widely with changes in load, especially reactive load. In order to maintain constant voltage, reactive current must be controlled from no load to full load. Hence special technologies

must be employed to increase the effective capacitance during starting and decrease it during normal operation. [1].

In self-excited mode, output frequency and voltage are affected by speed, the load and terminal capacitor. Changing any of above parameter will change the frequency and magnetizing reactance of asynchronous generators [1].

The schematic diagram of a three phase delta connected self –excited asynchronous generator feeding a three phase unbalanced load is shown in figure 3. The delta connection is deliberately here since a star connected three phase asynchronous motors has be reconnected in delta to feed single phase loads.

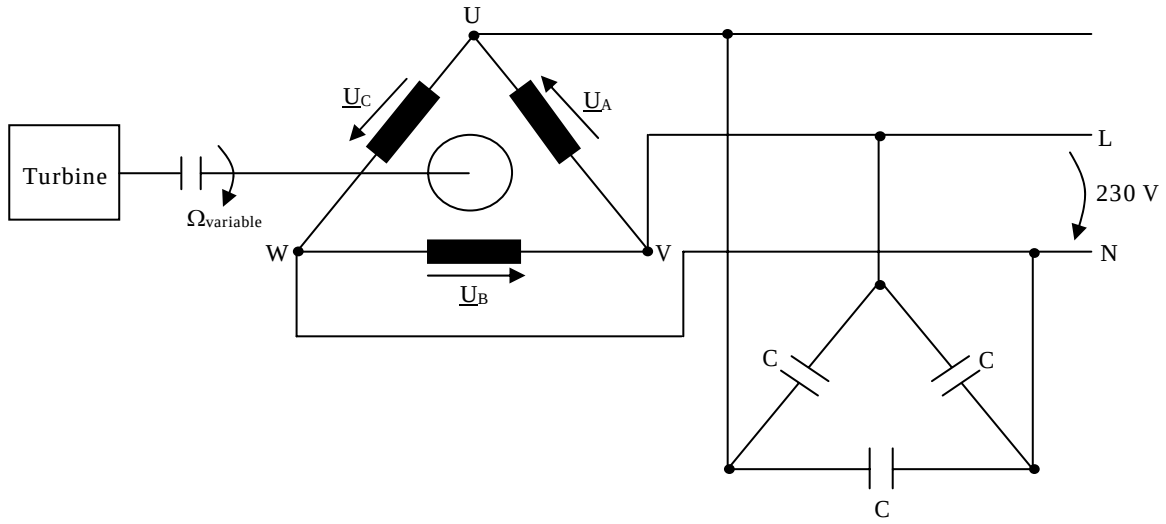



Figure 3 Schematic diagram of self-excited asynchronous generator

## 4. SIMULATION RESULTS OF THE SEAG

In order to evaluate the operating principles of the self excited asynchronous generators we consider two situations: three phase operation in grid connection mode and single phase connection mode.

### 4.1. Three phase grid connected operation of the SEAG

The equivalent model of the SEAG operating in three phase mode is presented in fig. 4.

The equivalent per phase impedance seen by the terminals [7] represented in equation (6) is :

$$\underline{Z} = R_1 + jX_1 + \frac{1}{\frac{1}{jX_m} + \frac{1}{R_m} + \frac{1}{R_2/s + jX_2}} \tag{6}$$

where $R_1$, $X_1$ is stator resistance and reactance, $R_2$, $X_2$ is rotor resistance and reactance $R_m$, $X_m$ magnetizing equivalent resistance and reactance, $s$ is slip , $F$ is frequency , $v = n_s/n_r$.

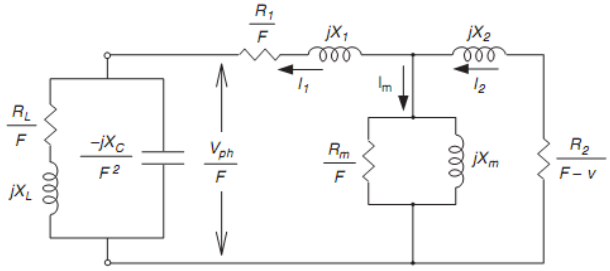



Figure 4 Equivalent circuit diagram of self-excited asynchronous generator

In order to simulate the operation of the SEAG it is necessary to use the d-q model of the SEAG. The d-q model of the induction generator in flux linkage state variables is given in equation (7):

$$\begin{cases} p\lambda_{qs} = V_{qs} - (R_s / L_{1s})(\lambda_{qs} - \lambda_{mqsat}) \\ p\lambda_{ds} = V_{ds} - (R_s / L_{1s})(\lambda_{ds} - \lambda_{mdsat}) \\ p\lambda_{qr} = \omega_r V_{qr} - (R_r / L_{1r})(\lambda_{qr} - \lambda_{mqsat}) \\ p\lambda_{dr} = \omega_r V_{qs} - (R_r / L_{1r})(\lambda_{dr} - \lambda_{mdsat}) \end{cases} \quad (7)$$

where $V_{ds}\, V_{ds}$ represents d, q axis voltages $\lambda_{qs}, \lambda_{ds}$ d, q axis flux linkages, $\lambda_{mqsat}, \lambda_{mdsat}$ d-q saturated magnetizing flux, $R_s, R_r$ stator and rotor resistance, $L_{1s}, L_{1r}$ stator and rotor inductance , $\omega_r$ rotor speed.

The d-q model of the load side that consists of the excitation capacitors $C_s$ in parallel with an inductive load is given by equation (8):

$$\begin{cases} pQ_{qs} = -I_{qs} - I_{qL} \\ pQ_{ds} = -I_{ds} - I_{dL} \\ pI_{qL} = (V_{qs} - R_L I_{qL}) / L \\ pI_{dL} = (V_{ds} - R_L I_{dL}) / L \end{cases} \quad (8)$$

where $I_{qs}, I_{ds}$ is d, q axis current, $Q_{qs}, Q_{ds}$ charge across excitation capacitor, $R_L, L$ load resistance and inductance, $Q_s$ represents the charge across the excitation capacitor. The mechanical equation that describes the prime mover is:

$$\frac{d\omega_r}{dt} = \frac{P}{2J}(T_L + T_e) \quad (9)$$

$$T_e = (3/2)(P/2)(\lambda_{ds} I_{qs} - \lambda_{qs} I_{ds}) \quad (10)$$

where $T_e$ is the asynchronous generator electromechanical torque, $T_L$ is the mechanical load torque , $p$ is the induction generator number of poles, $J$ is the total inertia of the generator and the prime mover machine.

The parameters of test machine are given table 1. The simulation model of the SEAG is build in PSIM software (figure 5). The setup consists in two asynchronous identical machines from which one acts as prime mover. The prime mover machine is a electric drive running a constant speed above the synchronous speed of the SEAG generator.

Table 1. SEAG data

| Parameter name | Symbol | Value |
|---|---|---|
| Stator resistance | Rs | 0.294 |
| Stator inductance | Ls | 0.00139 |
| Rotor resistance | Rr | 0.156 |
| Rotor inductance | Lr | 0.00074 |
| Magnetising inductance | Lm | 0.041 |
| Moment of inertia | J | 0.0131 |
| Friction factor | F | 0.002985 |
| Pole pairs | p | 2 |

The main steady state characteristics of SEAGs are to be obtained at constant (given) speed though a prime mover, such as a constant speed small hydroturbines, does not have constant speed if unregulated.

The self excitation transients of the of the three phase generator operating in grid conection mode with three phase output are presented in fig. 6 and 7.

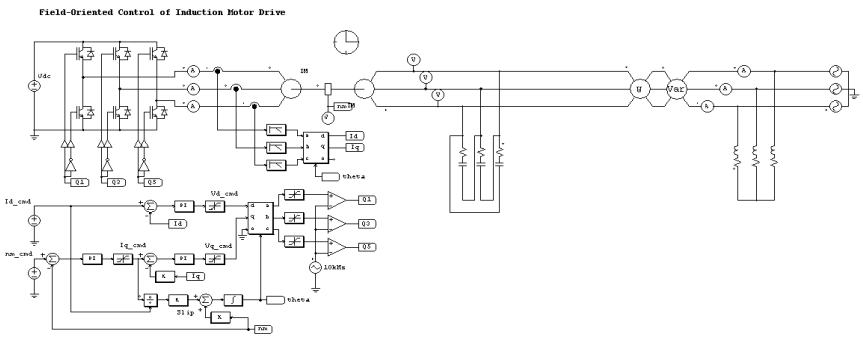
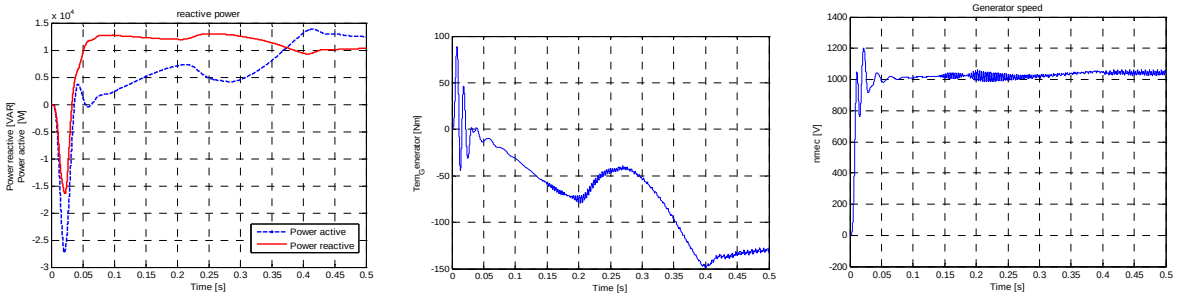
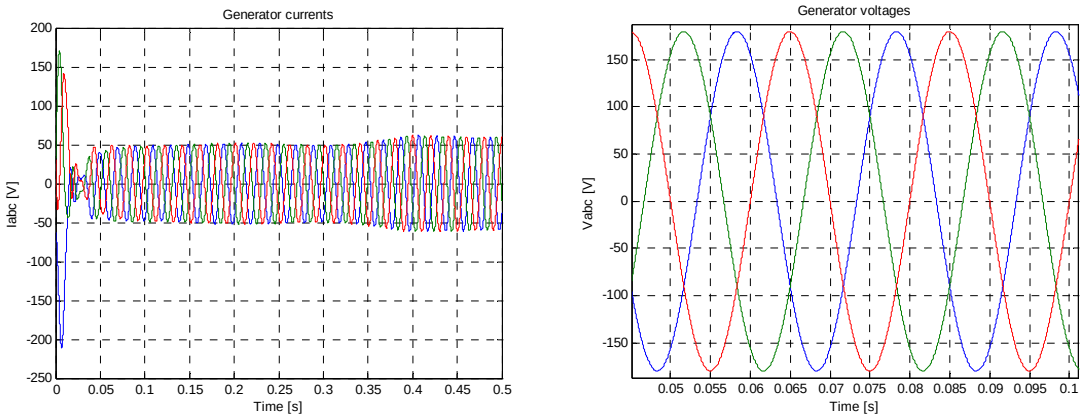



Figure 5 PSIM model of the tree phase SEAG




a) b) c)

Figure 6 Simulation results when SEAG is connected to a 3 phase grid
a) active and reactive power; b) electromagnetic torque; c)speed



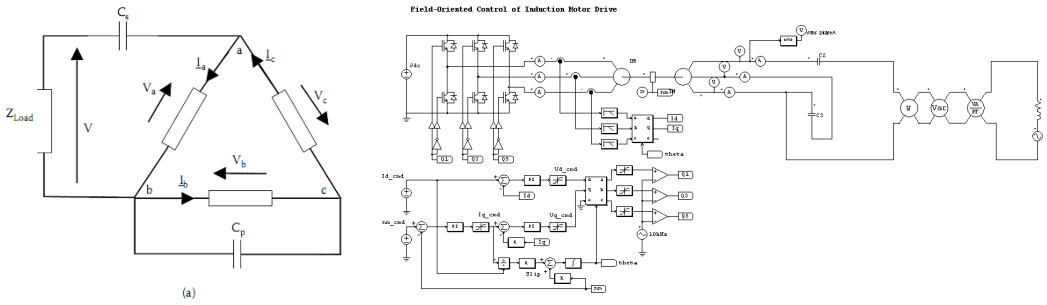

a) b)

Figure 7 Simulation results of generator currents and voltages

The reactive and active energy of SEAG during the startup function working as stand alone generator in three phase grid is presented in fig. 6a. As it can be noticed the required reactive energy varies during generator wakeup and reaches a minimum when the generator is running in steady state mode. The active power in the three phase grid also changes sign during generator wakeup injected/absorbed. The electromagnetic torque of the generator presents no pulsations.

### 4.2. Simulation of three-Phase SEAG with Single-Phase Output

When the SEAG is operating with a single phase load , the machine operates under unbalanced conditions thus it is imposed a different connection of the SEAG excitation capacitors. We consider here Steinmetz capacitor excitation connection [8] presented in figure 8 a.




a) b)

Figure 8 SEAG Steinmetz excitation connection and PSIM simulation test model

For the simulation of the SEAG in this operation mode we have implemented the generator model into the PSIM software figure 8 b. The single phase electromagnetic torque of the SEAG is presented in fig. 9.

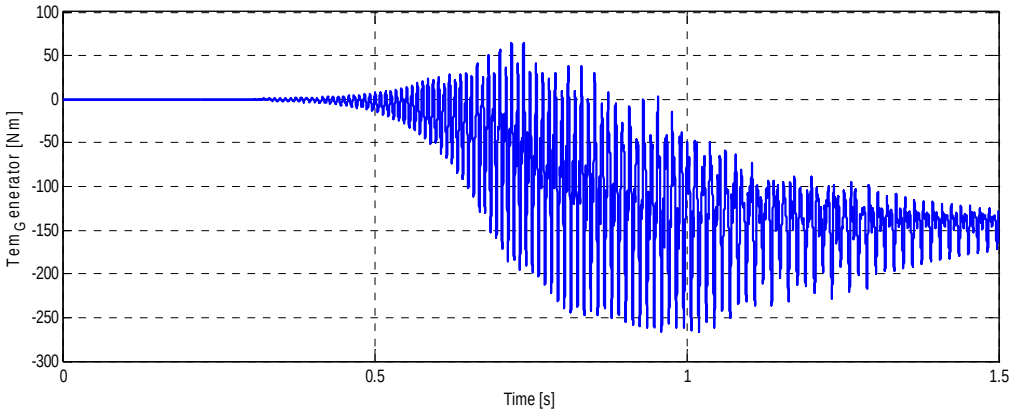



Figure 9 Electromagnetic torque of the SEAG operating in single phase grid connection

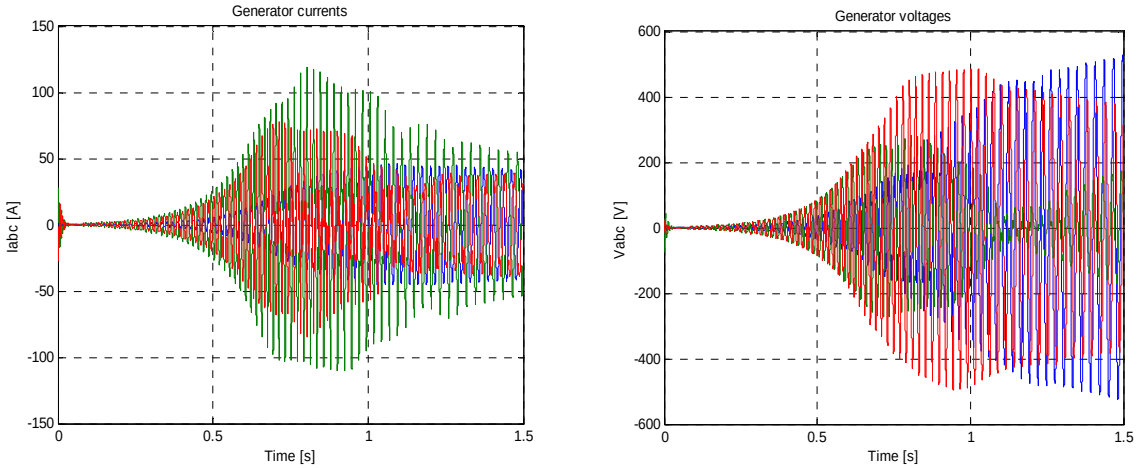



Figure 10 Generator currents and voltages when the SEAG is connected to one phase grid

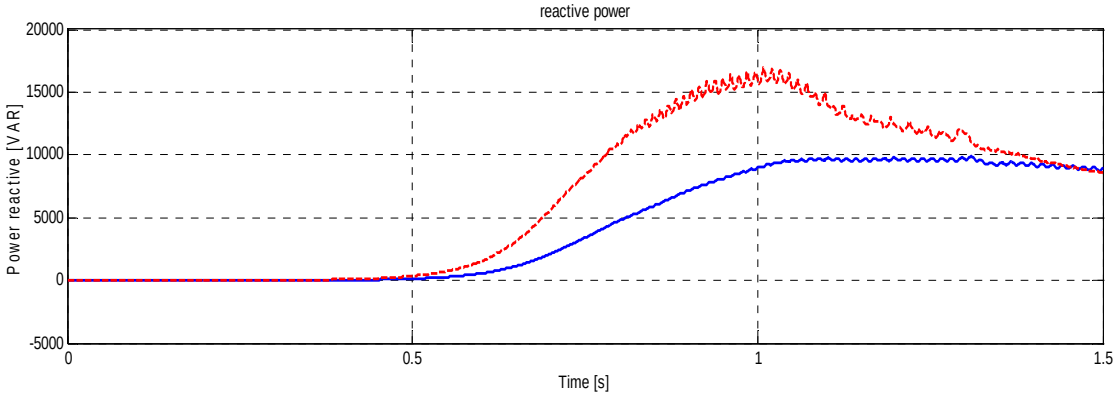



Figure 11 Active power and reactive power of the SEAG

Figure 10 and 11 shows transients of the SEAG during startup of the generator.

## 5. CONCLUSION AND FUTURE WORK

In the present paper we consider the operation of the single phase SEAG during self excitation process for two situation three phase grid operation and single phase grid operation. The necessary reactive power is evaluate in both cases. As it can be observed the torque pulsations are not negligible and the current pulsations are present. In order to operate the SEAG in single phase grid connection a special attention should be accorded to symmetrisation scheme and capacitor selection.

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# YIELD FACTORS OF A PHOTOVOLTAIC PLANT

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**Abstract**:
The paper gives the definition of the main yield factors that characterizes the performances of a photovoltaic plant. This are analyzed for a grid connected photovoltaic plant at the University in Resita, in use since spring 2008, were the main climatic and technique parameters of the photovoltaic plant are monitoriesed and heaped in an data base for further analysis.

**Keywords**:
yield factors, photovoltaic plant, photovoltaic system

## 1. INTRODUCTION

Accurate and consistent evaluations of photovoltaic (PV) system performance are critical for the continuing development of the PV industry. These performance parameters allow the detection of operational problems; facilitate the comparison of systems that differ with respect to design, technology or geographic locations.

## 2. SPECIFIC YIELD FOR SOLAR PHOTOVOLTAIC PLANTS

Parameters describing energy quantities for the PV system and its components have been established by the International Energy Agency (IEA) Photovoltaic power System Program and are described in the IEC standard [1]. The generally definition of yield factors of power plants, expressed in simplified terms, describes how many times energy generated during plant operation covers the energy used for constructing the plant. An exact definition would be: 'The yield factor is the ratio of net energy production during plant life and the cumulative energy used for construction, operation and operating supply items'. This concept is only meaningful in the context of using regenerative energy sources, as photovoltaic plants, insular ore grid connected.

Three of the IEC standard 61724 performance parameters [2] may be used to define the overall system performance with respect to the energy production, solar resource and overall effect of system losses. These parameters are the performance ratio, final PV system yield and reference yield.

The final PV system yield $Y_f$ is the net energy output $E_{PV}$ divided by the nameplate d.c power $P_{maxG,STC}$ (STC – Standard Test Condition 1000 W/m², 25°C) of the installed PV array. It represents the number of hours that the PV array would need to operate at its rated power to provide the same energy. The units are hours or kWh/kW:

$$PR = \frac{AC - GridinjectedEnergy}{PVSystemEnergyInSTC} \quad (1)$$

The $Y_f$ normalizes the energy produced with respect to the system size, being a convenient way to compare the energy produced by PV systems of differing size.

The specific plant losses are described through $L_C$ - capture losses, losses that are caused by obfuscation, temperature grown, mismatching, limitation through dust, losses generated by energy conduction in the photovoltaic modules and $L_S$ – system losses, caused by inverter, conduction and loses of passive circuit elements.

The reference yield $Y_r$ is the total in-plane irradiance H divided by the PV's reference irradiance G. It represents the under ideal conditions obtainable energy. If G equals 1 kW/m², then $Y_r$ is the number of peak sun hours or the solar radiation in units of kWh/m². The $Y_r$

defines the solar radiation resource for the PV system. It is a function of the location, orientation of the PV array, and month-to month and year-to-year whether variability:

$$Y_A = \frac{E_{PV}}{P_{max\,G,STC}} \quad (2)$$

To compare on different locations mounted grid connected PV systems, the performance ratio is a decisive value [2]. The performance ratio is the Yf divided by the Yr. By normalizing with respect to irradiance, it quantifies the overall effect of losses on the rated output due to: inverter inefficiency, wiring, mismatch and other losses when converting from d.c. to a.c power, PV module temperature, incomplete use of irradiance by reflection from the module front surface, soiling or snow, system down-time and component failures.

$$Y_f = \frac{E_{PV,AC}}{P_{max\,G,STC}} \quad (3)$$

Performance ratio PR values are typically reported on a monthly or yearly basis. Values calculated for smaller intervals, such as weekly or daily, may be useful for identifying occurrences of component failures. Because of losses due the PV module temperature, PR values are greater in the winter than in the summer and normally fall within the range 0.6 to 0.8. If the PV module soiling is seasonal, it may also impact differences in PR from summer to winter. Decreasing yearly values may indicate a permanent loss in performance. Considering the increasing degree of effectiveness, the performance ratio PR factor can reach ideal annual values between 0.8 and 0.84.

The PR being a dimensionless quantity that indicates the overall effect of losses [5] on the rated output, does not represent the amount of produced energy, because a system with low PR in a high solar resource location might produce more energy than a system with a high PR in a low solar resource location. However, for any given system, location and time if a change in component or design increase the performance ratio PR, the final yield Yf increase accordingly. PR values are useful for determinations if the system is operating as expected. Large decrease in PR indicates events that significantly impact performance, such as inverters not operating or circuit-breaker trips. If the PR decrease moderate or small, it indicates that a less sever problem exists. The performance ratio PR can identify the existence of a problem, but not the cause. To identify the cause of the existing problem, a research at the site is needed.

## 3. GRID CONNECTED PHOTOVOLTAIC PLANT AT THE UNIVERSITY 'EFTIMIE MURGU' RESITA

The grid connected photovoltaic system [3] mounted at the 'summer theater' of the University `Eftimie Murgu` Resita, since middle of may 2008, is putted together from four high performance standard solar modules of type Multisol 150, manufactured by Scheuten Solar – Germany [6], with a total capacity of 600W/h. The system is completed with a Sunny Boy 1100 inverter and a completely online monitoring system of the PV, made from a Sunny Webbox and the Sunny Sensorbox. This monitoring system [4], build up like in figure 1, allows a detailed supervision of the PV plant, produced energy, measuring and saving values of solar radiation, ambient and module temperature, wind speed and direction.

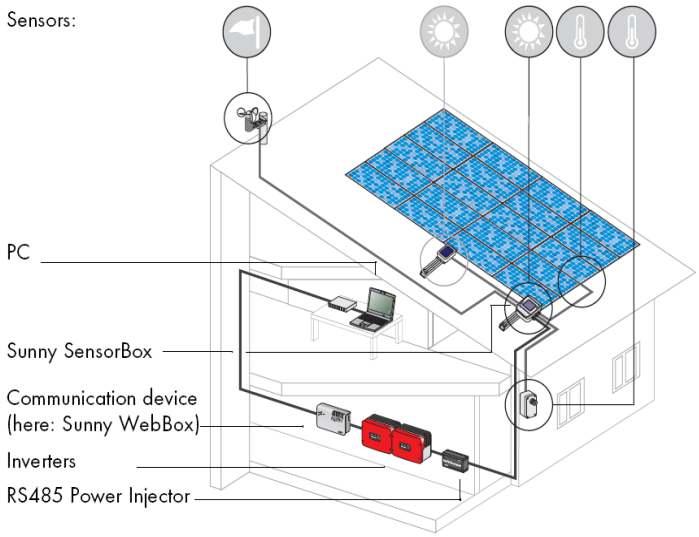



Figure 1 Complete scheme, photovoltaic and monitoring system

The measured values and the current energy yield are visualized and archieved in the Internet, through the sunny web portal [7], figure 2.

## 4. SPECIFIC YIELD FOR THE SOLAR PHOTOVOLTAIC GRID CONNECTED SYSTEM AT THE EFTIMIE MURGU UNIVERSITY

This paragraph allows us an overview of the specific yield factor $Y_A$ for the grid connected photovoltaic system, for a time period of almost one year, from middle of May 2008 until the end of March 2009. Figure 3 represents the energy production and the specific yield factor for this period. A more detailed, daily, overview of the yield factor in the analyzed period is given in table 1.

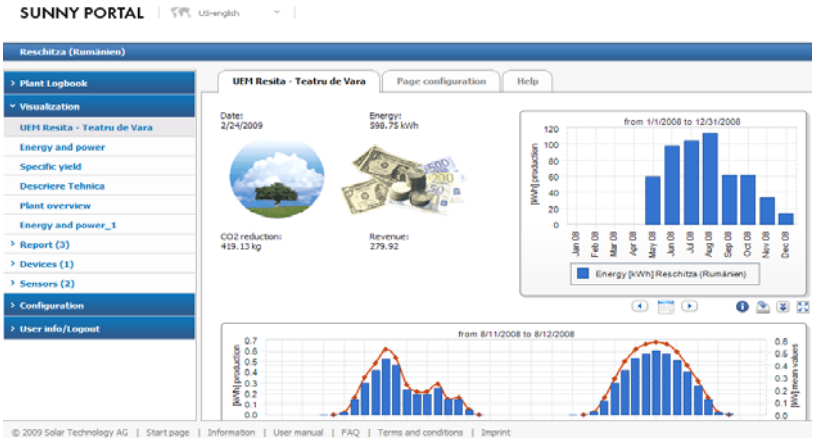



Figure 2 Sunny web portal on-line monitoring

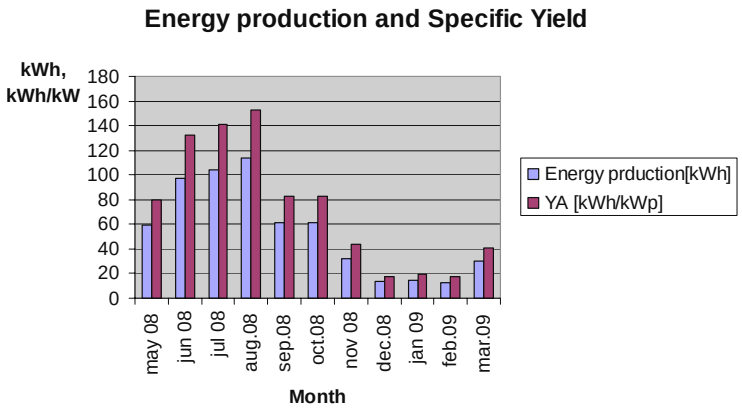



Figure 3. Energy production and array yield

Table 1 Daily Specific Yield Factor

| | Specific Yield Factor - YA [kWh/kWp] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | may 2008 | jun. 2008 | jul . 2008 | aug. 2008 | sept . 2008 | oct . 2008 | nov. 2008 | dec. 2008 | jan . 2009 | febr. 2009 | mart. 2009 |
| 1 | 0,00 | 4,72 | 5,78 | 6,49 | 5,65 | 4,64 | 1,57 | 2,30 | 0,12 | 2,32 | 0,00 |
| 2 | 0,00 | 5,15 | 5,99 | 5,80 | 4,54 | 1,59 | 1,61 | 1,84 | 0,00 | 1,69 | 0,03 |
| 3 | 0,00 | 6,11 | 5,76 | 5,69 | 5,39 | 3,80 | 2,68 | 0,27 | 0,22 | 0,85 | 1,31 |
| 4 | 0,00 | 5,22 | 4,96 | 5,61 | 5,18 | 2,43 | 2,28 | 0,51 | 0,24 | 1,15 | 3,62 |
| 5 | 0,00 | 3,65 | 3,92 | 5,81 | 5,24 | 0,12 | 1,12 | 1,68 | 0,24 | 0,97 | 1,05 |
| 6 | 0,00 | 2,12 | 6,08 | 6,28 | 5,68 | 2,51 | 1,70 | 0,16 | 0,77 | 3,26 | 4,73 |
| 7 | 0,00 | 1,78 | 5,80 | 5,78 | 4,82 | 2,89 | 2,35 | 0,12 | 2,16 | 2,66 | 0,30 |
| 8 | 0,00 | 2,16 | 4,51 | 5,76 | 2,97 | 2,54 | 1,24 | 0,38 | 0,01 | 1,89 | 0,39 |
| 9 | 0,00 | 2,45 | 4,95 | 2,46 | 5,73 | 2,09 | 1,66 | 0,49 | 0,64 | 0,09 | 3,11 |
| 10 | 0,00 | 1,96 | 3,22 | 4,81 | 5,28 | 2,88 | 2,95 | 1,74 | 1,11 | 1,93 | 1,61 |
| 11 | 0,00 | 5,34 | 5,99 | 4,73 | 3,82 | 3,89 | 2,69 | 0,85 | 0,38 | 0,32 | 2,53 |
| 12 | 0,00 | 4,46 | 5,81 | 6,08 | 3,86 | 4,27 | 2,53 | 0,19 | 1,07 | 0,00 | 0,97 |
| 13 | 0,00 | 3,88 | 5,65 | 5,86 | 0,82 | 3,59 | 2,36 | 0,54 | 0,76 | 0,00 | 0,72 |
| 14 | 0,00 | 2,96 | 4,61 | 5,28 | 1,07 | 2,09 | 1,28 | 1,73 | 0,65 | 0,00 | 3,95 |
| 15 | 1,58 | 2,32 | 1,15 | 5,85 | 0,15 | 3,50 | 2,30 | 1,24 | 0,22 | 0,00 | 6,35 |
| 16 | 5,59 | 5,27 | 3,53 | 4,95 | 0,69 | 3,59 | 2,36 | 0,88 | 0,08 | 0,00 | 0,50 |
| 17 | 4,68 | 5,70 | 5,11 | 5,28 | 0,57 | 0,12 | 0,20 | 0,89 | 1,70 | 0,00 | 0,80 |
| 18 | 5,39 | 3,41 | 4,97 | 6,14 | 0,35 | 4,23 | 1,27 | 0,05 | 2,57 | 0,00 | 0,24 |
| 19 | 4,70 | 3,41 | 5,93 | 6,23 | 1,07 | 3,64 | 0,39 | 0,12 | 2,03 | 0,00 | 3,11 |
| 20 | 5,24 | 5,36 | 6,12 | 5,97 | 0,55 | 3,89 | 2,24 | 0,08 | 2,32 | 0,00 | 4,77 |
| 21 | 3,72 | 5,89 | 5,08 | 5,57 | 0,69 | 3,62 | 0,09 | 0,11 | 0,45 | 0,00 | 1,85 |
| 22 | 0,76 | 6,00 | 0,51 | 4,45 | 1,64 | 3,61 | 0,38 | 0,49 | 0,80 | 0,00 | 5,15 |
| 23 | 4,85 | 1,89 | 1,23 | 4,26 | 3,14 | 3,43 | 0,14 | 0,15 | 0,46 | 0,00 | 0,00 |
| 24 | 6,62 | 5,58 | 2,19 | 1,89 | 2,51 | 0,18 | 0,95 | 1,70 | 0,22 | 0,00 | 0,00 |
| 25 | 4,74 | 5,84 | 1,11 | 4,53 | 0,64 | 0,30 | 0,16 | 0,01 | 0,31 | 0,00 | 0,00 |
| 26 | 5,05 | 5,70 | 2,70 | 6,18 | 0,80 | 0,64 | 0,04 | 0,08 | 0,20 | 0,00 | 0,00 |
| 27 | 5,85 | 5,20 | 6,09 | 3,89 | 0,58 | 3,39 | 0,77 | 0,04 | 0,95 | 0,00 | 0,00 |
| 28 | 5,73 | 1,76 | 5,11 | 3,59 | 1,73 | 3,20 | 1,88 | 0,05 | 0,08 | 0,00 | 0,00 |
| 29 | 6,08 | 5,95 | 5,70 | 1,26 | 2,66 | 1,76 | 1,18 | 0,00 | 0,09 | 0,00 | 0,00 |
| 30 | 5,59 | 6,03 | 6,14 | 3,97 | 4,89 | 1,15 | 2,57 | 0,01 | 0,18 | 0,00 | 0,00 |
| 31 | 5,32 | 0,00 | 6,14 | 5,23 | 0,00 | 3,15 | 0,00 | 0,01 | 0,55 | 0,00 | 0,00 |

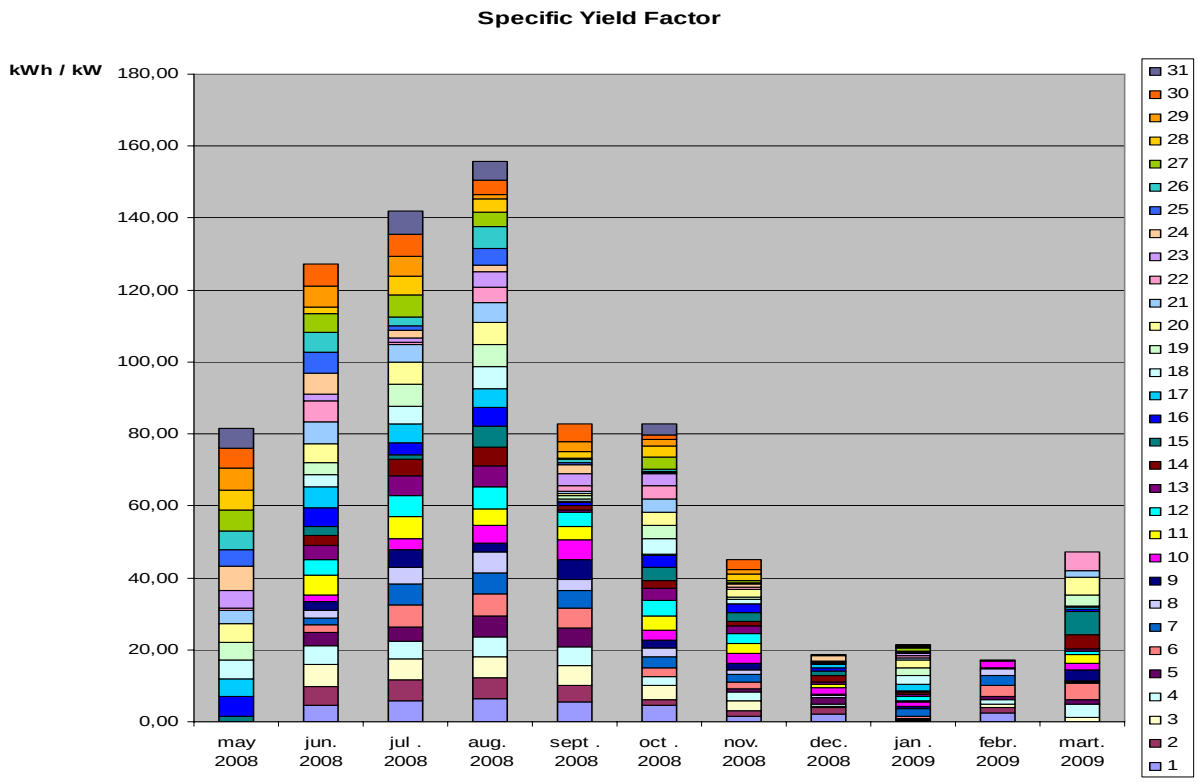



Figure 4 Daily yield factor, May 2008 – March 2009

## 5. CONCLUSIONS

Analyzing the specific yield factor, the photovoltaic plant owner can have a permanent look of the time, in hours expressed, that the system works in STC and obtains indicate or a higher energy production. As shown, during summer the yield factor has a much higher density in June, July and August and the lowest in December, January and February.

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[6] www.scheutensolar.com
[7] www.sunnyportal.com

# PERFORMANCE RATIO OF A PHOTOVOLTAIC PLANT

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**Abstract**
Based on the grid connected photovoltaic plant at the University 'Eftimie Murgu' in Resita, injecting energy in the public grid since spring 2008, we define and analyze the performance ratio and the final yield factor. With these two factors given, we are able to assure a critic overview of the plant performance.

## 1. INTRODUCTION

To be able to choose the right photovoltaic equipment, starting from modules through inverters, for grid connected plants, at least one year of consistent evaluations of system performance are needed. One of those performance parameters that allow the detection of operational problems and facilitate the comparison of systems is given by the final yield factor and the performance ratio.

## 2. YIELD FCATOR AND PERFORMANCE RATIO FOR GRID CONNECTED SOLAR PHOTOVOLTAIC PLANTS

The International Energy Agency (IEA) for Photovoltaic Power System Program has define, based on existing experience, a number of performance parameter for photovoltaic plants, that are now concentrated in the IEC standard [1], concept that are only meaningful in the context of using regenerative energy sources, as photovoltaic plants, insular ore grid connected. The main parameters are performance ratio and the final PV system.

The performance ratio PR is defined as the energy output $E_{PV}$ that is injected in the grid, AC part, divided by the nameplate d.c power $P_{maxG,STC}$, obtained in Standard Test Condition (STC - 1000 W/m², 25°C) of the installed PV array. It represents the number of hours that the PV array operates at its rated power.

$$PR = \frac{AC - GridinjectedEnergy}{PVSystemEnergyInSTC} \quad (1)$$

Performance ratio PR values are typically reported on a monthly or yearly basis. Another yield value is the final Yield factor. As the performance ratio, it expresses plant performance on the AC site. It is definite as the monthly grid injected energy divided to the nameplate power of the photovoltaic generator in standard test conditions. The result offers an overview referring to monthly pro one kWp plant power, in the grid injected energy, ore the so called monthly specific energy production.

$$Y_f = \frac{E_{PV,AC}}{P_{\max G,STC}} \quad (3)$$

PR values calculated can be also calculated for smaller intervals, such as weekly or daily. This is may be useful for identifying occurrences of component failures. Depending on geographical location and season the PR values fall normally within the range 0.2 to 0.8. If PR decreases yearly, this may indicate a permanent loss in performance. Ideal annual values for the performance ratio PR factor are between 0.8 and 0.84.

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PR does not indicate the amount of produced energy, because a system with low PR in a high solar resource location might produce more energy than a system with a high PR in a low solar resource location. But however, for any given system, location and time an increase of the performance ratio PR supposes accordingly an increase of the final yield $Y_f$ too.

If PR registers a deep decrease, that indicates events with significant performance impact, like inverters that are not operating proper. When the PR decrease moderate, this indicates that the plant has less sever problems. So, based on the performance ratio PR analyzes, it can be clearly identified if the systems work like plant ore problems exist, but not the cause.

## 3. GRID CONNECTED PHOTOVOLTAIC PLANT AT THE UNIVERSITY 'EFTIMIE MURGU' RESITA

The grid connected photovoltaic system [3] mounted at the University `Eftimie Murgu` Resita, has in his structure, following components: four high performance standard solar modules of type Multisol 150, manufactured by Scheuten Solar – Germany [6], with a total capacity of 740W/h; a Sunny Boy 1100 inverter and a completely online monitoring system [7] of the PV system: Sunny Webbox and Sunny Sensorbox (solar radiation, ambient and module temperature, wind speed and direction).



Figure 1. The solar photovoltaic modules and equipment at the "E.Murgu" University Resita

## 4. PERFORMANCE RATIO AND FINAL YIELD FACTOR FOR THE GRID CONNECTED PV SYSTEM AT THE "EFTIMIE MURGU" UNIVERSITY

In this paragraph we will obtain an overview of the final yield factor $Y_f$ for the grid connected photovoltaic system, from May 2008 until the March 2009. Figure 2 represents the monthly performance ratio; figure 3 the final yield factor for this period. A comparison between those two plant performances indicators are given in figure 4.

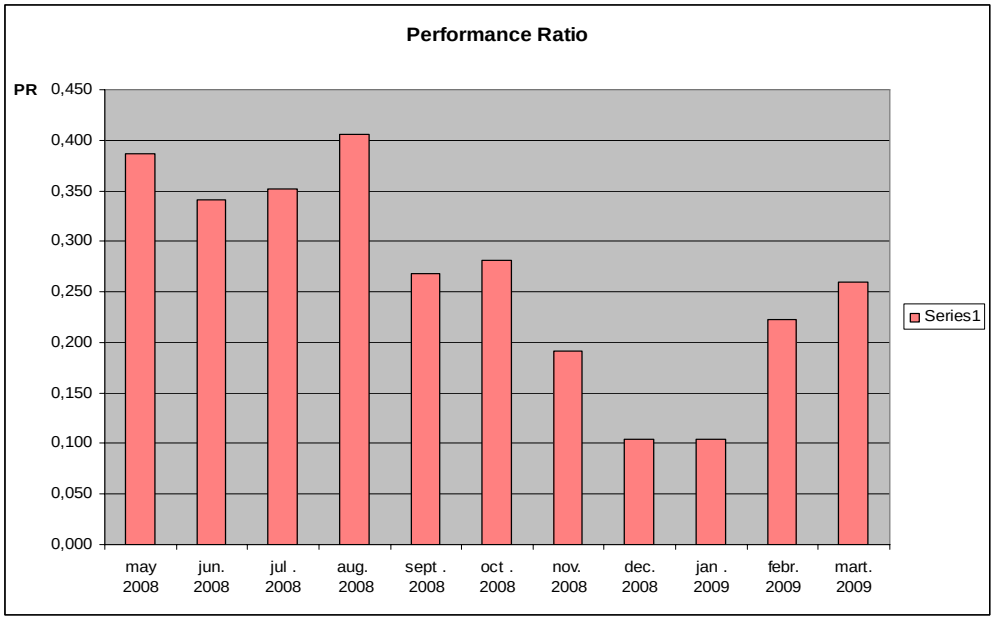



Figure 2. Monthly grid connected PV system performance ratio, May 2008 – March 2009

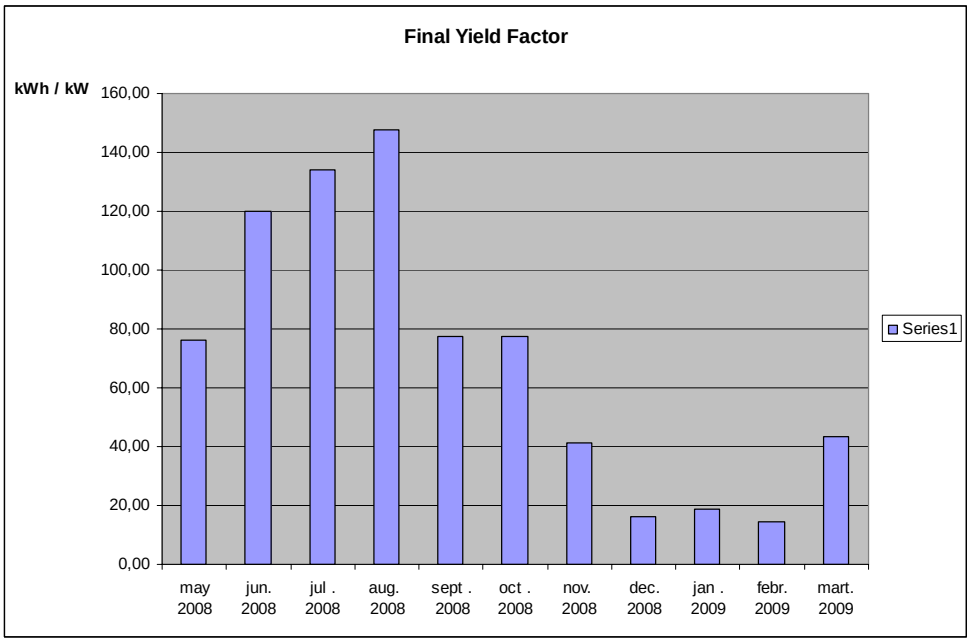



Figure 3. Final yield factor, May 2008 – March 2009

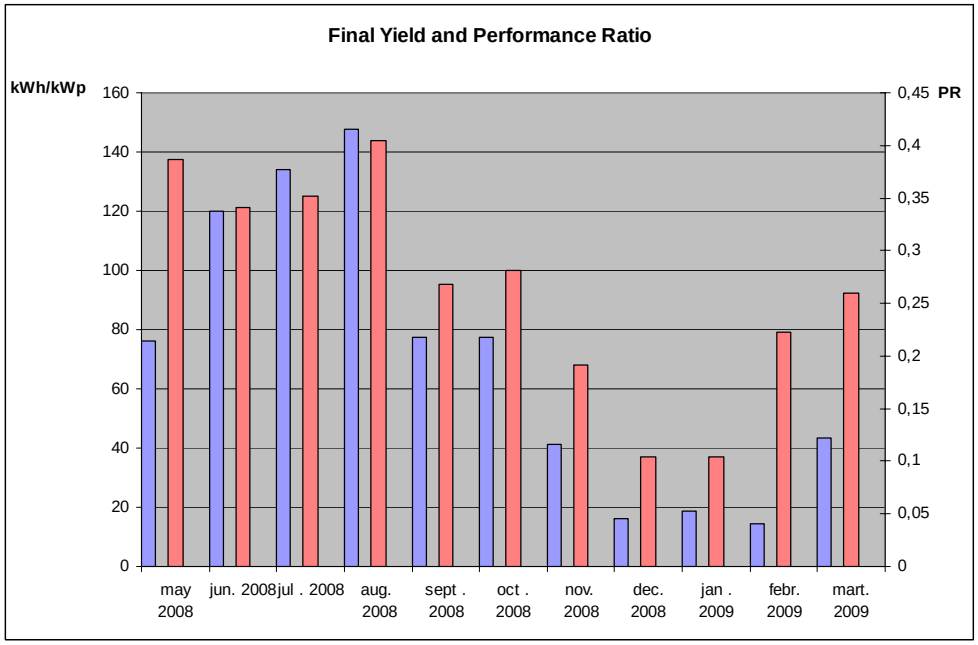



Figure 4. Comparison between Final Yield and Performance Ratio, May 2008 – March 2009

## 5. CONCLUSIONS

Based on the analyze of the final yield factor and the performance ratio of an photovoltaic grid connected plant, we can always have a overview of the plants performance and check in the right if we register system losses.

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[4.] Cristian P. Chioncel, Dieter Kohake, Petru Chioncel, Nicoleta Gillich *Solar photovoltaic monitoring system implemented on the location Resita*, Analele Universităţii "Eftimie Murgu" Reşiţa, Fascicola de Inginerie, ISSN 1453 – 7394, 2008
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[6.] www.scheutensolar.com
[7.] www.sunnyportal.com

# PREDICTION OF THE SIGNALS USING THE NEURONAL NETWORKS

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**Abstract**:
This paper work refers to the prediction problems which are used with the help of the neuronal networks. The network is made of a neuron whose function is linear and who has the past few 5 input values of the useful signal x(t) – this signal must be predicted.
The training algorithm is Widrow-Hoff. This algorithm decreases the number of square errors between the output of the network and the required value, and it eventually establishes the "weight" factor.

**Keywords**:
Prediction, algorithm, neuronal networks, signal

## 1. INTRODUCTION

This identification [2], [3] is based on some neuronal methods and it has been lately used a research method due to mathematical research about the approximation properties of the neuronal networks - MLP (Multilayer Perceptron) and RBF (Radial-Basis Function) type [1]. The development of this new domain has been spectacular due to a remarkable contribution of some Automatics scientists. They have used the MLP networks for the non-linear identification and they have decided to use the RBF-type patterns. Thus, we have to point out the fact that the most important automatic application of those techniques, who are specific for the neuronal networks, is the use of the MLP features with sinoid nodes inside the hidden layer(s). On the other hand, those companies who produce technical-scientific software have begun developing specific facilities for the neuronal networks, so that the first version of the Neuronal Network Toolbox (NNT) should be enclosed in the MATLAB 4.2 environment – it had a major impact on the interest of the automatics specialists. NNT, from the earliest to the most recent version, has been designed to cover a range of applications of the neuronal networks, the designers had no intention to develop the Simulink blocks simultaneously [4]. These blocks are used for designing dynamic patterns.

## 2. NEURONAL NETWORKS. TRAINING NEURONAL NETWORKS

The neuronal networks can be made of simple processing elements, such as perceptrons or neuronals (Figure no. 1), and they make up one-layer networks, or of multiple elements and they make up multi-layer networks [1]. All these network-types enclose some elements that are distributed within the connection „weights" amongst different layers that make up each network [6]. The properties of the neuronal networks are: contain memory, shape acknowledgment, control and identification of the non-linear processes, etc. These properties are obtained through learning, such as in the case of the physiological systems. Specific training algorithms could be used in order to determine the values of those weights/percentages who represent the solution to the problems we solve by using the neuronal networks. The training algorithms could be divided in two separate categories: supervised instruction methods and non-supervised instruction methods. In the case of those methods belonging to the first category, the instruction is called supervised because we know both the input and the output sizes. The system is shaped up with the help of a neuronal network and the weight amongst the layers have random values. By comparing the input sizes that we already know and those of the output of the network (after we have used the input data set), we get an error signal. This signal helps us establish

and adjust the weights amongst the layers of the network, in order to diminish a performance criterion [8].

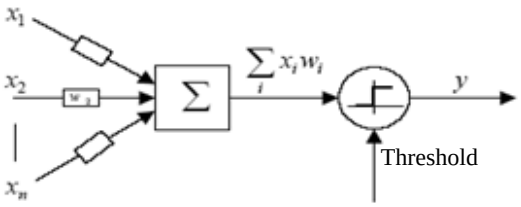



Figure no. 1 Classic perceptron model

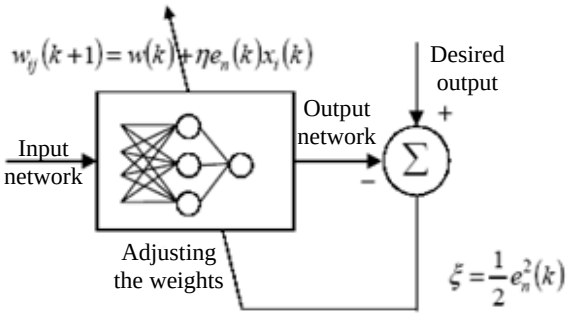
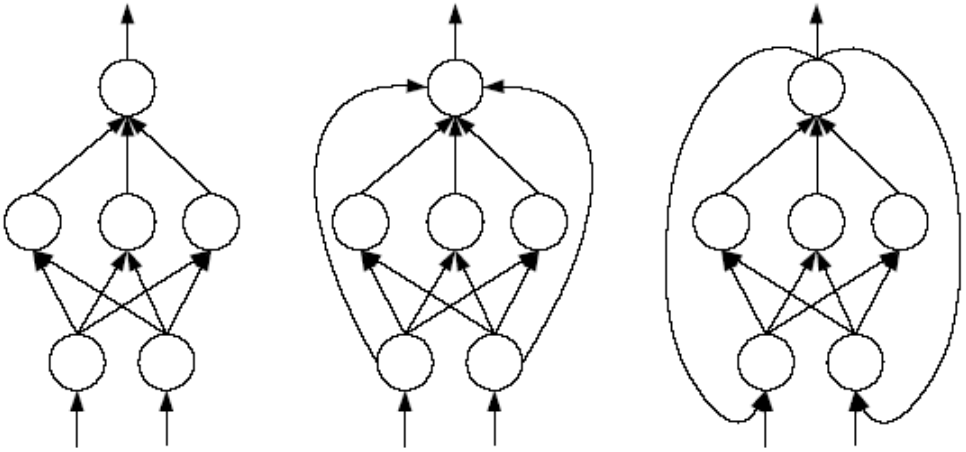



Figure no. 2 Supervised instruction mechanism for neuronal networks

The non-supervised learning methods do not uses already-known input sizes during the training stage of the neuronal network, by using only the input sizes for adjusting the weights. Thus, we can establish some input categories who correspond to some inputs from the data set, or „winner take all" outputs – in this case, the output neuron who has the highest activity wins and turns active, meanwhile the others do not work. This method is called self-organisation and we could use it successfully in matters of shape acknowledgement.



a) b) c)

Figure no. 3„Feed forward" neuronal networks topologies a), b) and „feedback" neuronal networks topology c)

According to this topology, the artificial neuronal networks could be classified in two categories - „feedback" and „feed forward". In the case of a „feed forward" network the neuronal output is sent to other neurons who do not receive any information from the input neurons from the surface layers - Figure 3 a) and b).

## 3. NEURONAL NETWORKS USED FOR SIGNAL PREDICTION

The design of the linear prediction neuron is described in Figure no. 4. The network is made of a linear active neuron and the input receives the last five values of the useful signal x(t) - this signal must be predicted [4], [7].

We write the matrix P, $p = [x(t) \quad x(t-1) \quad x(t-2) \quad x(t-3) \quad x(t-4)]$, and the five delay values of the x(t) signal, who are going to be represented at the input of the neuronal network. The matrix and the values are going to represent the data we need for the supervised training, by using the Widrow-Hoff algorithm. This algorithm decreases the sum of the square errors between the output and the required value, and establishes the weight vector who is able to solve the problem.

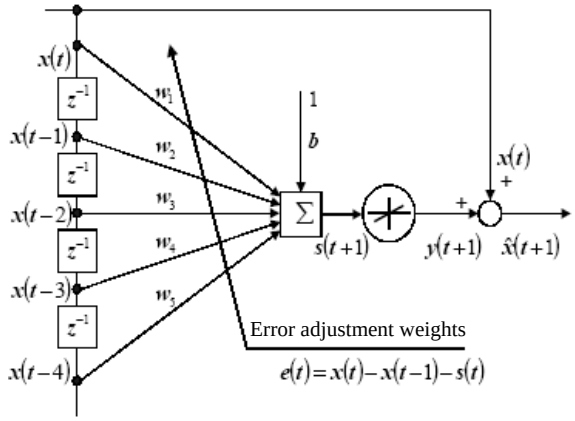



Figure no. 4 Linear prediction neuron

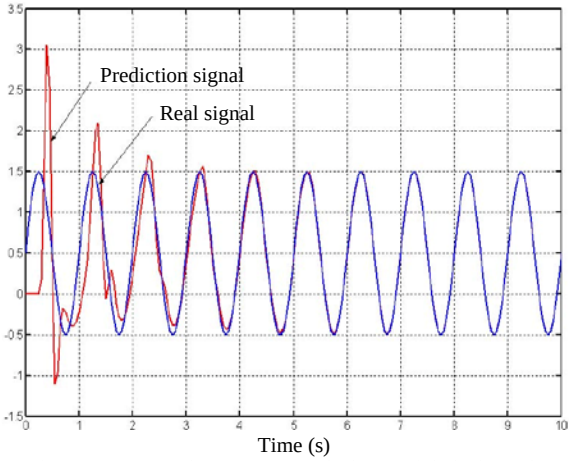



Figure no. 5 The proposed sinusoidal signal (blue) and the network predicted signal (red)

We consider a sinusoid signal $x(t)=0.5+\sin(2\cdot\pi\cdot t)$ - in Figure no. 5 it is coloured in blue. The learning ratio of the training algorithm is $\eta=0.1$, considering that it is constant during the training process. The network turns active and the training algorithm is used for a period of 200 steps. We could see that after about 100 repetitions the network is able to predict the signal we propose – Figure no. 5, where the red signal represents the output of the neuronal network during the training process. Figure no. 6 describes the prediction error - the difference between the real and the predicted signal. This signal tends to reach 0 after a certain time.

Figure no. 7 describes the values of the simple perception weights during the training process. The identification time of the process lasts according to the value we choose for the learning ratio. If we want a faster identification then, the value must be increased, but the values we have estimated during the first stages reach important values. We could also use another training method that should vary the learning ratio throughout the process, for improving the methods.

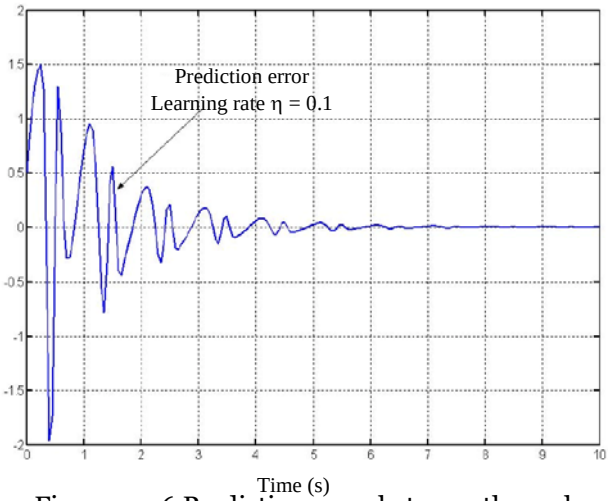



Figure no. 6 Prediction error between the real and predicted signal

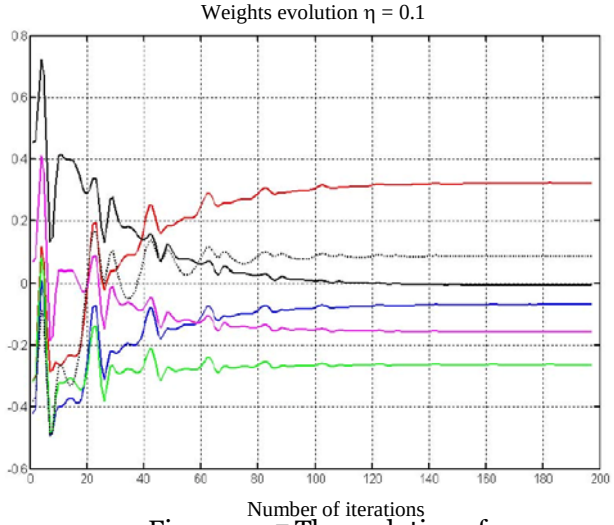



Figure no. 7 The evolution of the weights during the training process

## 4. CONCLUSIONS

All the neuronal networks could be made of simple processing elements, such as perceptions or neurons, so they should make up some single-layer networks, or made of several elements and they should make up some multi-layer networks. The „information" within all these networks is distributed within the connection weights amongst the different layers that make the network. Studies have proven that the prediction of the neuronal networks signals is extremely effective.

This paper work has described the linear neuron used for predictions, the training process, and the results we had obtained. The network is made of one neuron, according to the linear active process, which has the last five input values we have to predict.

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# ERROR HANDLING AND MESSAGES WITH APPLICATION SERVER ABAP

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**ABSTRACT**

Application Server ABAP is an integrated part of the application platform within SAP NetWeaver. In this paper we will present the tools and concepts we can use to develop solid ABAP based applications, that deal with the error and problem situations occurring in our programs. We catch exceptions and describe it for the end user. We use client-side validation and server-side validation to inform the user about the program status and exceptions occur. ABAP offers us full support to do that through exception classes, message classes, assistance classes, a special Hook method in Web Dynpro ABAP, a special control structure for catching exceptions and more.

## 1. INTRODUCTION

SAP NetWeaver is an infrastructure software that supports the integration and development of heterogeneous system landscapes as they are typically found in companies today [1].

Application platform of the SAP NetWeaver integration platform has two stacks: ABAP stack and Java stack or Application Server ABAP and Application Server Java with two programming interfaces ABAP and respective Java.

Application Server ABAP (AS ABAP) offers us through ABAP language many possibilities to handle the exceptions that occurs in our applications, offers us tools to develop robust programms. A good user interface catch exceptions and describes for the user the errors that occurs.

One of the key quality criteria for software is the robustness of a program. It should be able to deal with the situation and should not crash [2].

In ABAP we have classical exception handling and class based exception handling. The SAP documentation [3] recommends us to use class based exception handling where every exception class derives directly or indirectly from the CX_ROOT super-class.

To structure possible exceptions we have three abstract exception classes that derive from CX_ROOT super-class. Fig. 1 shows the exception classes relationship [4].

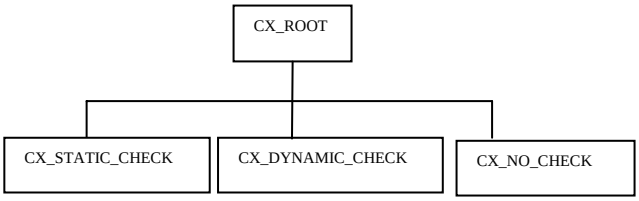



Fig. 1 The tree of exception classes in ABAP

We can handle an exception in an ABAP programme with TRY - ENDTRY control structure. Fig. 2 shows an example of catching and handling exceptions.

The messages that we can use in ABAP language are “A” termination message, “E” error message, “I” information message, “S” status message, “W” warning message ,” X “ exit message and define how the ABAP runtime should process the message [5].

When an exception is raised using RAISE EXCEPTION, the runtime environment searches for a handler. Once a handler is found, the control flow processes the code of the handler before continuing. If no handler can be found, the program ends with a runtime error.

We can use catch CX_ROOT to catch all errors that occurs.

Report YTRY_ENDTRY Active

```
19  FIELD-SYMBOLS <fs_ytb_student> LIKE LINE OF it_ytb_student.
20  DATA: oref TYPE REF TO zcx_exception_otr,
21        text TYPE string.
22
23  START-OF-SELECTION.
24    text = pr_matr.
25    TRY.
26        SELECT mandant matricol nume datan ex_promovate
27        FROM ytb_student
28        INTO TABLE it_ytb_student
29        WHERE matricol = pr_matr.
30        LOOP AT it_ytb_student ASSIGNING <fs_ytb_student>.
31          WRITE:/ <fs_ytb_student>-mandant,
32                  <fs_ytb_student>-matricol,
33                   <fs_ytb_student>-nume,
34                   <fs_ytb_student>-datan,
35                   <fs_ytb_student>-ex_promovate.
36        ENDLOOP.
37        IF sy-subrc <> 0.
38          RAISE EXCEPTION TYPE zcx_exception_otr
39        EXPORTING
40          textid = zcx_exception_otr=>zcx_exception_otr1
41          parameter1 = text.
42        ENDIF.
43      CATCH zcx_exception_otr INTO oref.
44        MESSAGE oref TYPE 'I'.
45    ENDTRY.
```

```
TRY.
  [try_block]
 [CATCH cx_class1 cx_class2 ...
                        [INTO oref].
  [catch_block]]
  ...
 [CLEANUP [INTO oref].
  [cleanup_block]]
ENDTRY.
```

Fig. 2 TRY-ENDTRY structure example

## 2. THE STUDY

### 2.1 WORKING WITH EXCEPTION CLASSES AND TEXTS FOR XCEPTIONS

Each exception has assigned a text that describes the exception and can be for example Online Text Repository (OTR) text or text from a message class.

OTR is a central place for texts that offers us tools for its processing and administration. The texts that are stored here can contain maximum 255 characters [6].

We can create our own exception classes as global classes with Class Builder or as local classes in our programs. Some of the advantages of using class-based exception handling are [7]:

- Object-oriented concept of inheritance
- Exception classes have integration with ABAP message concept
- Exception class can hold many different types of exceptions

Function module YFM_WITH_EXCEPTION_CLASS Active

Attributes | Import | Export | Changing | Tables | Exceptions | Source code

```
4   *"  IMPORTING
5   *"     REFERENCE(IN_IDPROD) TYPE  YTIPD-IDPROD
6   *"  EXPORTING
7   *"     REFERENCE(EXP_YTIPD) TYPE  YTAB_YTIPD
8   *"  RAISING
9   *"     YCX_EXCEPTION_CLASS_OTRTXT
10  *"----------------------------------------------------------------------
11    data oref type ref to ycx_exception_class_otrtxt.
12    try.
13        select  *
14        from ytipd
15        into table exp_ytipd
16        where idprod = in_idprod.
17        if sy-subrc <> 0.
18          raise exception type ycx_exception_class_otrtxt
19          exporting
20                textid = ycx_exception_class_otrtxt=>ycx_exception_txt
21                id = in_idprod.
22        endif.
23      catch  ycx_exception_class_otrtxt into oref.
24        message oref type 'E' display like 'I'.
25    endtry.
26  endfunction.
```

Fig. 3 Exception class and Function Module

#### A. Exception class with OTR text

When we create an exception class in ABAP Workbench we can chose if this is with message class or without message class.

This type of classes have attributes inherits from the CX_ROOT super-class. From this attributes we use very often the TEXTID attribute and PREVIEUS attribute.

Fig. 3 shows a Function Module that access data from a database table and use an user defined exception class. When the user enters an id that doesn't exist in the database table, an eception of type YCX_EXCEPTION_CLASS_OTRTXT is raised and a proper error message is shown to the end user.

Fig. 4 shows the new defined exception id and attribute for this exception class. In the Text tab we can find the exception id YCX_ECEPTION_TXT that we have used in our Function Module.

Class Interface YCX_EXCEPTION_CLASS_OTRTXT Implemented / Active

Properties | Interfaces | Friends | Attributes | Texts | Methods

Long Text

| Exception ID | Text |
|---|---|
| CX_ROOT | An exception occurred |
| YCX_EXCEPTION_CLASS_OTRTXT | Action not supported! |
| YCX_EXCEPTION_TXT | The id &id& don't exist! |

Class Interface YCX_EXCEPTION_CLASS_OTRTXT Implemented

Properties | Interfaces | Friends | Attributes | Texts | Metho

| Attribute | Level | Visi... | Re... | Typing | Associated Type |
|---|---|---|---|---|---|
| <CX_ROOT> | | | | | |
| CX_ROOT | Consta... | Publ... | | Type | SOTR_CONC |
| TEXTID | Instanc... | Publ... | ☑ | Type | SOTR_CONC |
| PREVIOUS | Instanc... | Publ... | ☑ | Type Re... | CX_ROOT |
| KERNEL_ERRID | Instanc... | Publ... | ☑ | Type | S380ERRID |
| YCX_EXCEPTION_TXT | Consta... | Publ... | | Type | SOTR_CONC |
| YCX_EXCEPTION_CLASS... | Consta... | Publ... | | Type | SOTR_CONC |
| ID | Instanc... | Publ... | | Type | YTIPD-IDPROD |

Fig. 4 The structure of YCX_EXCEPTION_CLASS_OTRTXT

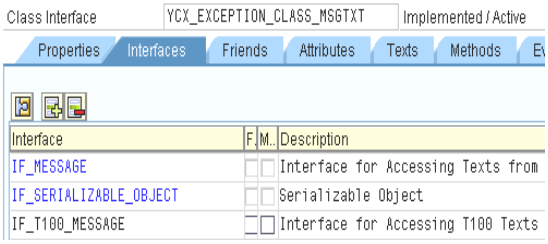



Fig. 5 Exception class with message class

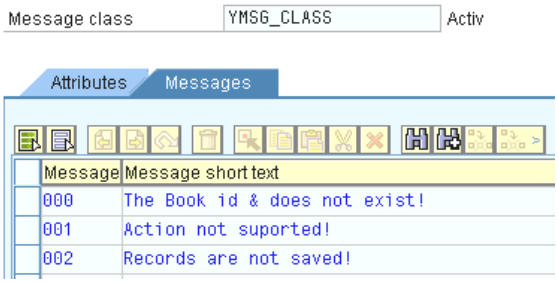



Fig. 6 Message Class YMSG_CLASS

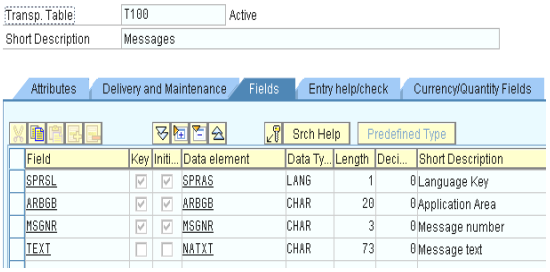



Fig. 7 The structure of T100 database table

**B. Exception class with text from a message class**

We create an exception class YCX_EXCEPTION_CLASS_MSGTXT with text from a message class. In this case exception class implements the interface IF_T100_MESSAGE and we can use exception texts from database Table T00.

Fig. 5 shows the defined exception class.

Before we can use this class we have to create a Message Class and assign it to our exception class. In Fig. 6 we presented the Message Class YMSG_CLASS, created with Message Maintenance SE91.

Messages are stored in the database Table T100 that has colums as: message number, short text, language key. Fig. 7 shows the structure of this table.

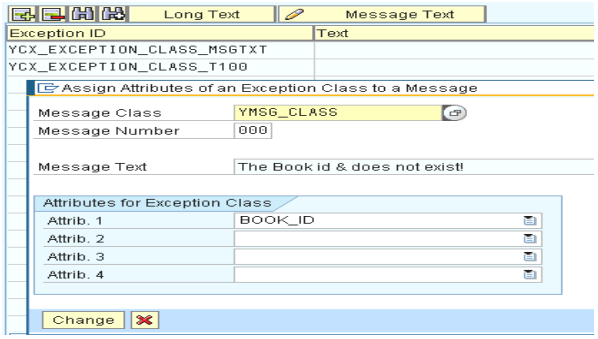



Fig. 8 Exception id mapped to message class and message number

Each exception id can be mapped to a message id from our message class. In Fig. 8 is shown a mapping example. As can be seen when we use text from a message class we have a restriction to maximum four placeholders. We can assign maximum four attributes from the exception class.

Fig. 9 illustrates the way we can use our exception class into an ABAP class that selects data from a database table through the help of SQL statements.

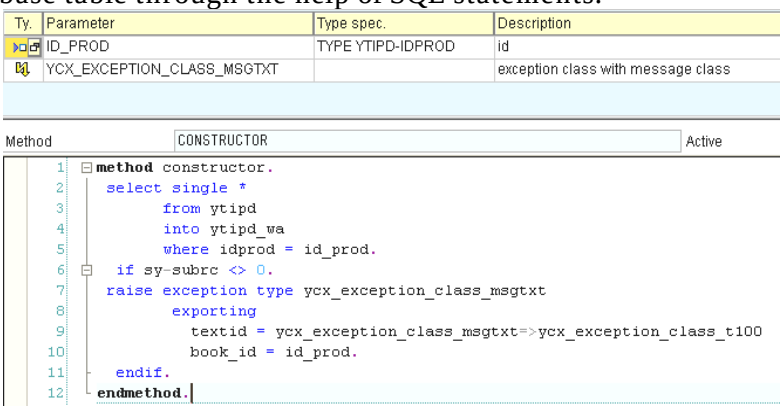



Fig. 9 ABAP class and exception class

## 2.2. MESSAGES, EXCEPTIONS AND WEB DYNPRO ABAP

Web Dynpro ABAP is the SAP Framework that uses Model View Controller MVC paradigm in order to build reusable multi-component web business applications.

Through a What You See Is What You Get view editor we can simply drag and drop the UI Elements that we need and we have fully support to work with messages [8].

The presentation of messages in the client is controlled by Web Dynpro Framework and Hook method wddobeforeaction( ) can us help to react to user inputs [9].

### A. Exception class and Web Dynpro ABAP

Web Dynpro ABAP offers us support to work with exception classes through methods of the Message Manager.

In Fig. 10 we present the way we can use in a Web Dynpro application, the class defined hereinbefore. What is more important is the fact that we can catch the proper exception and show it in browser in a MessageArea UI Element.

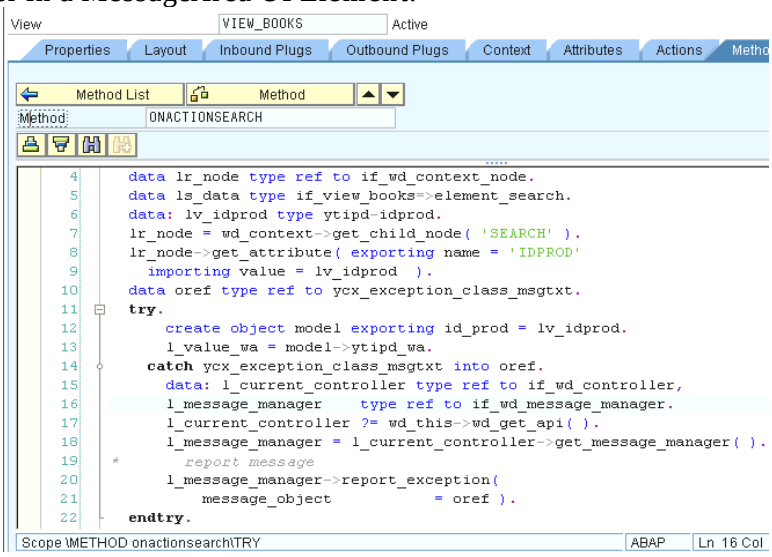



Fig. 10 Catch and show of the exception message

All the messages that are shown with Web Dynpro ABAP are displayed as default at the begin of the screen. In our case we want to change this position and in this purpose we use a MessageArea UI Element. In fig. 11 we show the proper User Interface.

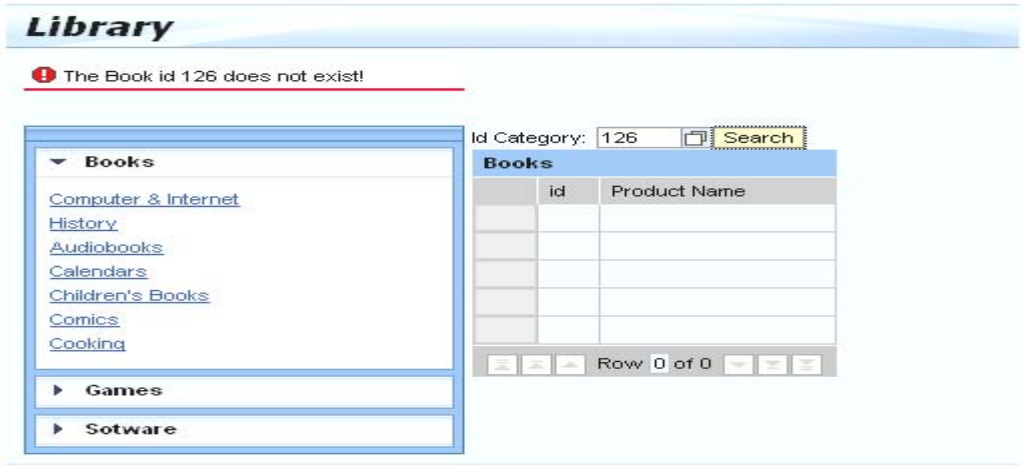



Fig. 11 The User Interface with Web Dynpro ABAP

### B. Assistance class and Web Dynpro ABAP

An assistance class is a regular ABAP class that inherits the CL_WD_COMPONENT_ASSISTANCE. Every Web Dynpro component has assigned just an assistance class that we can use as Model or to work with text symbols.

The class CL_WD_COMPONENT_ASSISTANCE provides central functions by which a Web Dynpro component can access text symbols of the assistance class [10]. As advantages of using assistance class we can specify [11]:

- Method calls of the assistance class have more performance as calls of methods of a Web Dynpro controller.
- Manage dynamic texts

In Fig. 12 we present the text symbols that we have defined for a created assistance class YCL_ASSISTANCE_CLASS_MSG.

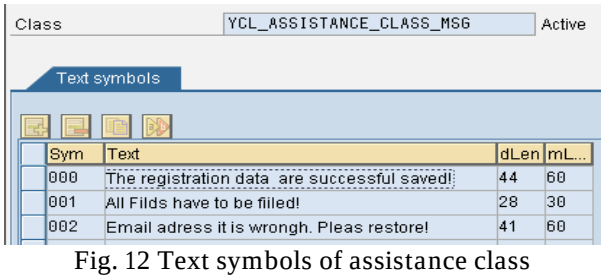



Fig. 12 Text symbols of assistance class

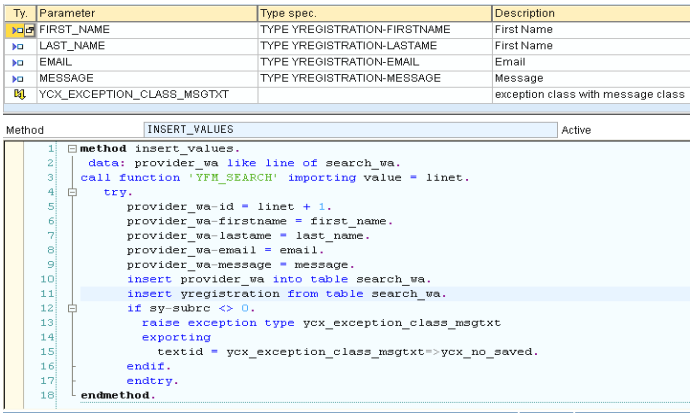



Fig. 13 Method of our assistance class

In our assistance class we define a new method INSERT_VALUES with which we can insert in the database table the informations that the user enter in the registration form. Fig. 13 shows the method codding.

To show a message to the user when he doesn't enter a proper value or to inform him that the data are successful saved (client-side validation) we use text symbols defined in our assistance class. When an exception occurs we use the exception class. Fig. 14 illustrates the way we can use the assistance class as model in our Web Dynpro application and the way we can catch the exceptions.

Through the attribute WD_ASSIST and the method WD_COMPONENT_ASSISTANCE ~GET_ TEXT( ) we can access text symbols of the assistance class from our component controller, Fig. 15.

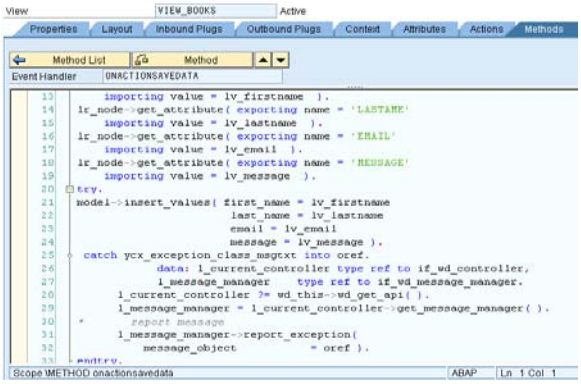



Fig. 14 Web Dynpro and assistance class

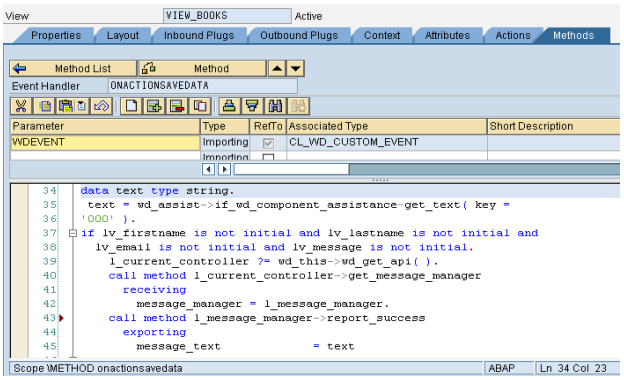



Fig. 15 Access of text symbols from assistance class

We have to specify that for client-side validation we can use even messages that are defined directly in the message class but is not recommended to involve the message texts directly in coding. In Fig. 16 we present the corresponding User Interface in Web Dynpro ABAP.

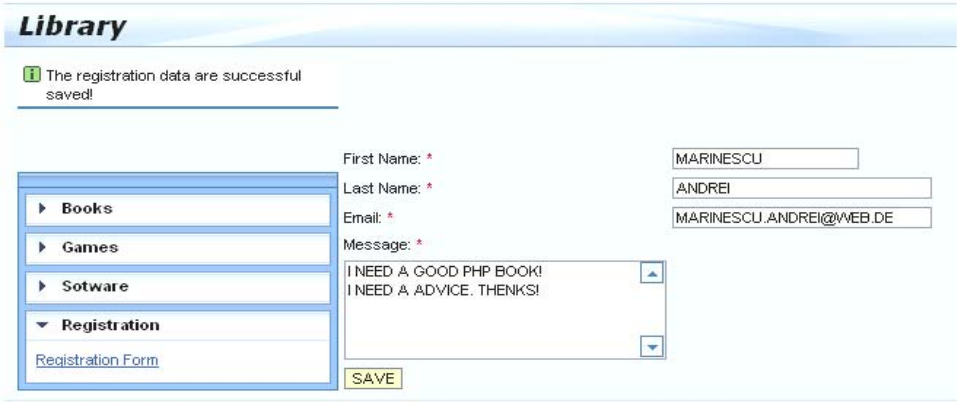



Fig. 16 User Interface with Web Dynpro ABAP

## 3. CONCLUSIONS

In this paper we have presented some of the concepts to develop robust software by ABAP programming language. When we develop an application we have to plan a good exception and messages handling to describe in detail the error situation, to check the data input from the user and to show the program status. We have seen the advantages of using the new class based exception concept of the ABAP language and some of the tools that Web Dynpro ABAP gives us in order to simplify the message and error handling.

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# CONTRIBUTIONS TO THE IMPLEMENTATION OF THE TELEMETRIC PROGRAMMABLE AUTOMATS BY RTU TYPE FOR AUTOMATION, MONITORING AND CONTROL INSTALLATIONS

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**Abstract:**
The equipment RTU (Remote Terminal Unit) monopolize much more the sphere of industrial applications who necessities the control and monitoring from distance of the processes, stored under histories form of land events, take some measures in case of damage or to alert the personal. So, with help of SCADA interface (Supervisory Control And Data Acquisition) all the process can be monitoring and controlling with the computer help. In the paper an application created with the help of the RTU Tbox equipment is presented, application used for the monitoring of a solar installation for the processing of hot water. The application is located in a mountain area, the solar system being made up of collectors with a surface of 2x16 mp, two 500 liter reservoirs and two heat switches.. It also presents an application for monitoring and control of a production line, made from 16 hydraulic presses, with the help of software SCADA Ethernet Tview. Because the major products realized by beneficiary (hub from auto) get to the export where the customs want a strict monitoring the times of vulcanization, of the temperatures and pressures uses, it is necessary to search the best solutions who permit a production control from computer and who can accomplish some conditions impose.
**Obs.:** The final results will be presented through online link, with authors' access only.
**Key words:**
technological lines automation, Remote Terminal Unit, control and monitoring

## 1. INTRODUCTION

RTU equipment is a device installed at distance from the centre of control, who acquires the data from the process. They are coded in an easy format to be transmitted to the control centre. Also, the RTU equipment can take the commands from the control centre, dispose of modules of inputs and outputs for the interaction with the process and of course by multiple module communications. A typical RTU dispose of communication interfaces (serials, interfaces Ethernet (LAN), GSM or GPRS, Radio, PSTN etc), by a processor, interfaces with digital or analogue inputs/outputs.

The systems of monitoring and control from the distance dispose of SCADA (*Supervisory Control and Data Acquisition*) type interfaces for visualizing in real time the applications from the field. The SCADA type software is already very well known due to the success obtained in applications such as those of power, water, oil products distribution, leading completely automatic lines in real time etc...

A SCADA system will control and monitor a local process or one from far away through communication channels and RTU-s from the field.

## 2. THE RTU CONCEPT – PRESENT AND FUTURE

With the help of inputs/outputs, a RTU will read/command the equipments from the field; it will connect to the devices with serial communications through the communication ports, all the processed information and events being stocked as historical (datalogging) in the memory assigned for this purpose. Once stocked, the information can be accessed

through different ways: through SCADA type software, through emails, through *SMS* messages, through a structure of files transferred by *FTP* (File Transfer Protocol) or through *Internet Explorer browsers* (Fig.1).

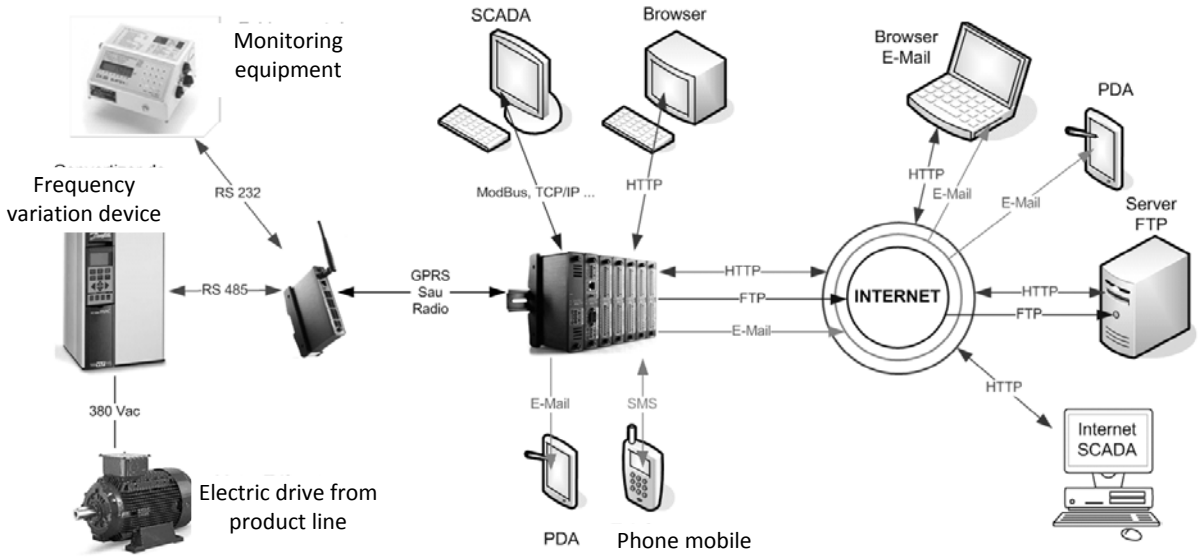



Fig. 1. *The principle scheme*

The data transfer from RTU to SCADA equipments is done through standard communication protocols; among the most popular transfer protocols for industrial applications, I mention the *Modbus* protocol (*Modbus ASCII, Modbus RTU, Modbus TCP/IP*). The SCADA software can be connected locally to the RTU through the *Modbus RTU* protocol or through the *Modbus TCP/IP* if the software is of *Internet* SCADA type. RTU equipment will generally communicate with a serial device (gas, water, power meter, frequency variation device etc.), with the help of *Modbus ASCII* protocol.

Presently, there is a tendency of the great producers of PLC (*Programmable Logic Controller*) equipments to develop and attach to PLCs the characteristics of actual RTU equipments: memory for *datalogging* (events journal) or multiplication of communication ports, but as long as there will be processes situated on field and far away from the control centre, RTU equipment is the answer.

RTU-s of the future will be equipped with faster and faster processors and multi-processors, with communication modules allowing higher and higher speeds for data transfer and a higher and higher capacity of stocking the historical from the process. The wired communication lines between different RTU equipments will remain of actuality, but the transfer protocols and the speeds will increase considerably. Wireless communications between RTU equipments will be used when the distances between them increase, or when the communication is done through SCADA type interfaces.

## 3. THE HARDWARE AND SOFTWARE ARCHITECTURE OF RTU [3]

***The hardware architecture of RTU equipments*** has the following variants:

- Modular – each module having previously established and dedicated functions (ex.: the power source module, the processor module, input/output communication modules). The modular series has the advantage of being able to develop the application in time by simply adding new input/output modules, it disposes of processors faster than 32 bits and it is set up in the DIN automatic case on runner.
- The "*All in One*" concept, meaning everything in one carcase, contains the processor, the communication modules and a fix number of digital and analogue inputs/outputs in the same carcase.

The systems type SCADA permit the monitoring and control of the equipments from the field with help of computer; to a simple command from *mouse* or *keyboard* its possible to give commands to process, all these can be monitored online on the screen of the operator.

The softwares type SCADA dedicated to the monitoring and control of the RTU equipment has in general the next facilities:

- they are *Data Collecting Centres:* they gather all the information and history from the RTU storing them in databases;
- they are *Supervisors:* by connecting to the RTU (local or wireless) and listing the parameters in real time;
- they are *WebServers*: allowing users to access the list of history, alarms etc., by means of the classical network (LAN) and of a *Internet Explorer browser*.

The field data can be collected:

- *locally*, through a *Ethernet* connection or a serial connection using the RS232, RS485 communication ports. The data transfer is done in this case by means of standardized communication protocols (TCP/IP, Modbus TCP/IP, Modbus ASCII, Modbus RTU, etc.);
- *wireless* by means of GSM/GPRS modems, Radio, PSTN etc. for real time monitoring or through FTP, E-mail services for acquiring history.

Generally speaking in order to insure continuity in acquiring data from the field, one uses a redundant configuration of communication, namely if the local communication fails the SCADA software will switch the application to another local or wireless communication line so that no data within the process is lost.

At the same time with the data acquisition these will be stored in a database which will allow the future visualization of the entire history of the process in graphics, alarm lists or chronologies, being able to be exported in different formats (SQL, MySQL, Oracle, Access etc.).

The SCADA software administrator has access to a control panel which will allow the configuration of all communication, acquisition, authentication parameters. (Fig. 2).

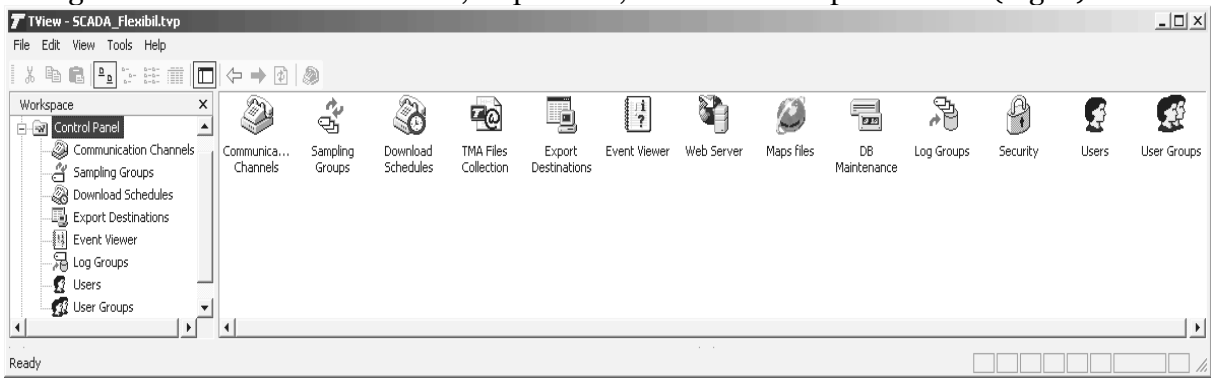



**Fig. 2.** The control panel

In general, the control panel has a series of interfaces like this:

- *the configuration of communication*: through LAN (Local Area Network), or through a modem (serial, GSM/GPRS etc.); one can configure redundancy groups for those cases when one of the communication lines fails, the next available line taking over the process data (Fig. 3);

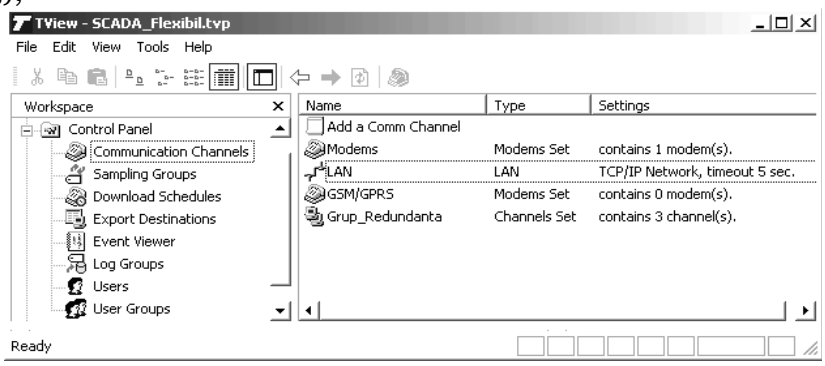



**Fig. 3.** Communication configuration interface

- *access level and user configuration,* having the possibility to add/delete with every user which has access to the SCADA interface (Fig. 4). The authentication is done with

username and password, the level of access being: without access rights, reading rights, reading and editing rights, these being established by the SCADA administrator

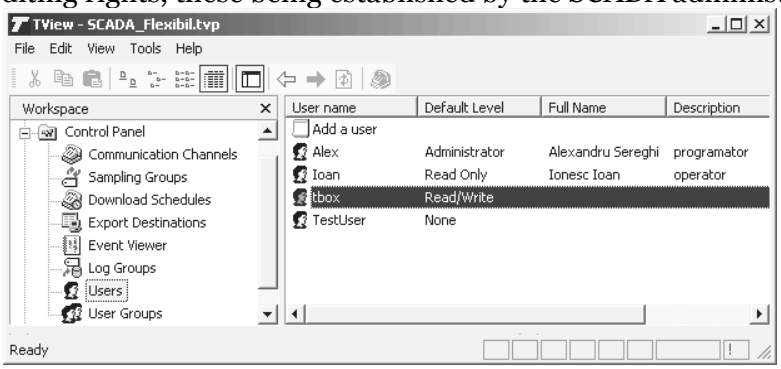



***Fig. 4**. Access level and user configuration interface*

- *visualization of events which happen during SCADA usage*. One can thus monitor the location from where users will access the monitoring and control interfaces, the warnings or error which can occur during the usage of the program, thus filling in the list of the SCADA interfaces advantages.

The software architecture of RTU equipments

The software met in the development of RTU applications is grouped in that of:

- *Programming* of the automation (programming the internal PLC);
- *Monitoring and control* of the conducted process (SCADA type software).

Programming Software of RTU equipments

New interfaces for programming RTU equipments dispose of more and more advanced programming tools and more intuitive windows for creating and administrating a programme.

The following steps intervene in the programming of RTU equipments:

- *The configuration of the RTU's properties:* it allows the selection, the adding and the modification of the application's main parameters, starting from communication parameters (the Modbus address, TCP/IP, communication drivers with equipments on field or other SCADA type software) up to things related to the security of communication ports or of the application itself;
- *The adding of input/output modules*: RTU equipments disposing of a high diversity of modules, from the classic ones with digital inputs/outputs, analogues on 14 bits or modules with temperature inputs (for PT100, PT1000 drills, etc), up to GSM/GPRS, PSTN, optical communication modules etc. Other RTU equipments or, through standard protocols, other equipments such as temperature controllers, measuring equipments (debits, levels, movements...), frequency variation devices etc, generally any equipment disposing of a communication port, can be added to the existing configuration of RTU equipments, due to the many ways of communication;
- *The realisation of Tags*: a *Tag* is the location of the RTU equipments' registers memory in which the value of a parameter (digital – a single memory bit, or analogue – 8, 16 or 32 memory bits) will be found. Each Tag will represent a direct or indirect link with the inputs or outputs from the process, in the programme which will be developed in the future (in *Ladder, Basic, Statement List, Function Block* etc.);
- *The realisation of the programme: Ladder* language, the most often used language in programming RTU equipments, represents the structure of the programme under the form of a ladder; *Basic* language presents the advantage of developing complex programme lines, but the most important fact is that the code lines are executed by the processor more rapidly compared to other programming languages, thus resulting a shorter scanning cycle;
- *The realisation of alarms:* is one of the elements which makes the difference between a RTU and classic PLCs. The interfaces with alarm lists allow the choosing of any event from the process we desire to start an alarm. The alarms will automatically be saved in a historic, enabling us to use them in the programme or send them towards the service personnel by SMS, Email, FTP etc.

- *The realisation of Datalogging*: is another distinct element specific to RTU equipments, being responsible for stocking the main parameters to be monitored, forming the historic of the process. The digital measures' passing from an estate to another can be stocked, but also the variations in time of the analogue measures.

The monitoring and control Software of RTU equipments

SCADA type interfaces allow the visualizing and control of field processes with the help of the computer; commands can be given towards the process by a simple mouse or key touch, all these being visualized in real time on the screen in front of the operator.

SCADA type software dedicated to monitoring and controlling from the distance of RTU equipments generally dispose of the following main facilities:

- They are *Data Collecting Centres:* they get all the information and historical from RTU equipments and stock them into data bases;
- They are *Supervisors:* through the connection to RTU (local or wireless) and display of parameters in real time;
- They are *WebServer:* allowing the access of users to the lists of historic, of alarms etc, through the classic network (LAN) and an *Internet Explorer* type *browser*.

The field data can be collected:

- *Locally*, through an *Ethernet* or serial connection using RS232, RS485 communication ports. The data transfer is done in this case through standard communication protocols (TCP/IP, Modbus TCP/IP, Modbus ASCII, Modbus RTU, etc.);
- *Wirelessly*, through GSM/GPRS, Radio, PSTN etc. modems for monitoring in real time or through FTP, Email services for historic acquisitions.
- Together with the data acquisition, it will be socked in a data base which will later allow the visualizing of the entire historic of the process in graphics, alarm lists or chronologies, being ready for export in different formats (SQL, MySQL, Oracle, Access etc.).

## 4. CONCLUSIONS

In conclusion we will present an application created by means of the RTU *TBox* equipment and namely monitoring a solar hot water production installation. The application is located in a mountain area, the solar system being made up of collectors with a total surface of 2x16 mp, two 500 liter reservoirs and two heat switches. The monitoring panel is equipped with a RTU TBox device specially designed for such applications, having 6 temperature inputs of the PT1000 type, 8 digital inputs, 2 analogue 4-20mA inputs, and 4 relay digital inputs. One of the main advantages of this type of equipment is the low energy consumption. Thus the monitoring panel was equipped with a 12Vdc battery, which in case of a power failure will continue to supply energy to the TBox equipment, thus the data acquisition being protected from any loss. The solar system supplier wanted a thermal energy threshold ensured with the implemented solution described above, so that it would be able to estimate the energy economy for the client achieved by introducing the solar panels. For this the following were required:

- heat and solar radiation monitoring by means of graphics according to time, with 10 minute acquisition rates and 10 day memory storage;
- water flow measuring;
- monitoring the recirculation pumps situation;
- sending through e-mail the database, process graphics, alarm lists every 24 hours;

The position of every sensor of the application is indicated in figure 5. The analogical radiation sensor with a 4-20mA output indicates the solar radiation in W/mp. The temperature sensors of the PT1000 type are linked to the system's inputs and outputs on the closed system of the solar panels and to the reservoirs' outputs. By means of relays one can monitor the situation of the recirculation pumps in the solar systems' panels. The recirculation pumps are powered according to the temperature difference between the input and output of the solar panel. The measurement of the flow was done with the help of a debitmetru which sends impulses at every liter of water being used.

The program which will be executed in RTU TBox according to the requirements was developed during the first stage of the project. The program was edited with the TWinSof

programming software. TWinSof allows the manipulation of the project on the interface of Windows and Linux operation systems.

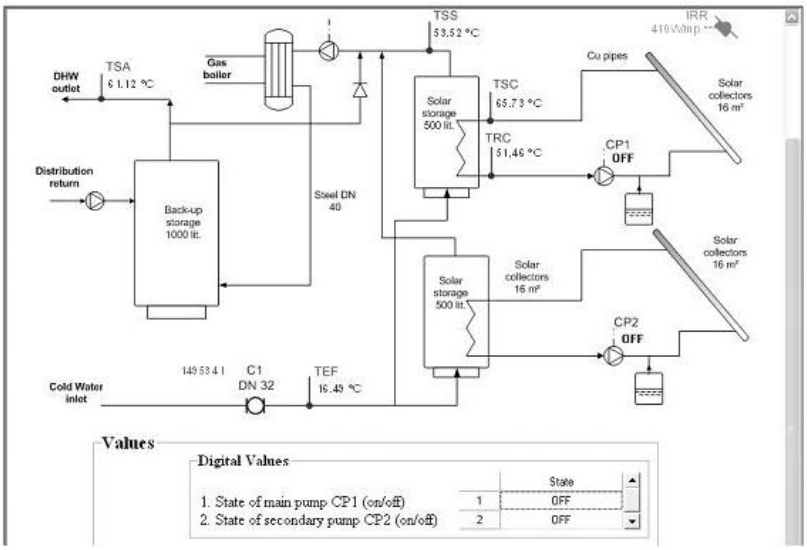



**Fig. 5.** Visualization interface

During the second stage of the project, once the RTU TBox was configured, the required graphics were configured, and a SCADA monitoring interface was created for field interventions and local visualization; this interface can be accessed by means of an Internet Explorer browser type. This interface was created in the WebFormEditor program, which is identical to TView in terms of the programming mode. The program graphics allows the creation of windows that are intuitive and in accordance with the field application, thus making it easy for the user to use the application. There are some *ActiveX*s, tables, and graphics available, with which one can develop user-friendly interfaces where the position of the sensors on the solar system plan is indicated. The temperatures, the flow, the situation of the pumps will dynamically indicate the values, according to the field values.

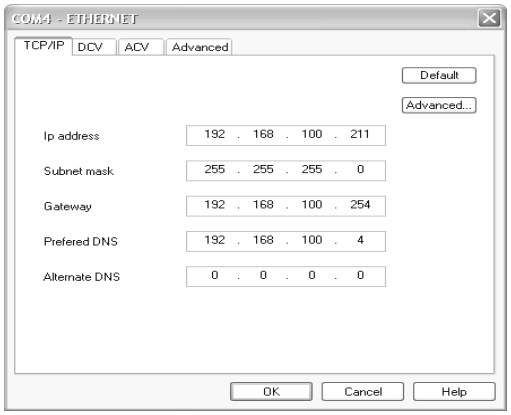



**Fig. 6.** Ethernet communication configuration

The sending the data through e-mail was achieved by connecting the TBox equipment to the internet. Through the Ethernet communication port programming interfaces from TWinSoft one introduced the communication parameters (see Fig. 6).

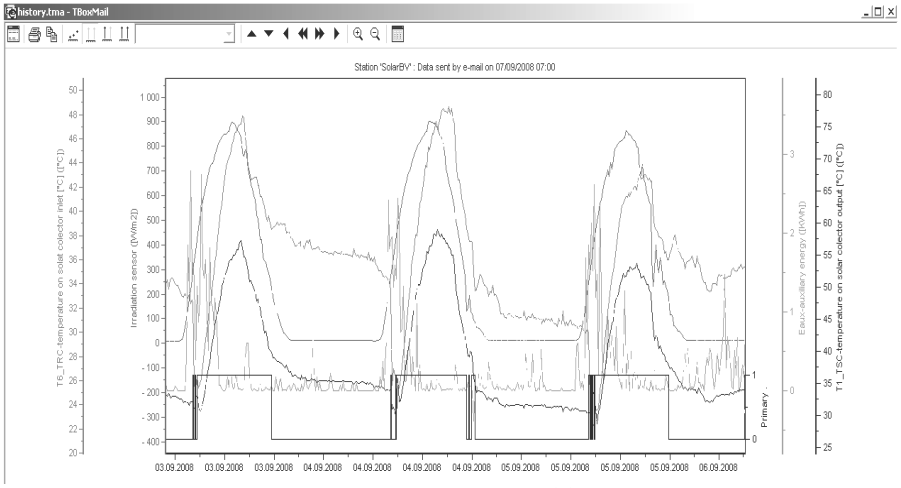



**Fig. 7.** Process graphic

The process graphics (Fig. 7) sent via e-mail contain all the monitoring data. Upon opening the graphic one can select the desired parameters. The graphic can be exported under .csv format and can be integrated into Microsoft Excel applications. Whenever necessary one can set the parameters, shrink or enlarge the graphics, having the possibility to print or export them under different formats (.jpeg, . bmp, .wmf, .emf, .txt).

As a conclusion, we'll present an application realized with the help of RTU *TBox* equipment in the industry of rubber based products. The monitoring and control of the entire production line is made with the help of *SCADA Ethernet TView* programme.

- The production line which is to be automated is formed of 16 hydraulic presses. Because most of the products need a strict monitoring of the vulcanization time, of temperatures and of the pressures used, the best solution needed to be found for allowing a computer controlled production and for fulfilling the following conditions:
- To allow the adding/modifying/deleting, through a window, of new production receipts for each press and their registration in a data base;
- To allow two working regimes: *Manual* (the initial case without automation) and *Automat* (the case in which the RTU TBox equipment will take over the control of the press);
- To register and display as graphics the main parameters of the process indifferently of the chosen working regime;
- To indicate all the events of interest in the list of alarms;
- To allow the access to the visualizing/controlling of data through a computer linked to internet.

The hydraulic presses are controlled by a manipulator through a control panel. The superior and inferior moulds are warmed with the help of some resistances and of some controllers with a PID curl for adjusting temperature, which dispose of a RS485 communication port.

In the first stage of the project, the programme to be executed in RTU TBox was developed. The programme was edited with the help of TWinSof programming software. TWinSof allows the manipulation of the project under Windows and Linux operating systems. First, the development of a communication driver was needed for the controllers from the production hall with the purpose of reading temperatures and setting temperature thresholds according to each production receipt.

In the second part of the project, once the programming of RTU TBox was done, the SCADA interface of monitoring and control from the distance was realized with the help of *SCADA Ethernet TView* software. The graphics of the programme allows us to create more and more intuitive windows in concordance with the application from the field, so that it is much easier to use the application. We have at our disposal many ActiveXs, tables, graphics to develop friendlier interfaces, where the hydraulic presses are indicated to be placed in the production hall. The estate of the presses (*supplied/unsupplied* with tension, working regime selected *automatically/manually*, production cycle *finished/stopped/in work*) s indicated in real time through messages and bright indicators alongside each press.

Each press will receive a receipt guiding the production in the automated regime. These receipts are created and edited where the most important parameters are the vulcanization time, pressures and prescribed reference temperatures. All receipts are saved in the table with *EntranceData* of the data base. In time, the receipts table will contain more and more registering, and in order to ease the finding of receipts and their reediting we developed a small filter with different searching criteria.

Returning to the process and to its monitoring in real time, windows can be created for each press, in which each parameter from the process can be visualized, indifferently of the working regime (automatic or manual).

The pressure and temperatures will indicate values in a dynamic way, corresponding to the values from the field. When the press works in automatic regime, the green arrow from the group of times will indicate the phase of the process in which the manipulator is found; in the table with production cycles, the stage of production can be followed with the exact number of successful/unsuccessful charges.

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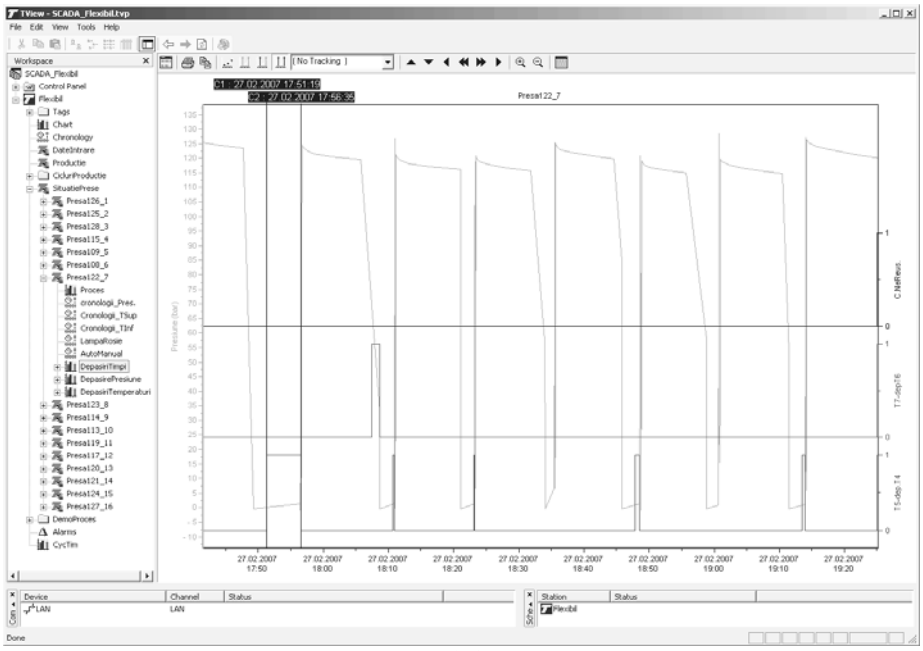


**Fig. 8.** Trial pressure

One of the greatest advantages of SCADA interfaces is the possibility of superposing the monitored parameters on graphics. In Figure 8 we can visualize pressure, superior temperatures, estate of the process (automatic/manual) and the situation of the bright indicator (Red Lamp) which indicates the end of vulcanization time and requires the intervention of the manipulator. Whenever we need, the parameter scales can be set, graphics can be increased or decreased, also having the possibility of printing and exporting them under different formats (.jpeg, .bmp, .wmf, .emf, .txt, .csv).

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# WORKING WITH ABAP PERSISTENT DATA

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**ABSTRACT**

SAP NetWeaver is the SAP integration platform that provides integration layers “People Integration”, “Information integration”, “Process Integration” and where the application platform is based on Application Server Java and Application Server ABAP so called ABAP stack and Java stack. Both application servers work with a different database schemas that cannot be locate in the same database. Relational database tables are most used to store persistent data with Application Server ABAP and have two database interfaces open SQL and Native SQL. In this paper we make a presentation of the ways we can access an ABAP database schema through classical ABAP tools as Function Modules and until to object-oriented access via Object Services.

## 1. INTRODUCTION

SAP NetWeaver is the SAP technology platform that SAP use to distribut its technology as a proprietary product, an entire group of so-called usage types ( Aplication Server, Business Inteligence, SAP NetWeaver Portal ...) [1].

The usage type SAP NetWeaver Aplication Server (AS) plays a central role in SAP NetWeaver and is subdivided in two usage types Aplication Server ABAP and Aplication Server Java with two programming interfaces ABAP and Java and two separated database schemas.

In Fig. 1 [2] we present the Aplication Server ABAP which we use to develop ABAP applications.

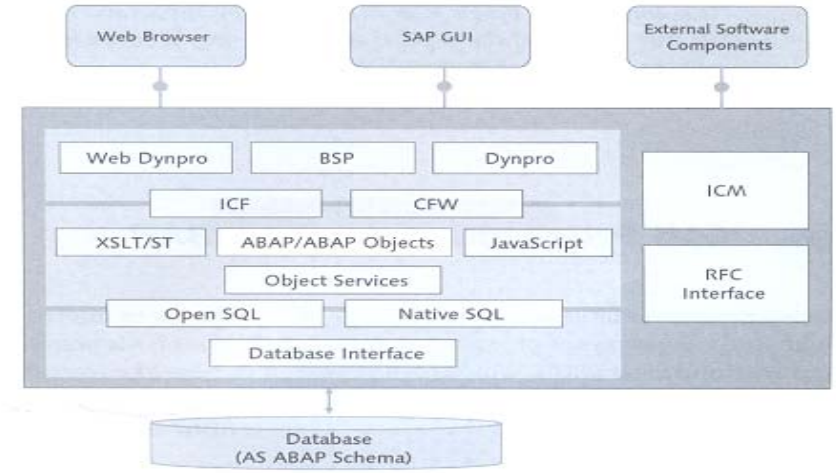



Fig. 1 Application Server ABAP [2]

As we can see the most of the AS ABAP can be divided in three layers: presentatin layer (Web Dynpro ABAP, Dynpro, BSP ), application layer (ABAP/ABAP Objects, XLT/ST, JavaScript) and persistence layer with two interfaces Open SQL and Native SQL.

In this paper we present the way we can acces the Database through Open SQL statments and Object Services. For this purpose we decouple the presentation logic from the application logic through Function Modules, usual ABAP classes and persistent classes.

ABAP supports both procedural (Function Modules, subrutines) and POO programming styles (Object Services, classes) and can be used easily to implement GUI - oriented (Dynpros) or browser-based (BSP, Web Dynpro) User Interfaces [3].

Function modules are procedures that are defined in function groups (special ABAP programs with type F) and can be called from any ABAP program. To create Function Modules and Function Groups we used Function Builder from ABAP Workbeanch. [4]

With help of Persistence Classes all SQL statements are hides from developer and provides instend set and get methods to access the database.

We presented follow some of the advanteges of using a new abstraction layer through Object Services: [5]

- Flexibility via Abstraction - we can simply substitute the coding in the busines objects class with methods from Web Services instend of the persistent objects;
- Functionality via Abstraction - It allows for a more complex mapping than a one-to-one relationship with the database;
- Simplicity via Abstraction

With help of persistent objects we can use fast and easy the ZIP compression technology available in ABAP to compress and decompress the large data that we store in database as xstrings. For our application we have choose to work with Web Dynpro ABAP framework because that offer us many advantages as for example What You See Is What You Get view editor with drag and drop support for UI elements so that we can us better concentrate of the business process.

## 2. THE STUDY

### 2.1 DATABASE EXAMPLE

To create a database table in the ABAP Dictionary we can use ABAP Dictionary Maintenance. To see all the tables and their relationship we can use table relationship Graphic. These tools are complete integrated in ABAP Workbeanch.

Normal application programs are not supposed to create any database table or to change their attribute and with open SQL statements we can only access database tables that we have created with the ABAP Dictionary tools [6]. To create a database table in our programs we can use native SQL, that offers us this possibility with the proper disadvantages.

To keep our application simple and easy to understand we have build a database that have six tables need to manage the Products in a virtual Library, Fig. 2.

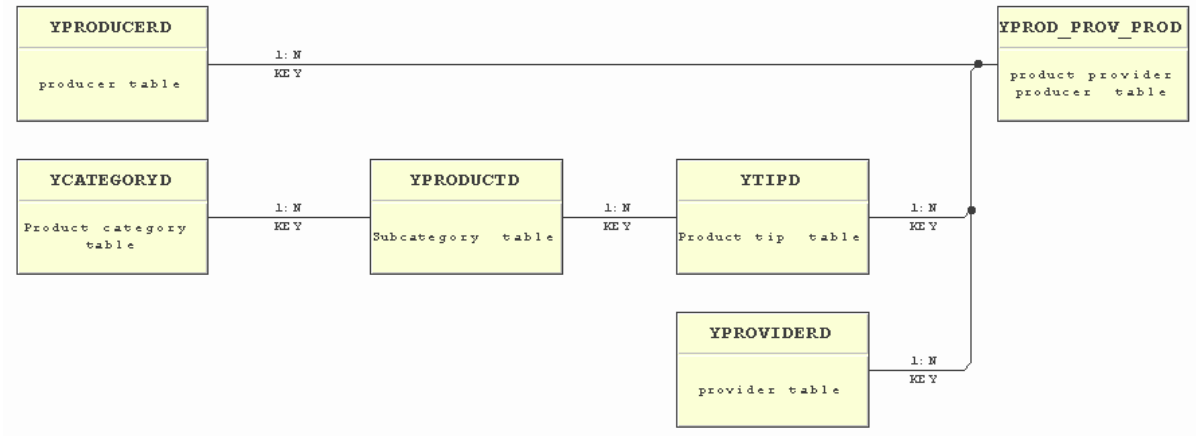



Fig. 2 The database used in our application

### 2.2. DATABASE ACCESS

Database tables are the most common data storage and we can access this ABAP database schema through Opens SQL or Native SQL or we can build a new abstraction layer through Object Services.

### 2.2.1 Database acces with Open SQL statments

SQL – Structured Query Language, is a largely standardized language for accessing relational database [7]. To acces our database with open SQL statements we can use classical ABAP tools or ABAP Objects.

**A. Clasical ABAP tools and database acces with Open SQL**

Classical ABAP has no classes and object-oriented modularization just the procedural modularization with Function Modules and subroutines.

In our example we want to show in a Web Dynpro application all the Books and publisher information for a specific Author. For this purpose we build a Function Group where we integrate a Function Module YFM_SEARCH, Fig. 3.

Function modules can have the following interface parameters: Import parameters, Export parameters, Changing parameters and Tables parameters.

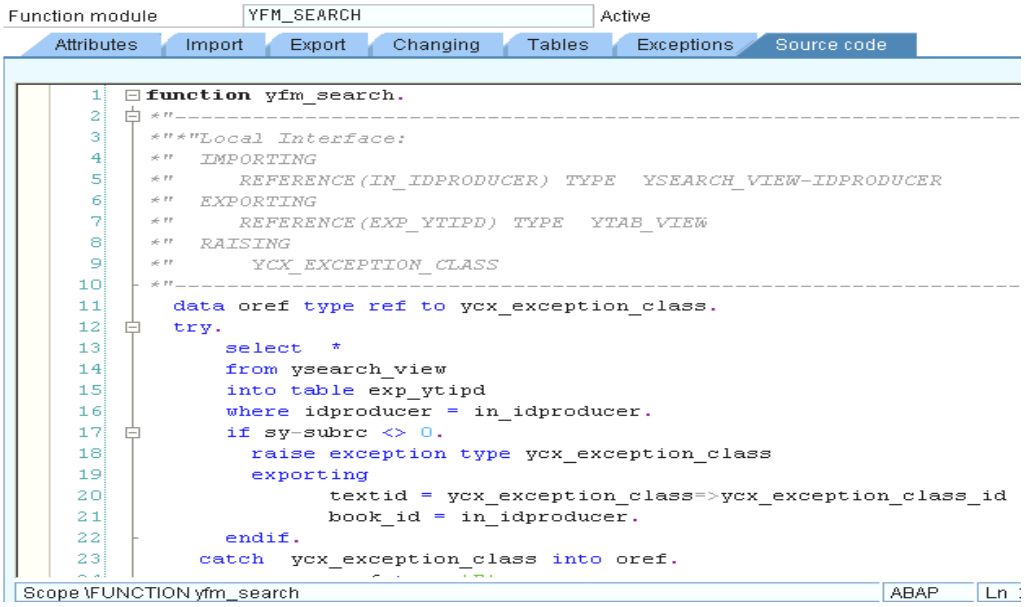



Fig. 3 Function Module YFM_SEARCH

We used this Function Module in a Web Dynpro application to offer a search possibility for the user, Fig. 4.

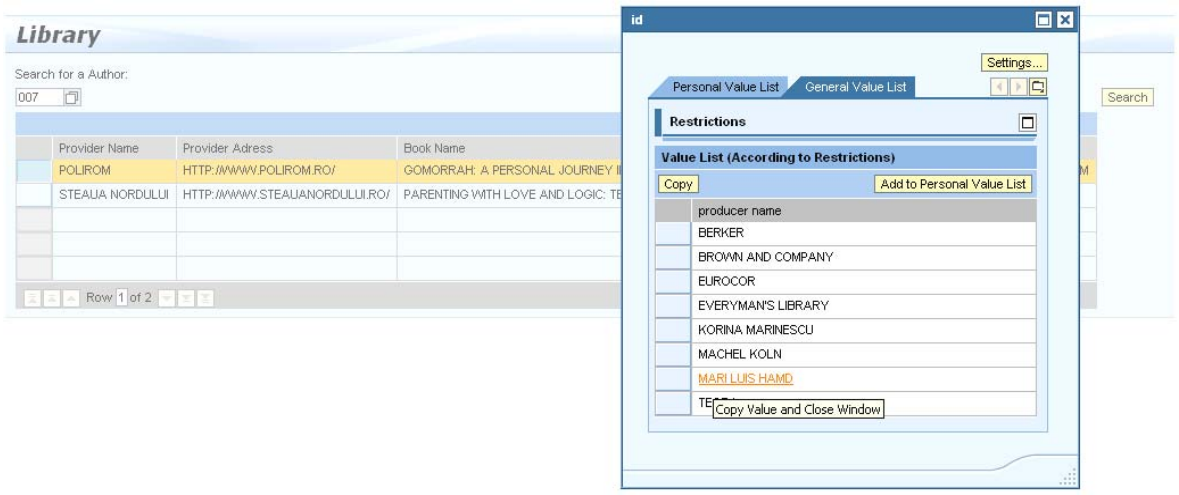



Fig. 4 The User Interface for YFM_SEARCH

Another example where we can use ABAP classical a Function Module is BAPI.

External access to the data and processes is possible by means of specific methods, so called BAPIs (Business Application Program Interfaces) that enable business functions in the SAP Systems to be integrated with business functions in non-SAP software, Fig. 5 [8].

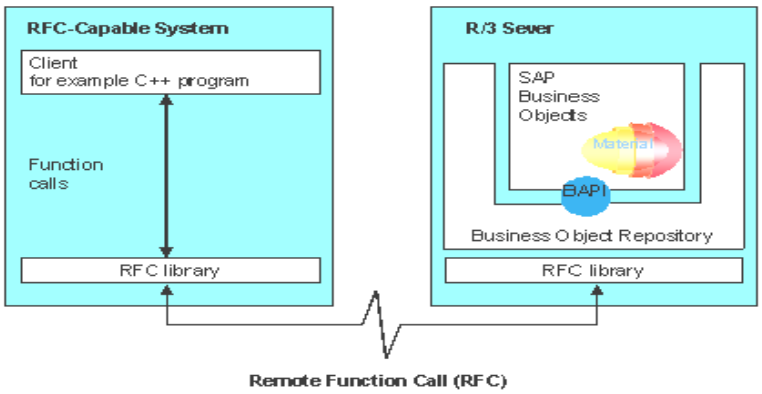



Fig. 5 Accessing a BAPI Function Module through RFC Calls [8]

We create a new Function Module named YBAPI_FUNCTIONMODULE, Fig. 6 with this module we can select all the Books that make part from a subcategory of Books category. After we save our Function Module we have to release him, to create an object YBAPI_OB with transaction SWO1 and to add a method (our Function Module YBAPI_FUNCTIONMODULE).

For example the code 001 represented Computer & Internet Books, code 002 represented History Books, Fig. 7.

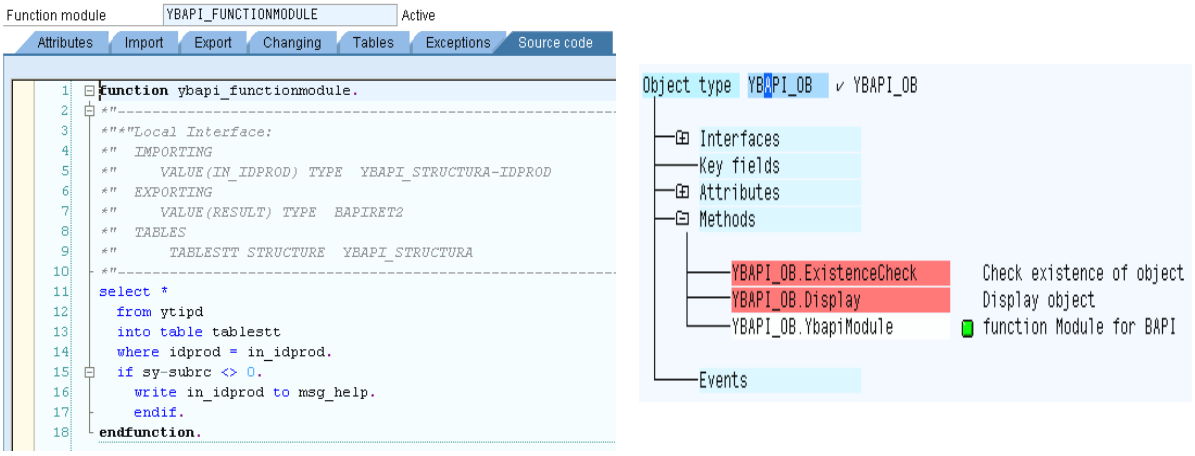



Fig. 6 Function Module YBAPI_MODEL_WD

| IDPROD | IDCAT | PRODUCT_NAME |
|---|---|---|
| 001 | 001 | COMPUTERS & INTERNET |
| 002 | 001 | HISTORY |
| 003 | 001 | AUDIOBOOKS |
| 004 | 001 | CALENDARS |
| 005 | 001 | CHILDREN'S BOOKS |
| 006 | 001 | COMICS |
| 007 | 001 | COOKING |

Fig. 7 Subcategory Books products from Library

Each function module underlying a BAPI and to use a BAPI method we need to know just some informations as for example the name of BAPI, the import parameters, the export parameters.

We import our BAPI in Web Dynpro ABAP as Model to build each view from our library web site, Fig. 8.

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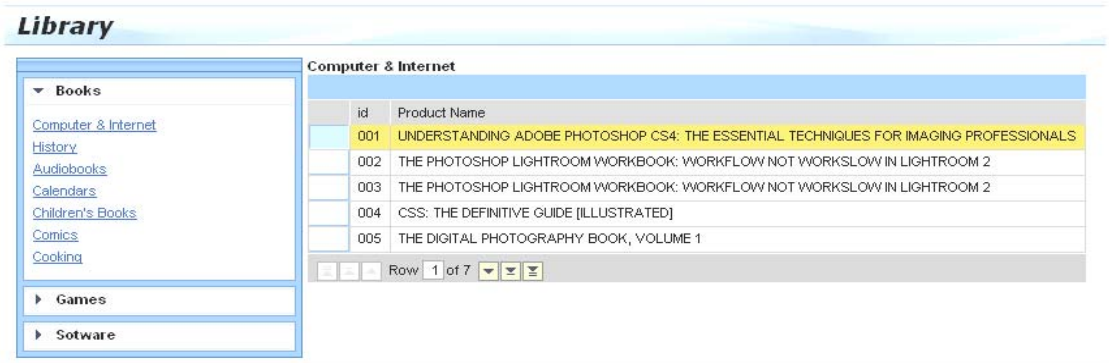



Fig. 8 The User Interface after service call creation

### B. ABAP Objects and database acces with Open SQL

After a succinct presentation of the classical ABAP tools that we can use to access a database and that already existed before ABAP Objects, we use now ABAP Object concepts.

Object-oriented programming is based on the encapsulation of data and its associated functionality in classes [9]. In ABAP Workbench we can build global classes with help of Class Builder and local classes that are coded in our ABAP programs. The most important components of a class are methods and attributes. To show the use and structure of a class we create a global class YCL_ABAP_INSERT, and methods for the database insert. In Fig. 9 we presented the method INSERT_PROVIDER of the global class YCL_ABAP_INSERT.

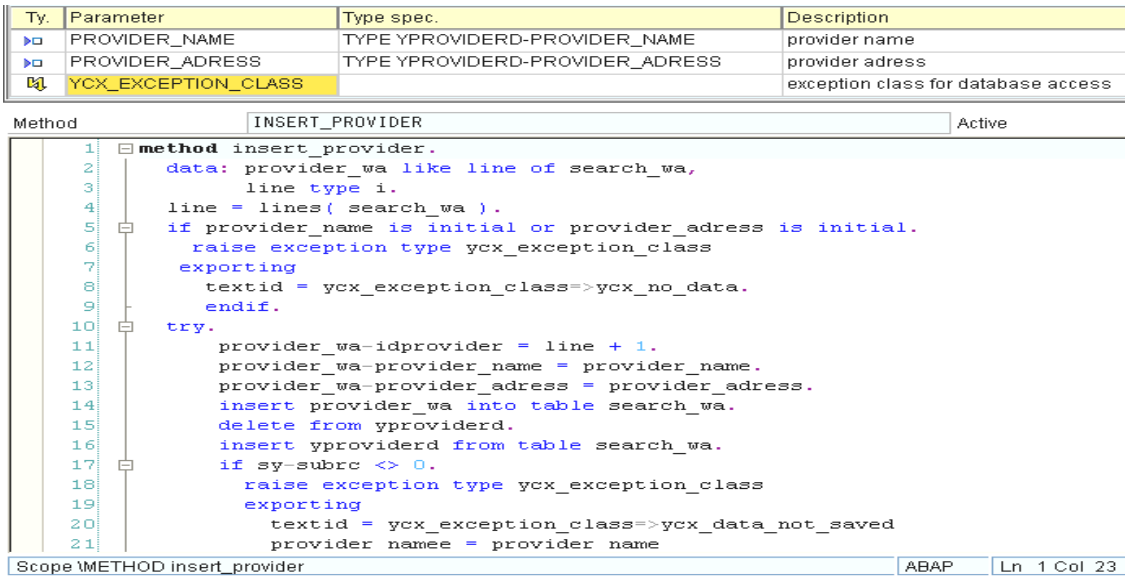



Fig. 9 ABAP Global Class, method INSERT_PROVIDER

The User Interface developed with Web Dynpro ABAP to show the use of the method INSERT_PROVIDER it is presented in Fig. 10.




Fig. 10 User Interface with Web Dynpro ABAP

### 2.2.2 Database acces with Object Services

If we use in our applications ABAP Objects to develop object-oriented applications then we can store the data from objects in database through Persistent classes with help of Object Services.

Object Services offer us several services as:

- Persistance Service – that help us to manage persistent objects in the database
- Transaction Service – that help us to update persistent objects
- Query Service – that help us to search and load persistent objects

The components of the Persistence Service that are relevant to ABAP programmers are presented in Fig. 11 [10].

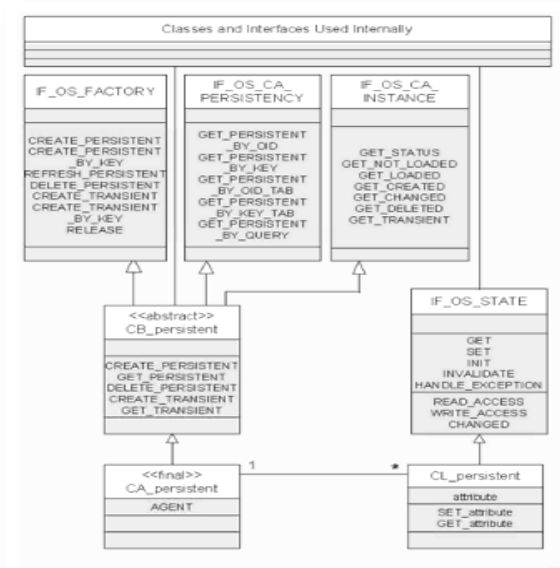



Fig. 11 The relevant components of the Persistence Service [10]

The Interface IF_OS_FACTORY through the method CREATE_PERSISTENT or CREATE_PERSISTENT_BY_KEY offers us the possibility to create a new persistent object.

The interface IF_OS_CA_PERSISTENCY through the method GET_PERSISTENT_BY_QUERY offer us the possibility to make a query for a database to import data from database tables that match conditions specify through proper parameters. Alongside GET_PERSISTENCE_BY_QUERY we can use the method GET_PERSISTENCE_BY_KEY_TAB to import persistent objects by specifying business key.

We create a persistent class YCL_PERSISTENT_ACCESS with help of Class Builder. As can be seen in Fig. 12 when we create a persistent class with the name YCL_<CLASS_NAME> or CL_<CLASS_NAME> the framework generate for as two extra classes YCA_<CASS_NAME> or CA_<CLASS_NAME> and YCB_<CLASS_NAME> or YCB_<CLASS_NAME>. After we define the persistent object the framework generate for us the SET and GET methods for the class attributes.

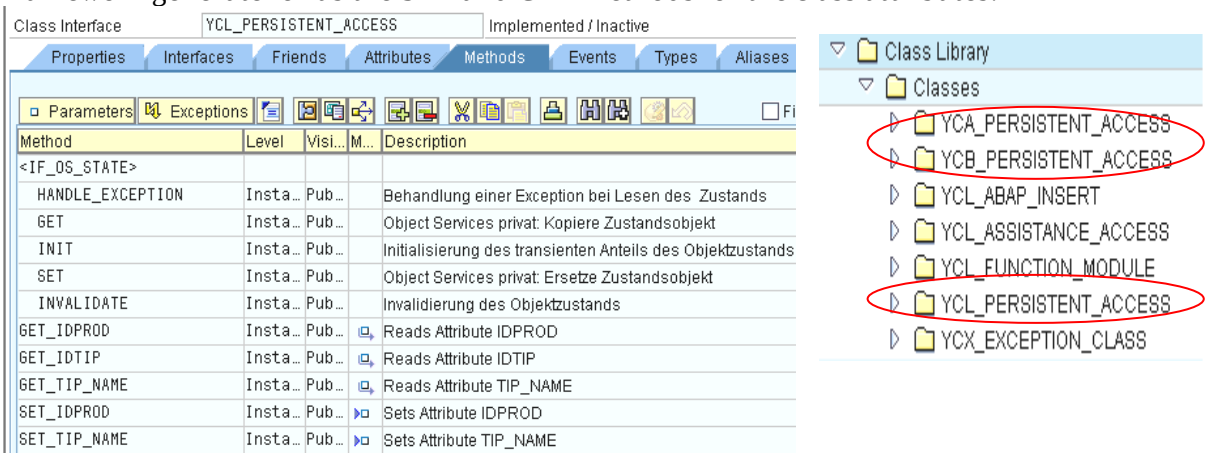


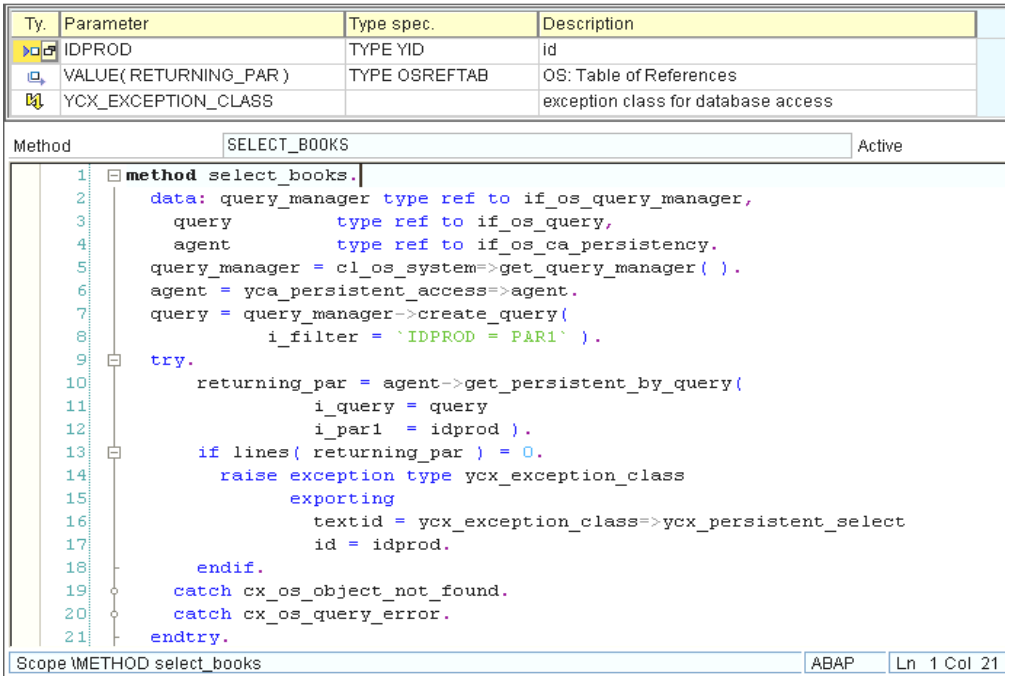

Fig. 12 ABAP persistent Class YCL_PERSISTENT_ACCESS

The attributs represented all the table fields and the generated get and set methods offer us the posibility to write and read individual filds in the database.

The main class it is YCL_PERSISTENT_ACCESS where we create our methods, the generated class YCA_PERSISTENT_ACCESS it is so called actor class that we use to manage our main class and the generated class YCB_PERSISTENT_ACCESS so caled base class it is a abstract super class with the framework functionality.

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We create a method SELECT_BOOKS, Fig. 13 that we can have all the Book records that we need to build a search posibility for a user.



| Ty. | Parameter | Type spec. | Description |
|---|---|---|---|
| | IDPROD | TYPE YID | id |
| | VALUE( RETURNING_PAR ) | TYPE OSREFTAB | OS: Table of References |
| | YCX_EXCEPTION_CLASS | | exception class for database access |

Method SELECT_BOOKS Active

```
1  method select_books.
2    data: query_manager type ref to if_os_query_manager,
3      query         type ref to if_os_query,
4      agent         type ref to if_os_ca_persistency.
5    query_manager = cl_os_system=>get_query_manager( ).
6    agent = yca_persistent_access=>agent.
7    query = query_manager->create_query(
8              i_filter = `IDPROD = PAR1` ).
9    try.
10       returning_par = agent->get_persistent_by_query(
11                 i_query = query
12                 i_par1  = idprod ).
13       if lines( returning_par ) = 0.
14         raise exception type ycx_exception_class
15               exporting
16                 textid = ycx_exception_class=>ycx_persistent_select
17                 id = idprod.
18       endif.
19     catch cx_os_object_not_found.
20     catch cx_os_query_error.
21   endtry.
```

Scope \METHOD select_books ABAP Ln 1 Col 21

Fig. 13 Method SELECT_BOOKS - YCL_PERSISTENT_ACCESS

A persistent class is a Protected class. To consume our YCL_PERSISTENT_ACCESS persistent class in Web Dynpro we build a assistance class used as model. In Fig. 14 we presented the User Interface after we have build a proper Search Help for yproductd-idprod

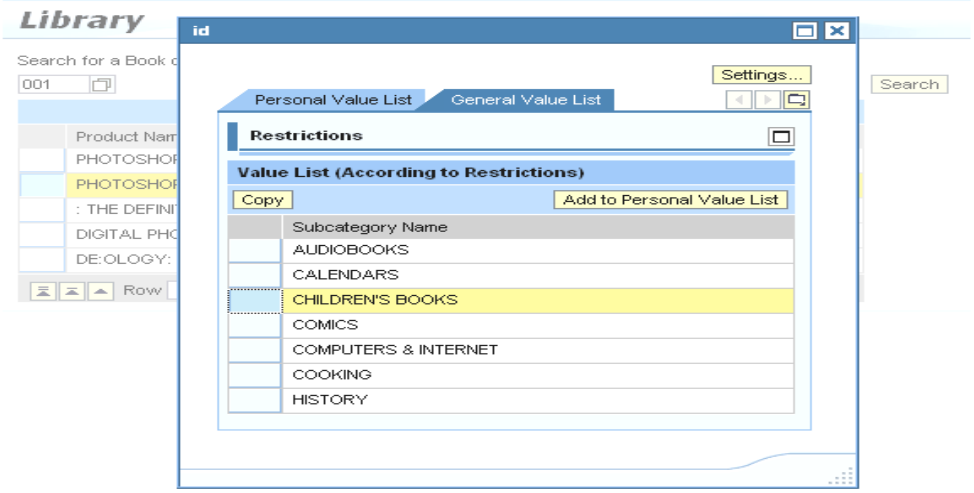



Fig. 14 User Interface with Web Dynpro ABAP

## 4. CONCLUSIONS

In this paper we have make a presetation of some of posibilitys that we have to acces a ABAP Database schema. We have seen the classical ABAP tools through Function Modules and Function Groups but also the new ABAP Objects concepts. Function Modules are not just a yesterday technology are used today too for Remoute Function Calls (RFC), BAPI or from a ABAP class or Web Dynpro component to access a specific functionality. We have seen that Applicatios Server ABAP offer us many posibilities to acces a database and samtimes we have to sacrifice pur object orientation for easier programming and we can combinate the old ABAP tools with the new ABAP object oriented concepts.

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[10] http://help.sap.com/saphelp_nw04s/helpdata/en/ab/9d0a3ad259cd58e10000000a11402f/frameset.htm

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# CONSIDERATIONS ABOUT NEURO-FUZZY ADAPTIVE SYSTEMS

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**Abstract**:
This paper work describes the shaping up of a system based on a input-output data set using ANFIS. First of all, we had to design the input-output data set to use during the training. The next step is to design a FIS structure that is going to be used in order to shape up a system who must be appropriate to the input-output data set. The FIS structure is going to be used in order to establish a primary set of functions needed during the training process.

**Keywords**:
neuro-fuzzy system, shaping up, structure , use

## 1. INTRODUCTION

The neuronal networks [1] could add high dynamic performance to the classical methods of adjustment, if they are used and designed properly [7]. This is possible if they adjust in real time, during the adjustment process [4]. Due to their ability of approximating the non-linear arbitrary functions, artificial neuronal networks are widely used in the domain of non-linear systems. Artificial intelligence could be also used successfully for parameter identification or for estimating different features of the process. The most important properties of the artificial neuronal networks (which are important for different applications during the automatic management) are: the ability of function approximation. Due to this ability of approximating arbitrary non-linear functions, artificial neuronal networks are highly important for the non-linear systems; information spreading; artificial neuronal networks have a parallel structure that allows the implementation of the systems' hardware; such an approach enables a highly margin degree in case of deficiencies than the classical alternatives; a parallel calculation higher degree; the ability of adaptation; the ability of generalization; neuronal networks could be used based on the data available previously - „off-line" learning or „on-line" learning (in real time): if the network is correctly used then, it has the ability of turning the data to a general outline, which is not possible in case of the data-set in use; shaping up the multi-variable systems; genuinely the neuronal systems have several inputs and outputs, and they are used in multi-variable systems; high degree of sturdiness in case of noise and incomplete inputs.

## 2. MULTI-LAYER NEURONAL NETWORKS. TRAINING METHODS.

Multi-layer neuronal systems are highly important for the domain of the artificial intelligence, because a lot of applications and classification and acknowledgement problems such as, the approximation of non-linear functions, the control and identification of the non-linear systems or the adaptation percolation - are solved out by using different types of networks. Multi-layer neuronal networks [5] eliminate a lot of limited features of the classical methods of the simple propagation or multi-layer perceptron – we refer to XOR. Generally speaking, such networks use feed forward propagation – meaning that in the case of those networks, there is no reaction amongst the neurons within the hidden layers or amongst those within the output and input layers, like those in Figure no. 1. Training methods for such network belong to the supervised methods, and they develop alongside the error back propagation algorithm - „back propagation" [7]. The main characteristic of these networks is the active function – it has both active continuous and/or derived non-linear functions, such as in Figure no. 2.

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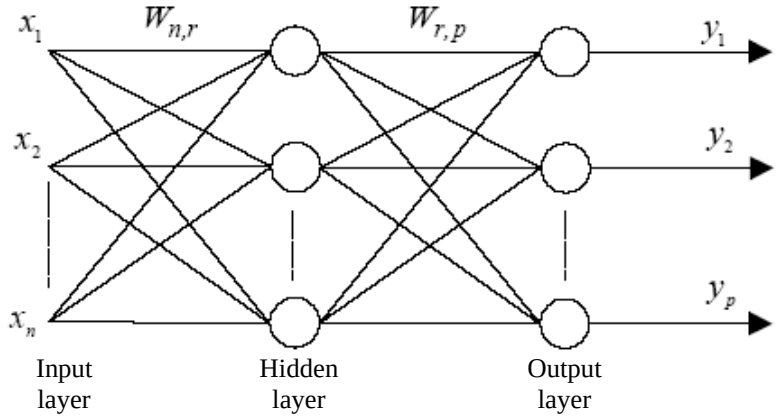



*Figure no. 1 One hidden- layer neuronal network*

The network in Figure no. 1 is made of one hidden layer who contains ,,n" neurons inside the input layer (n entries), „*r*" neurons inside the hidden layer, and „*p*" neurons inside the output layer [4]. The functions that make the neurons output layer active could be linear or sigmoid, meanwhile inside the hidden layer they must be sigmoid. In Figure no. 2 there are the most used functions that turn the multi-layer neuronal networks active, the sigmoid logarithmic function (left) and a hyperbole tangency function (right) are both coloured in blue, as well as their derivative functions - which are coloured in green.

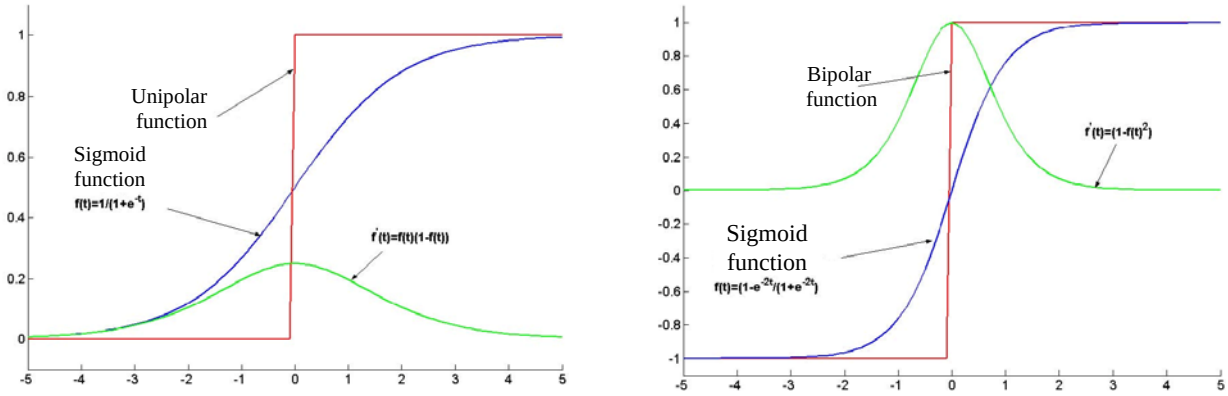



*Figure no. 2 Functions that make multi-layer neuronal functions active*

The error back propagation algorithm [7] uses three sets of data, one who turns the network active; other that is used for testing and validation of the weight we have come up with after the training stage; meanwhile the last one is the real data set. Choosing the data set for the training stage is highly important [29]. The data set must be representative for the matter under discussion, thus it should contain as much information as possible about the size-pairs of input values/output values we need. A correct data set will provide the network with the ability of generalization during the tests and the working process (real data sets), which reveal input values that have not been used during the training stage. Thus, the network shall come up with the right values at the output. We consider a training data set is made of ,,*m*" pairs who correspond to the most appropriate input and to the output vectors for the network:

$$\left(X^1, d^1\right), \left(X^2, d^2\right) .. \left(X^m, d^m\right) \quad (1)$$

In such conditions, when the input of the network uses the ,,*k*" data set, we could calculate the values for the output layer neurons, according to the moment when they turn active $s_j^k$, $j = 1 \ldots p$; as well as for the active function $f^i$, when the output value is the following:

$$y_j^k = f^i\left(s_j^k\right), \quad j = 1 \ldots p \quad (2)$$

We can define the square output error referring to the input vector $X^k$:

$$E_k = \frac{1}{2}\sum_{j=1}^{p}\left[d_j^k - y_j^k\right] = \frac{1}{2}\sum_{j=1}^{p}\left[d_j^k - f^i\left(s_j^k\right)\right] = \frac{1}{2}\left(e^k\right)^T e^k \quad (3)$$

Total error for all „*m*" data-sets is the sum of the $E_k$ errors:

$$E = \sum_{k=1}^{m} E_k \quad (4)$$

## 3. NEURO-FUZZY ADAPTIVE SYSTEM (ANFIS)

In order to design a fuzzy model [2] we should make the following steps: outputs are associated to input member functions which are turned into laws in order to get a certain set of output features; the output feature changes into output member functions, and the latter turn into a single output value or a decision associated to the output. If we want to shape up such a system, based on an input-output data-set, we should use the ANFIS shaping [6].

During the first stage, we create the input-output data set which we are going to use during the training stage.

The next stage is to design a FIS structure which is going to be used in order to shape up a system which must acquire the input-output data pair.

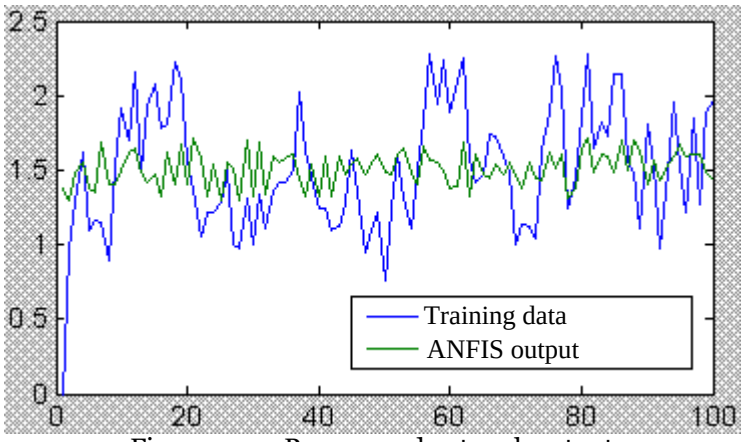



Figure no. 3 Process and network output

The FIS structure we have already created is going to be used in order to get a primary set of member functions used in training.

In order to check out the FIS system we have used, we should compare its output to the „y" input belonging to the training set. The output of the system we use and the „y" size we have obtained during experiments are described in Figure no. 3.

In order to identify [3] the ANFIS process, there is the possibility of using a graphical interface. Once we use this interface, it is possible to upload the data set in order to turn the network active – these data is uploaded on the work space or on the disk. After we have uploaded the data, the output data are graphically described alongside some information about them (number of entries, number of entry pairs) - Figure no. 4.

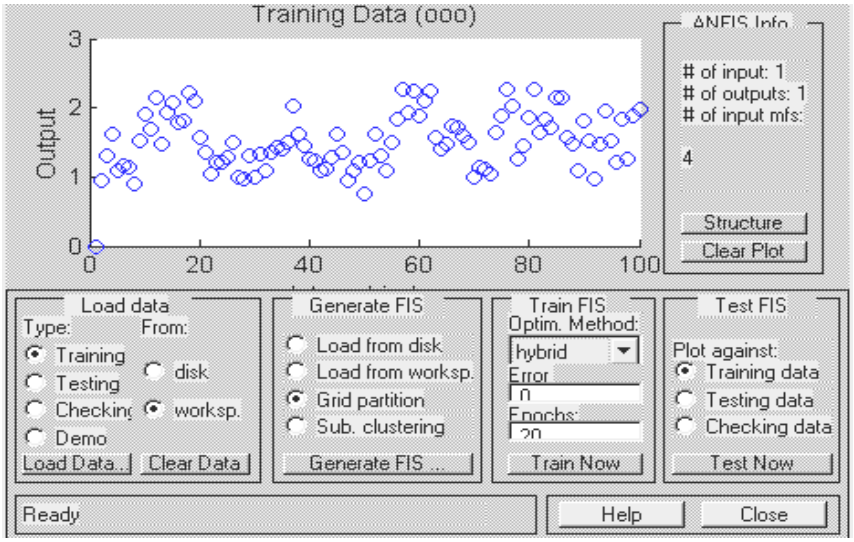



Figure no. 4 ANFIS graphic interface; training data

The next step is to define the FIS structure which is about to be used (Figure no. 5).

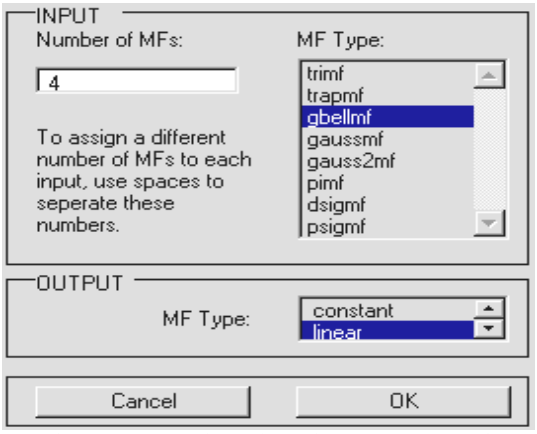



Figure no. 5 Choosing the FIS network parameters

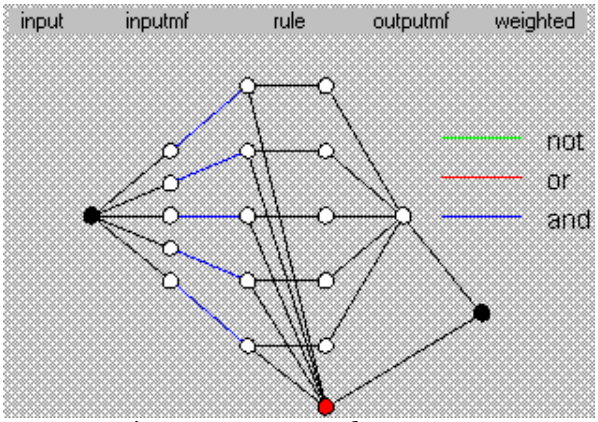



Figure no. 6 Network structure

The structure we have created could be graphically described. Therefore, the primary relations, the logical operations, and the implemented laws are ready to be performed - Figure no. 6.

After we have defined the parameters, we are able to perform the network training. The value of the error must be equal to 0; the best method of training is either '*hybrid*' or '*back propagation*' - the number of repeated stages to be performed. Figure no. 7 represents the evolution of the error during each stage of the training. If the training of the network is performed again then, it is going to work below the error value it had reached earlier. We see that once the number of periods increases, the error decreases, but not below to a certain value. That value is the limit. When it is reached, the number of repetitions does not cause a significant error decrease. If the number of repetitions increases, it reaches the „y" value of the output – Figure no. 8.

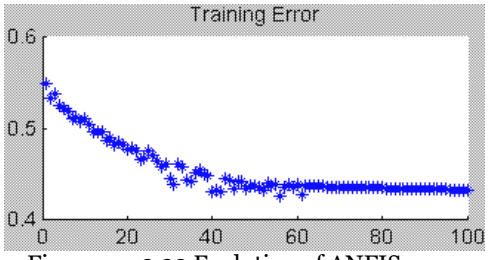



Figure no. 3.32 Evolution of ANFIS error

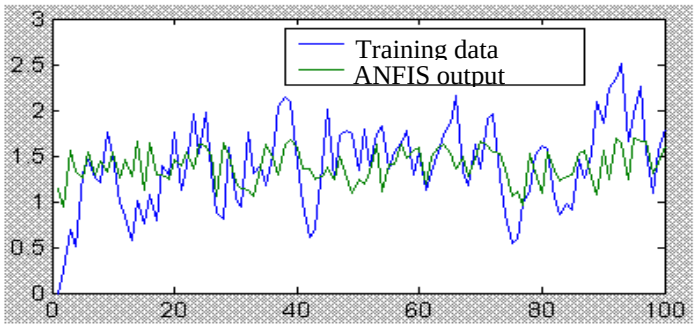



Figure no. 8 Evaluation of ANFIS after an increased number of repetitions

## 4. CONCLUSIONS

We have performed the shaping up of a system based on an input-output data set and we have used the ANFIS shaping-up method for that. We have created an input-output data set and we have created the FIS structure and the network training.

We have found out that once the number of periods increases, the error decreases, but it does not go below a certain margin. If it goes below that margin, the number of repetitions is increased and it does not produce any significant decrease of the error. If the number of repetitions increases, we find out that it reaches the right "y" value.

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# A STUDY ABOUT A RESISTIVE STEPPED TRANSDUCER USED FOR WATER LEVEL MEASUREMENT

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**Abstract:**
In this work is analyzed a resistive stepped transducer used for water level measurement. For sending remote the information regarding the level, is used a level-frequency converter with an astable circuit with CD 4047. Experimentally it was determined the frequency modification from output depending on the water level in two situations: when the transducer's steps above the water are wet and when these steps are dry. In both situations is found a non-linear frequency modification, depending on the level. Were calculated the transducer's resistances in such way that the frequency will modify linearly with the level.

**Keywords:**
level, resistive transducers, level-frequency converters

## 1. INTRODUCTION

Electric measurement of the non-electric measures is applied on large scale in almost all domains. The advantages of the measuring electric methods against the non-electric methods are: high precision, high sensitivity, possibility for sending remote information, great adaptability, possibility and safety of recording, possibility to process the values obtained by measurement [1,2].

In practice, there are many conversion methods of the level of a liquid into an electric signal. When measuring the liquids level, there can be more measuring methods: with floating mechanism and electric transmission, impulse system for level's remote measurement, capacitive measuring methods, methods based on radioactive radiations, methods based on pressure measurement, methods based on mass measurement, resistive methods [3,4,5,6]. Level's measurement can be continuous or discontinuous [2].

## 2. RESISTIVE LEVEL TRANSDUCER WITH LEVEL-FREQUENCY CONVERTER

The resistive transducers are safe in operation and should achieve a conversion as good as possible of the level into another measure. An astable circuit alternates between two different output voltages. The output remains at each voltage level for a defined period of time. The astable circuit has two outputs, but no input [7].

The resistive level transducer with level-frequency converter is presented in fig.1.

The level-frequency conversion takes place in two steps: a level-resistance conversion achieved with the stepped level transducer itself (resistive transducer), followed by a resistance-frequency conversion made by a symmetric astable trigger circuit.

The integrated circuit CD 4047 is capable of operating in either the monostable or astable mode. It requires an external capacitor (between pins 1 and 3) and an external resistor (between pins 2 and 3) to determine the output pulse width in the monostable mode, and the output frequency in the astable mode. Astable operation is enabled by a high level or low level on the astable input. The output frequency, at 50% duty cycle, is determined by the timing components [7]. Features like astable circuit of CD 4047 [8]:

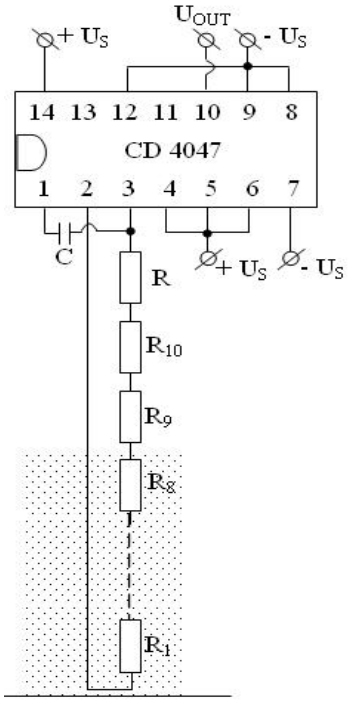



Figure 1. Resistive level transducer with level-frequency converter

- wide supply voltage range: 3 ÷ 15 V;
- low power TTL compatibility;
- free-running or gatable operating modes;
- 50% duty cycle;
- good astable frequency stability:
  - typical=±2%+0.03%/°C at 100 kHz, $U_s$=10 V;
  - frequency=±0.5%+0.015%/°C at 10 kHz, $U_s$=10 V.

The astable trigger circuit has the integrated circuit CD 4047, the capacitance C and the transducer's resistors ($R_1 \div R_{10}$). The resistive transducer is formed by putting in serial the resistances $R_1 \div R_{10}$ (the steps of the transducer's resistances). By increasing the level, are short-circuited, in order, the resistances $R_1$, $R_2$, …, $R_{10}$. The modification of the equivalent resistance from the transistors' bases leads to the frequency modification of the voltage $U_{out}$. For the symmetric astable circuit, the output signal's frequency is [8]:

$$f = \frac{1}{4.4 \cdot R \cdot C} \quad (1)$$

Its are chosen the transducer's resistances $R_1 = R_2 ... = R_{10} = 18$ kΩ. It is notice in fig.1, that $R_{CB}=R_{23}$, the resistance between the pins 2 and 3 of CD 4047 (the resistance of transducer).

The transducer's resistances were introduced in plastic boxes with Φ 22 mm diameter and 30 mm length, and the boxes were filled with electrical insulating paste. The boxes where mounted on a stainless steel support. The transducer has the active length of 1 m, and the distance between two successive resistances is 10 cm. The resistances are serial, with tinned copper plates with the surface of 12.5 cm² and the distance against the metallic support of 1 cm (distance between plates). The resistive level transducer with level-frequency converter was practically tested into a tank of which principle diagram is presented in fig.3. In fig.2: 1 – tank, 2 – filler funnel, 3 – filler tap, 4 – tube scaled in level units, 5 – drain tap, 6 – vent valve, 7 – support. In fig. 3 is the resistive transducer used in experiments.

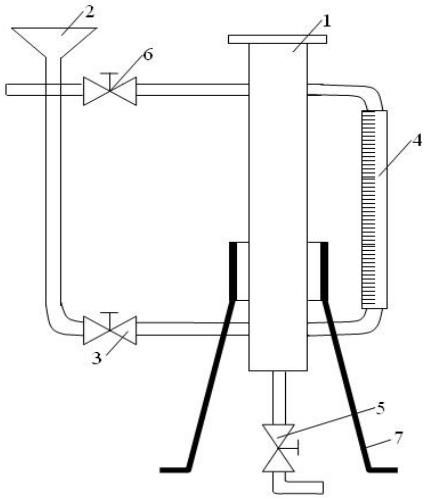



Figure 2. The tank used for checking the resistive transducer

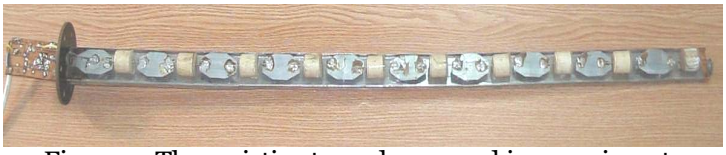


Figure 3. The resistive transducer used in experiments

To determine the frequency's real values depending on resistivity, should be determined the resistivity of the water used in experiments. In order to determine the resistivity of the potable water, it was used the volt-ammeter measuring method of the resistance. This method was used in alternate current to avoid the water's electric polarization phenomena. It was used an experimental device formed by two plane-parallel plates of surface $S_1$=20.8 cm² and distance between them of $l_1$=1.8 cm in upstream (fig.4) and downstream (fig.5) montage.

The potable water resistances and resistivities for the upstream montage are determined with the relations:

$$R = \frac{U}{I} - R_{mA} \quad (2)$$

$$\rho = \left(\frac{U}{I} - R_{mA}\right) \cdot \frac{S_1}{l_1} \quad (3)$$

and for the downstream montage with:

$$R = \frac{U}{I \cdot R_v - U} R_v \quad (4)$$

$$\rho = \frac{U}{I \cdot R_v - U} R_v \cdot \frac{S_1}{l_1} \quad (5)$$

For the measuring instruments, $R_v$=1000Ω and $R_{mA}$=275Ω. The measurement results and the calculation of resistances and resistivities are given in table 1. From table 1 it results the average value for the potable water resistivity used in experiments: $\rho_{avg}$=52.35 Ω·m.

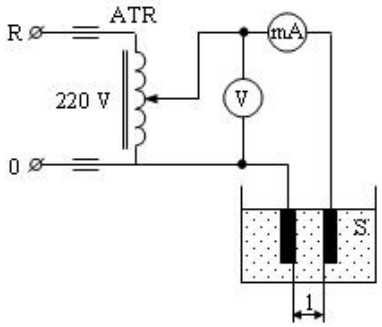



Figure 4. The volt-ammeter method – upstream montage

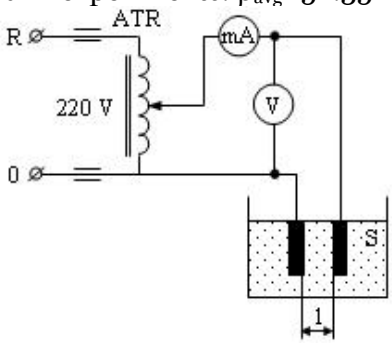



Figure 5. The volt-ammeter method – downstream montage

By measuring the resistances, the transducer has the following values for the resistance steps (fig.1,3): $R_1$=17.66 kΩ; $R_2$=17.5 kΩ; $R_3$=17.3 kΩ; $R_4$=16.96 kΩ; $R_5$=17.12 kΩ; $R_6$=16.98 kΩ; $R_7$=17.26 kΩ; $R_8$=17.5 kΩ; $R_9$=17.08 kΩ; $R_{10}$=17.32 kΩ and $R_B$=121.4 kΩ and C=101 pF.

The measurements of the signal's frequencies from the circuit's output were made with the TRMS Protek 506 multimeter. To verify the operation of the transducer from fig.1, was measured the output frequency, by short-circuiting the resistance steps.

Table 1. Determination of water's resistivity

| Electric Measures | Montage type | | | | | | Average value |
|---|---|---|---|---|---|---|---|
| | upstream | | | downstream | | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| U [V] | 0.52 | 0.88 | 1.75 | 0.26 | 0.63 | 0.75 | - |
| I [mA] | 0.78 | 1.15 | 2.4 | 0.8 | 1.825 | 2.34 | - |
| R [Ω] | 391 | 493 | 453 | 482 | 524 | 470 | 468.8 |
| ρ [Ω·m] | 45.2 | 56.8 | 52.5 | 55.6 | 60.6 | 54.2 | 54 |
| Electric Measures | Montage type | | | | | | Average value |
| | upstream | | | downstream | | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| U [V] | 0.35 | 0.7 | 1.38 | 0.32 | 0.43 | 0.74 | - |
| I [mA] | 0.47 | 0.97 | 1.95 | 1.08 | 1.42 | 2.45 | - |
| R [Ω] | 469 | 445 | 435 | 421 | 434 | 433 | 439.5 |
| ρ [Ω·m] | 54.2 | 51.5 | 50 | 48.7 | 50 | 50 | 50.7 |

If the tank is empty (h=0), the transducer has all the resistances:

$R_t = R_{1\text{-}10} = R_1 + R_2 + \ldots + R_{10}$ (6)

If the tank has h=10cm of water, then the transducer's resistance is:

$R_t = R_{2\text{-}10} = R_2 + R_3 + \ldots + R_{10}$ (7)

For h=90 cm, the transducer's resistance is:

$R_t = R_{10\text{-}10} = R_{10}$ (8)

For h=100 cm, the transducer's resistance is $R_t$=0.

For $U_s$=10V it was made a comparative analysis in table 2, between the frequency's calculated values ($f_c$) and the measured ones ($f_m$). It was determined the relative error with:

$$\varepsilon_r = \frac{f_c - f_m}{f_m} \cdot 100 \ [\%] \tag{9}$$

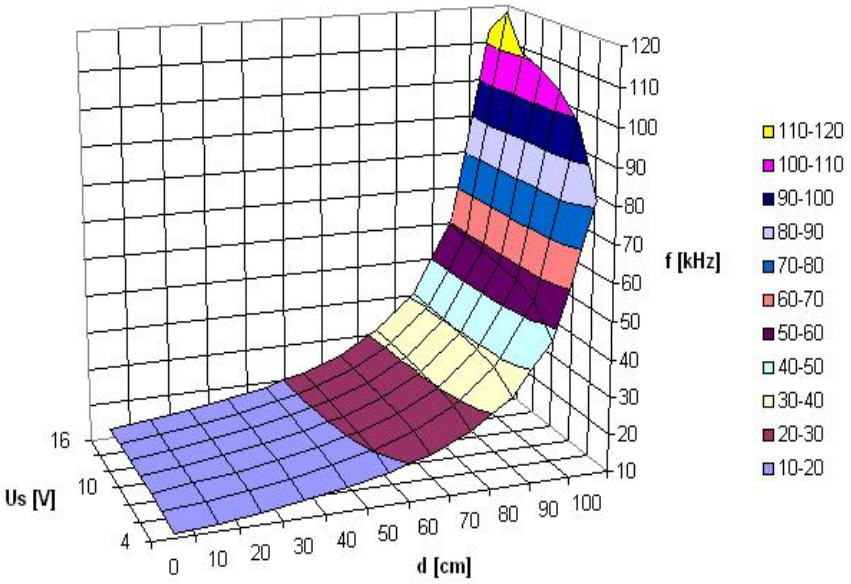



Figure 6. The output signal's measured frequency (f) depending on level (h) and supply voltage ($U_s$), when the resistance steps are short-circuited

From table 2, one can notice that, for the h=0-100 cm $\varepsilon_r$ is acceptable, that validate the calculate frequency with (1).

In fig.7 and 8 were measured the circuit's output signal frequencies depending on h and $U_s$, in two situations:

- at a rapid water level modification, the superior resistance steps remain wet (fig.7);
- at a slow water level modification, the superior resistance steps having time to dry-up (fig.8).

The first situation is rarely met in practice than the second situation.

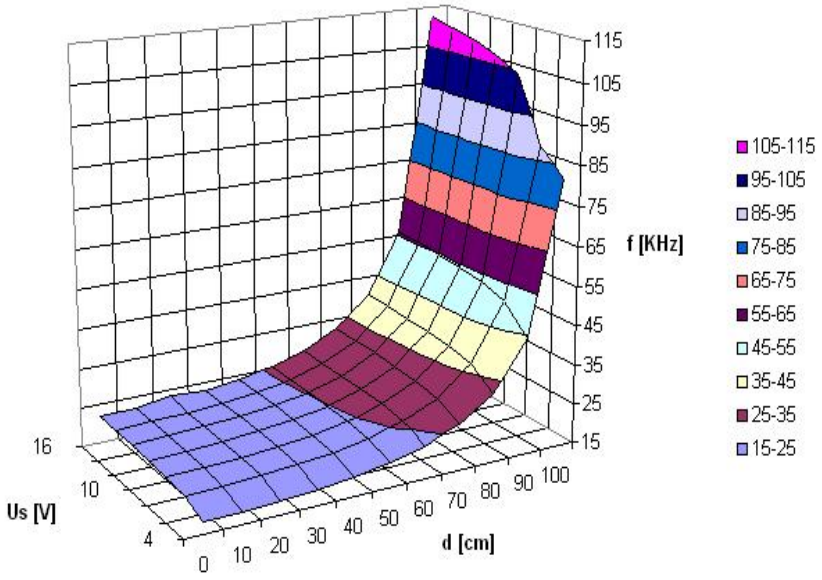



Figure 7. The output signal's measured frequency (f) depending on level (h) and supply voltage ($U_s$), when the transducer is introduced in water, the resistance steps above the water being wet

Table 2. The calculated and measured frequency depending on the level (by short-circuiting the steps) $U_s$=10V

| h [cm] | 0 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|
| $f_c$ [kHz] | 11.8 | 13.04 | 14.46 | 16.27 | 18.55 | 21.6 |
| $f_m$ [kHz] | 12.39 | 13.44 | 14.73 | 16.32 | 18.34 | 21.04 |
| $\varepsilon_r$ [%] | -6.2 | -4.66 | -3.34 | -1.99 | -0.57 | 0.71 |
| h [cm] | 60 | 70 | 80 | 90 | 100 | |
| $f_c$ [kHz] | 25.81 | 32.18 | 42.92 | 63.67 | 124.87 | |
| $f_m$ [kHz] | 24.67 | 30.39 | 39.78 | 57.61 | 108.7 | |
| $\varepsilon_r$ [%] | 2.01 | 3.41 | 5.01 | 7.08 | 9.73 | |

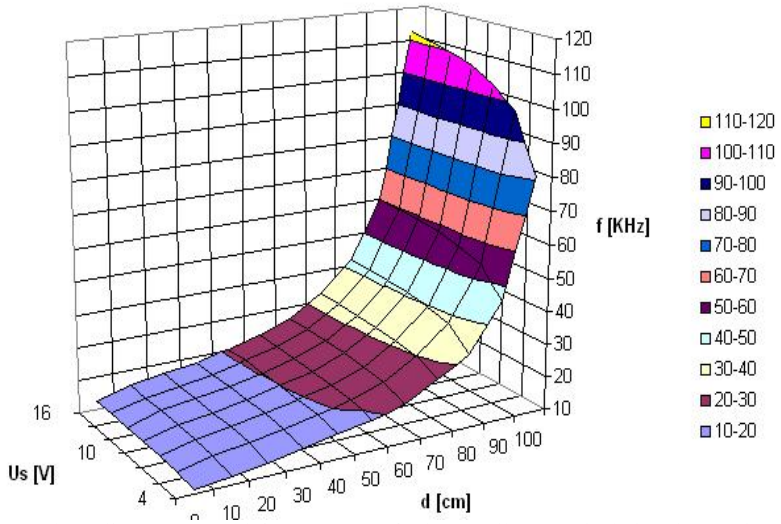



Figure 8. The output signal's measured frequency (f) depending on height (h) and supply voltage ($U_s$), when the transducer is introduced in water, the resistance steps above the water being dry

For determining the signal's frequency depending on the transducer's resistance, it should be used the transducer's electric model in real operation conditions (is taken into account the water resistance between the transducer's plates). Further, the resistance steps above the water are assumed to be dry. The resistance between the plates, when the water is at their mid-height, is $R_s$:

$$R_s = \rho \cdot \frac{l}{\frac{S}{2}} \tag{10}$$

where $\rho$ is the water resistivity, l is the distance between the transducer's plates, and S is the common surface between the plates, when the water is at their mid-height. With the calculated data ($\rho$) and measured data (l, S) is obtained $R_s$=1.68 kΩ. For h=0 (fig.1), the transducer's resistance is given by (fig.9):

$$R_{CB0} = \sum_{i=1}^{10} R_i \tag{11}$$

With the resistances' measured values is obtained $R_t=R_{CB0}$=294.08 kΩ. For h=10 cm, in situation when the water is at the mid-height of the plate for the first step, the electric model of the transducer's resistance is $R_t=R_{CB1}$ is presented in fig.10.

$$R_{CB1} = \sum_{i=2}^{10} R_i + \frac{R_1 \cdot R_s}{R_1 + R_s} \tag{12}$$

Is obtained $R_{CB1}$=277.95 kΩ. For h=20 cm, in situation when the water is at the mid-height of the plate for the first step, the electric model of the transducer's resistance is $R_t=R_{CB2}$ is presented in fig.11. Step 1 is completely under water, the metallic plates being completely covered. Their equivalent resistance is $R_s/2$.

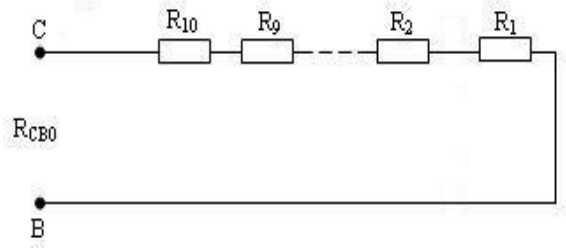



Figure 9. Electric model for h=0

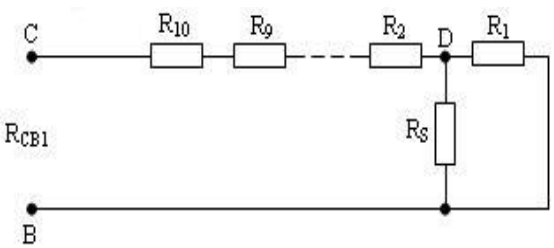



Figure 10. Electric model for h=10cm

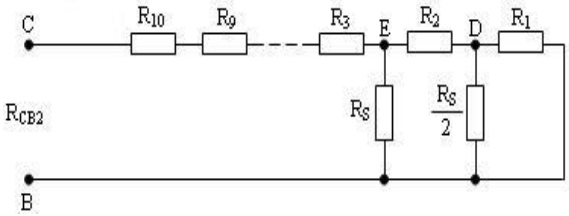



Figure 11. Electric model for h=20cm

$$R_{CB2} = \sum_{i=3}^{10} R_i + \frac{\left(\frac{R_1 \cdot R_s}{2 \cdot R_1 + R_s} + R_2\right) \cdot R_s}{\frac{R_1 \cdot R_s}{2 \cdot R_1 + R_s} + R_2 + R_s} \tag{13}$$

Is obtained $R_{CB2}$=260.45 kΩ. Calculating little by little, are determined also the other values of the resistances for the other values of the water height (table 3). In table 3, $f_m$ is the output signal's frequency when $U_s$=10V, and the resistance steps above the water are dry.

Table 3. The measured and calculated frequency depending on $R_{CBi}$

| h [cm] | 0 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|
| $R_{CBi}$ [kΩ] | 190.7 | 99.69 | 69.1 | 52.87 | 42.82 | 35.98 |
| $f_c$ [kHz] | 12.58 | 22.57 | 32.56 | 42.55 | 52.54 | 62.54 |
| h [cm] | 60 | 70 | 80 | 90 | 100 | |
| $R_{CBi}$ [kΩ] | 31.02 | 27.26 | 24.32 | 21.95 | 20 | |
| $f_c$ [kHz] | 72.53 | 82.52 | 92.51 | 102.5 | 112.5 | |

## 3. LINEARIZATION OF THE CHARACTERISTIC OF THE RESISTIVE LEVEL TRANSDUCER WITH LEVEL-FREQUENCY CONVERTER

The characteristics from fig.7 and 8 are non-linear. The issue is to determine the values of the transducer's resistances in such way that the frequency indication depending on level to be linear. Is imposed the modification of the output signal's frequency between 12.58 kHz and 112.5 kHz, with 9.992 kHz step. From (1) is calculated the resistance depending on frequency:

$$R = \frac{1}{4.4 \cdot f \cdot C} \tag{14}$$

This frequency interval is divided to the number of resistance steps of the transducer, and then, by (14) are determined the resistances $R_{CBi}$ from the transducer's electric model (table 4). Further, is considered that when the water is at a certain level, the water covers half of the surface S common between the two plates, and the water's equivalent resistance is $R_S$. If the plates are completely covered, then the water's equivalent resistance is $R_S$ /2. For h=0 (fig.9):

$$R_{CB0} = \sum_{i=1}^{10} R_i \tag{15}$$

From (15), it results $R_1$=92.66 kΩ. For h=10 cm (fig.10):

$$R_{CB1} = \sum_{i=2}^{10} R_i + \frac{R_1 \cdot R_S}{R_1 + R_S} \tag{16}$$

By making the difference between $R_{CB1}$ (16) with $R_{CB0}$ (15), is obtained:

$$R_{CB1} - R_{CB0} = R_1 - \frac{R_1 \cdot R_S}{R_1 + R_S} \tag{17}$$

From (27), $R_2$=30.53 kΩ.

Proceeding similarly by achieving the transducer's electric model for each case in part, are obtained also the other resistance values which will determine a linear modification of the frequency depending on level.

Table 4. The resistances calculated and used in experiments
for the circuit from fig.2 – linearized characteristic

| Resistance | $R_1$ | $R_2$ | $R_3$ | $R_4$ | $R_5$ |
|---|---|---|---|---|---|
| calculated [kΩ] | 92.66 | 30.53 | 16.16 | 9.98 | 6.76 |
| measured [kΩ] | 93 | 30.6 | 16.18 | 9.95 | 6.7 |
| Resistance | $R_6$ | $R_7$ | $R_8$ | $R_9$ | $R_{10}$ |
| calculated [kΩ] | 4.68 | 3.69 | 2.87 | 2.3 | 1.88 |
| measured [kΩ] | 4.65 | 3.7 | 2.87 | 2.3 | 1.89 |

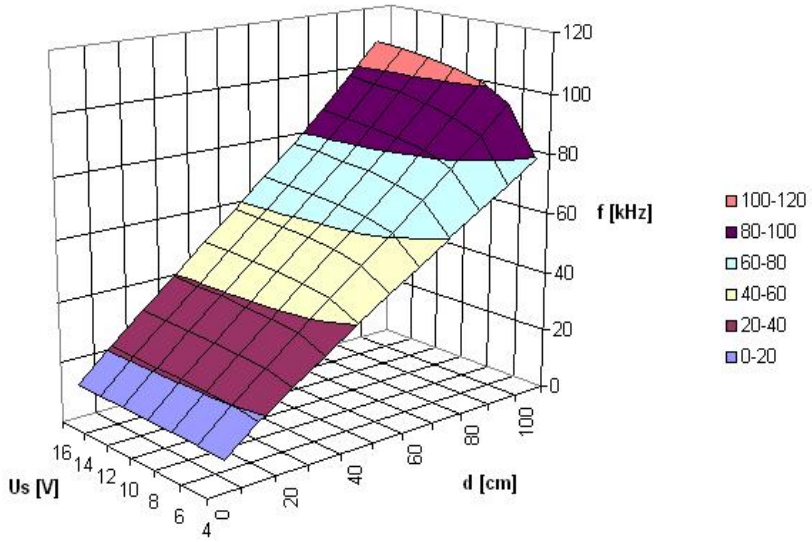



Figure 12. The measured frequency of the output signal (f) depending on level (h) and supply voltage ($U_s$) after liniarization

## 4. CONCLUSION

It was analyzed a 10-step resistive transducer connected to an astable trigger circuit in such way to achieve the level-frequency conversion. The condition (wet or dry) of the resistances above the water influences the transducer's operation. For equal values of the transducer's resistance steps, the frequency depends non-linear on the water level. Were analytically determined the transducer's resistance steps in such way that the frequency to depend linearly on the level. The transducer can be used in applications where the level does not fluctuate (does not modify up and down with high speed) in order that the insulating support of the resistances above the water to have time to dry-up. Can be also used other electronic circuits attached to this type of transducer, that should achieve the level-frequency conversion.

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# DISCSP-NETLOGO-EDUCATIONAL SOFTWARE MEANT FOR THE IMPLEMENTATION AND EVALUATION OF THE ASYNCHRONOUS SEARCH TECHNIQUES IN NETLOGO

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**ABSTRACT**:
The wide spreading of computer networks and of the Internet will result in the necessity of developing distributed software, which is supposed to work under these media, and to turn into account the advantages of a distributed and concurrent environment. The implementation of such techniques can be done in any programming language allowing a distributed programming, such as Java, by means of RMI. Nevertheless, for the study of such techniques, for the analysis of their completeness and for their evaluation, it is easier and more efficient to implement the techniques under certain distributed media, which offer various facilities, such as NetLogo.
In this article there is proposed a general implementation and evaluation model in NetLogo for the asynchronous techniques. This model, we believe, will allow the use of the NetLogo environment as a basic simulator for the study of asynchronous search techniques. This model can also be used for building educational software which can be used when studying the asynchronous search techniques with agents.

**Keywords**
Artificial intelligence, distributed programming, constraints, agents

## 1.INTRODUCTION

The adjustment of the software technologies to the distributed equipment represents an important challenge for the next years. The wide spreading of computer networks and of the Internet will result in the necessity of developing distributed software, which is supposed to work under these media, and to turn into account the advantages of a distributed and concurrent environment.

The constraint programming is a model of the software technologies, used to describe and solve large classes of problems as, for instance, searching problems, combinatorial problems, planning problems, etc. A large variety of problems in the A.I field and other domains specific to computer sciences could be regarded as a special case of constraint programming. Lately, the A.I community showed a greater interest towards the distributed problems that are solvable through modeling by constraints and agents. The idea of sharing various parts of the problem between agents that act independently and that collaborate between them using messages, in the prospective of gaining the solution, proved itself useful, as it conducted to obtaining a new modeling type called Distributed Constraint Satisfaction Problem(DCSP) [3,4].

There exist complete asynchronous searching techniques for solving the DCSP, such as the ABT (Asynchronous Backtracking) and DisDB (Distributed Dynamic Backtracking) [1,3,4]. There is also the AWCS (Asynchronous Weak-Commitment Search) [3,4] algorithm which records all the nogood values. The ABT algorithm has also been generalized by presenting a unifying framework, called ABT kernel [1]. From this kernel two major techniques ABT and DisDB can be obtained. The implementation of asynchronous search techniques based on distributed constraints can be done in any programming language allowing a distributed programming, such as Java, C, C++ or other. Nevertheless, for the study of such techniques, for their analysis and evaluation, it is easier and more efficient to

implement the techniques under certain distributed environment, which offer various facilities, such as NetLogo [8], [5,6,7].

NetLogo, is a programmable modelling environment, which canl be used for simulating certain natural and social phenomena. It offers a collection of complex modelling systems, developed in time. The models could give instructions to hundreds or thousands of independent agents which could all operate in parallel. NetLogo is the next generation in a series of modeling languages with agents that began with StarLogo [8]. It is an environment written entirely in Java, therefore it can be installed and activated on most of the important platforms (Windows, Unix) .

The aim of this article is to introduce an as general as possible model of implementation and evaluation for the asynchronous search techniques, in two possible cases: synchronous and asynchronous. This model can be used in the study of agents behavior in several situations, like the priority order of the agents, the synchronous and asynchronous case, leading, therefore, to identifying possible enhancements of the performances of asynchronous search techniques. This model can also be used in creating some educational software to be used in the study of asynchronous search techniques with agents by the students. For this purpose we have chosen the NetLogo environment, which is a programmable environment [8].

We will see the way one can simulate agents, how constraints can be implemented, how various measurement units for asynchronous techniques in the ABT and AWCS family can be implemented. Unfortunately, there is no distributed environment dedicated to modeling with distributed constraints, all the existent media are general ones, with more general targets. The implementation of agents and constraints implies a certain calculation effort, bigger or smaller, according to the performances of the given environment. The use of this support for educational software can ease the actual implementation of asynchronous techniques. This educational software ca be approached by students on the site [7]

## 2. THE IMPLEMENTATION OF APPLICATIONS WITH AGENTS IN NETLOGO

### 2.1 The NetLOGO objects

The NetLogo world is made of agents. Each agent carries out a task, all the agents execute simultaneously and concurrently. The NetLogo language allows three types of agents: turtles, patches and the observer. The turtle type objects are agents that can move on in the NetLogo world, which is bidimensional and is divided in a grid of patches. Each patch is a square piece that represents the support on which turtle objects can move. The observer doesn't have a fixed location, it can be imagined as being situated above the world of turtles and patches objects. The observer can be regarded as a system agent that can initiate various operations for the other agents. NetLogo uses commands and reporters to tell the agents what to do (the commands and the reporters are NetLogo primitives). The commands are actions for the agents, but the reporters return certain values.

NetLogo allows the defining of different "types" of turtles, called breeds. Once a breed has been defined, we ca establish a different behavior for it. Those objects are used for simulating various objects existent in DCSP problems. For example, the agents from the n queens problem can be defined using breed type objects (a construction of type breeds [queens]). That thing allows the fixing of a special behavior for each agent-queen. When breed type objects are defined, automatically there is created an agentset for each breed.

A very important problem is related to the way of execution of an agent's attached procedures, agent simulated using breed type objects. The DCSP applications require the simultaneous and asynchronous execution of the code attached to each agent. That thing is possible in NetLogo because the commands are executed asynchronously, each object of the "turtle" type or "patch" executes its list of commands as soon as possible. There are two ways of performing each agent's commands. The first one consists in "aligning" the commands executed by each turtle, through placing all the commands in the ask block. That way, the executed steps won't be synchronized. In exchange, using an ask command for each operation, a synchronization of all the operations performed by the agents will be obtained, each turtle will wait until the other turtle objects will finish their computations.

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### 2.2. Modelling and implementing the process of the agents' execution

In this paragraph there is presented a solution of modelling and implementation for the existing agents' process of execution in the case of the asynchronous search techniques. That modelling, applying a technique for detecting the algorithms' termination, allows us to obtain two multi-agent systems that can be applied for implementing and evaluating the most outstanding asynchronous search techniques. That modelling ca be used also for implementing most of the asynchronous search techniques, such as those from the AWCS family [3,4], ABT family [1], DisDB [1]. The modelling proposed in this paragraph allows the obtaining of implementations for asynchronous search techniques derived versions in which various situations that exist in reality are simulated: delays in supplying the messages, message management, etc. Implementation examples for those techniques can be found on the NetLogo site ([6] and in [5, 7].

Any implementation for the asynchronous search techniques supposes the following two steps:

- programming the agents such as they run concurrently
- designing the user interface.

The modelling of the agents' execution process will be structured on two levels, corresponding to the two stages of implementation. The definition of the way in which asynchronous techniques will be programmed such that the agents to run concurrently and asynchronous will be the internal level of the model. The second level refers to the way of representing the NetLogo application, and is the exterior level. The first aspect will be treated and represented using turtle type objects. The second aspect (that is connected with the problem to be solved) refers to the way of interacting with the user, the user interface. Regarding that aspect, NetLogo offers patches type objects de tip and various graphical controls. Anyway, patches type objects will allow the simulation of the application's interface.

#### 2.2.1. Agents' simulation and initialization

First of all, the agents are represented by the breed type objects (as we saw in the previous paragraph, those are of the turtles type). In there fig. 1 is presented the way the agents are defined together with the global data structures proprietary to the agents.

```
breeds [agents]
globals [variables that simulate the memory shared by all the agents]
agent-own [message-queue current-view nogoods messages-received_ok messages-received_nogood]
;message-queue contains the received messages.
;current-view is a list indexed on the agent's number, of the form [v0 v1 v2...],  vi = -1 if we don't know the value o that agent.
;nogoods is the list of inconsistent positions  [0 1 1 0 ... ] where 0 is a good position, and 1 is inconsistent.
;messages-received_ok and messages-received_nogood are variables that count the number of ok and nogood messages received by an agent.
```

Figure 1. Agents' definition in the case of the asynchronous search techniques

The initialization of the agents supposes building the agents and initialization of the necessary data structures for the agents' operation. For initialization there is proposed an initialization procedure for each agent, procedure presented in figure 2 (the procedure will be called setup). Typically the num-agents required for the running of the asynchronous search technique are built and the most important data structures are initialized.

```
to setup-agenţii // the agents defined with the breeds [agenţi] are used
; the num-agents agents are created and are initialized
 create-custom-agenţi num-agents [
   set messages-received_ok 0
   set current-view get-list num-agents -1
   set nogoods get-list num-agents 0
   set message-queue []
   ...
   ]
end
```

Figure 2. The initialization procedure for each agent-setup

### 2.2.2. Representation and manipulation of the messages

Any asynchronous search technique is based on the use by the agents of some messages for communicating various information needed for obtaining the solution. The manipulation of the messages supposes first of all message representation. This thing can be achieved in Netlogo by using some indexed lists. To represent complex messages that contain many information, Netlogo allows the use of lists of lists. The way of representation of the main messages encountered at the asynchronous search techniques is presented as follows:

- (**list** "ok" agent value agent_costs) – messages of the *ok* or *info* type*;*
- (**list** "nogood" agent current-view agent_costs) - messages of the *nogood* or *back* type;
- (**list** "addl" $agent_1$ $agent_2$ agent_costs)
- (**list** "removel" $agent_1$ $agent_2$ agent_costs )

### 2.2.3. Definition and representation of the interface

As concerning the interface part, it can be used for the graphical representation of the DCSP problem's objects (queens or nodes) of the patch type. It is recommended to create an initialization procedure for the display surface where the agents' values will be displayed.

For the case of the graph coloring problem, the representation of nodes and links is done in the same way [5,6,7]. The two initialization procedures will be attached (using a setup procedure) to a start button of the application, as in the sequence in figure 3.

```
to setup
  ca
  setup-patches
  setup-nodes
  ask nodes [procedura_inițializare]
end
```

Figure 3. Setup procedure of the NetLogo application

## 3. IMPLEMENTATION AND EVALUATION METHODOLOGY FOR THE ASYNCHRONOUS TECHNIQUES

In this paragraph there is presented a methodology of implementation for the asynchronous search techniques in NetLogo, using the model presented in the previous paragraphs 2. That methodology supposes the identification of the application's objects, building the agents and of the working surface for the application. There are also built the communication channels between agents, routines for message handling and the main program of the application. The methodology contains more elements specific to NetLogo necessary for finalizing the implementation of the asynchronous search techniques. Any implementation based on the presented model, will require the following of the next steps.

### P1. Defining the DCSP application's objects.

Starting from the type of problem that is implemented, it will be defined the objects of the DCSP application. In figure 4 is presented a solution of agents modelling and also for the working surface of th eapplication. As in the modeling examples are proposed *breeds [queens]* (for modeling the agents associated to the queens from the problem of the n queens) or *breeds [vertices]* (for modeling the agents associated to each node from the problem of graph coloring).

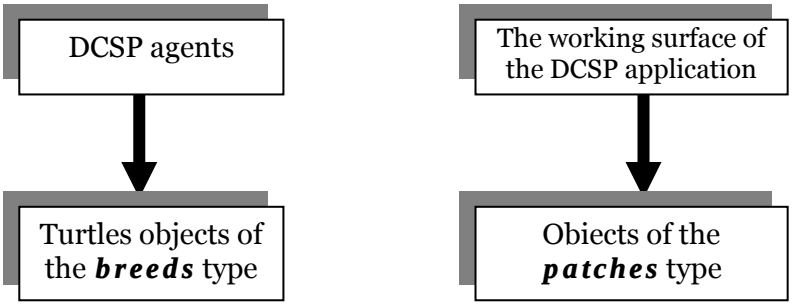
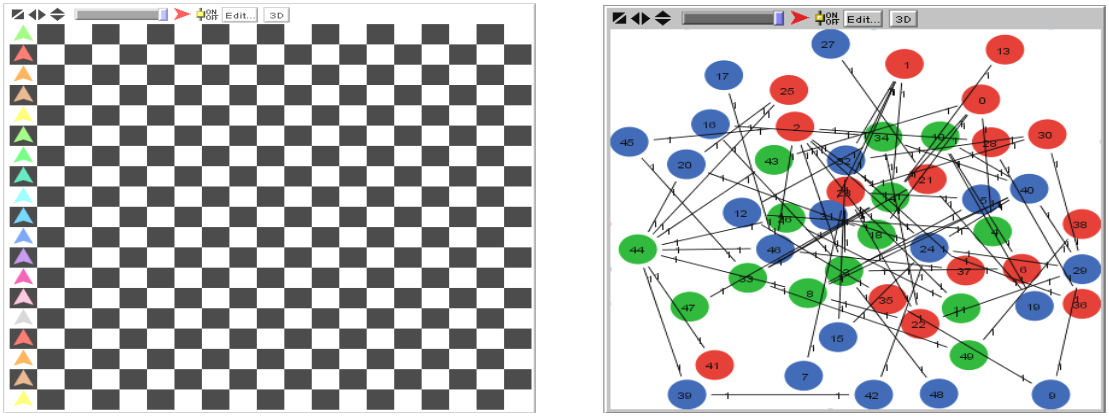



Figure 4. Identification of the objects of the DCSP application

In exchange, to model the surface of the application are used objects of the *patches* type. Depending on the significance of those agents, they are represented on the Netlogo surface. In figure 5 are presented two ways in NetLogo for representing the agents of the *queens* type, respectively *noduri*.



(a) queens (b) nodes

Figure 5. Examples of reprezentation of the agents on the NetLogo surface

**P2. Message handling. The FIFO type message chanel.**

Any agent keeps its working context at least as two proprietary structures: current_view and its nogood list. That context is used to take decisions, inclusively for building messages. For the proposed model, the data structures that store the working context of each agent can be simulated with lists. A representation solution is presented in figure 6 (a)

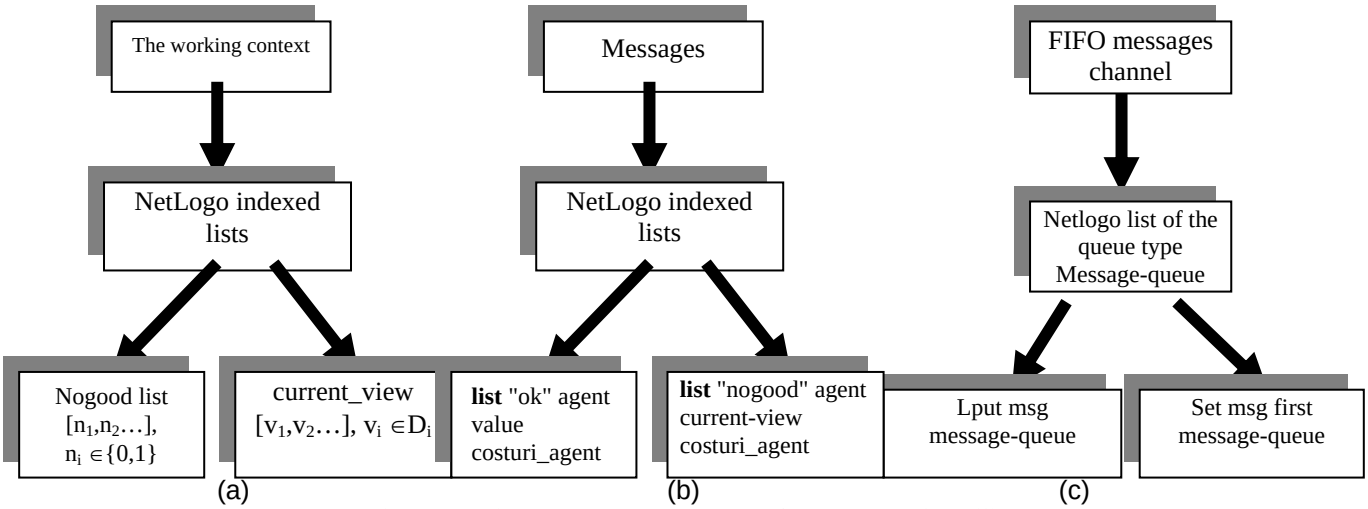



Figure 6. The necessary structures for message handling

```
to receive-message [msg]
  without-interruption [
    set message-queue lput msg message-queue]
end
```

```
to-report retrieve-message
  without-interruption [
    set msg first message-queue
    set message-queue butfirst message-queue]
```

```
to handle-message
  if (empty? message-queue) [stop]
  set msg retrieve-message
  if (first msg = "ok")[
   ok msg ]
  . . .
```

Figure 7. Message handling

Message handlinf supposes first of all message representation. In figure 6.(b) is presented the way of representation of the main messages found at the asynchronous techniques. Simulareation of message queues for each agent can be done using Netlogo lists, for which are defined routines of handling corresponding to FIFO principles (figure 6.(c)). These structures keep the messages received by each agent. Starting from NetLogo elements presented in figure 6, we can build three procedures for handling messages from the message queue, routines presented in figure 7. The first receive-message routine is used for receiving a new mesaage, the second routine retrieve-message has as its purpose the extraction of a message from the waiting queue, being called in the message treatment routine. The last routine handle-message identifies the message type, calling the appropriate message handling routine.

**P3. Application initialization an of each agent. "The main program" for application**

The initialization of the application supposes the building of agents and of the working surface for them. When the agents are built the required initializations are also done. Usually, is initialized the working context of the agentul (current-view), the message queues, the variables that count the effort carried out by the agent. In figure 8 are presented the two routines of application initialization and of agents initialization.

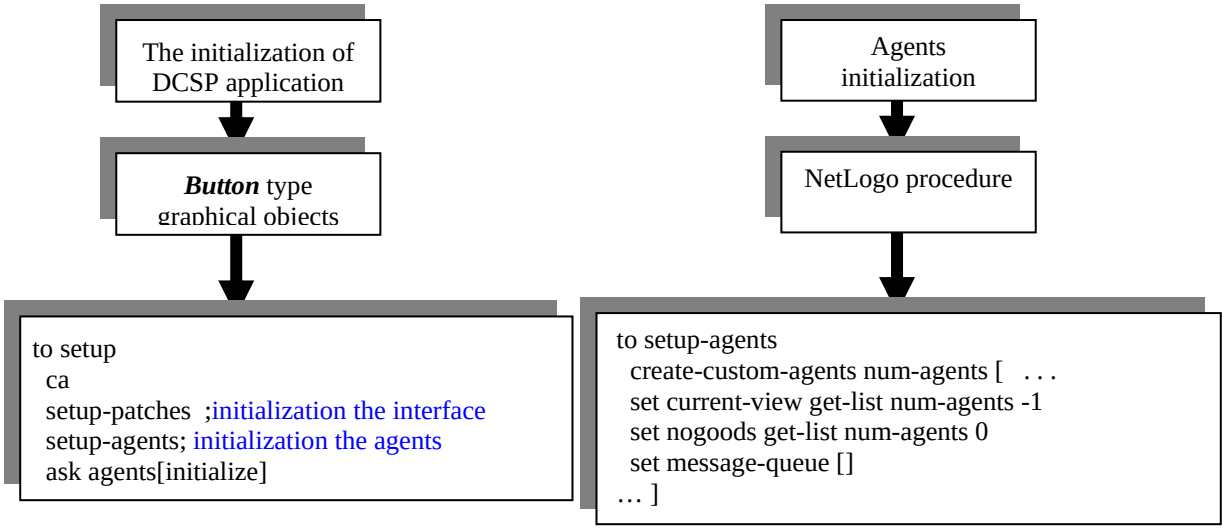



Figure 8. Initialization of the DisCSP application

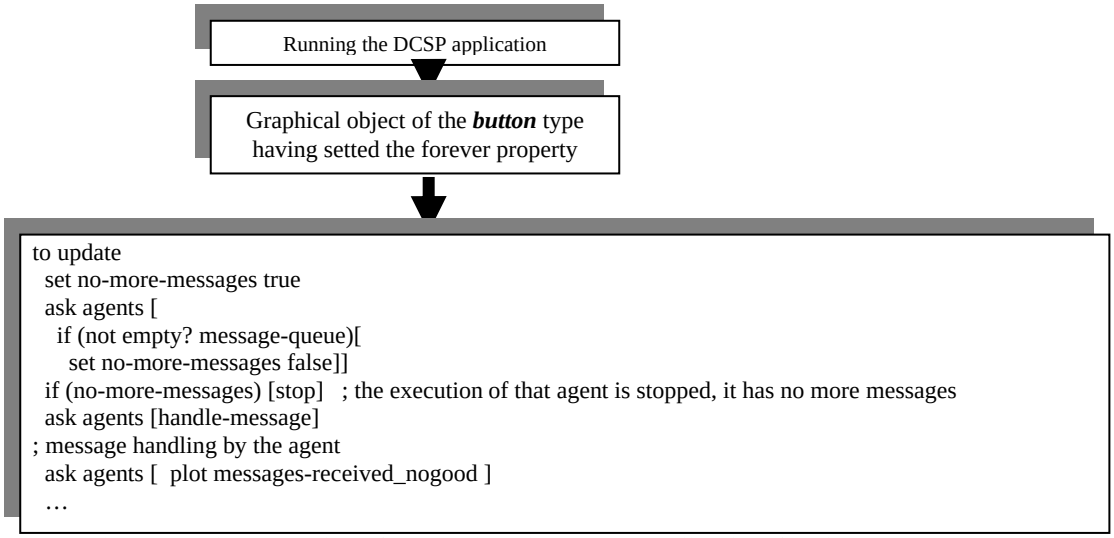



Figure 9. The procedure for running the DCSP application for the system SEIS

The working surface of the application should contain NetLogo objects through whom the parameters of each problem could be controlled: the number of agents, the density of the

constraints graph, the number of colors. These objects allow the definition and monitorization of each problem parameters.

For the application running is proposed the introduction of a graphical object of the button type and setting the *forever* property. That way, the attached code, in the form of a NetLogo procedure (that is applied on each agent) that will run continuously, until emptying the message queues and reaching the *Stop* command (which in NetLogo stops the execution of an agent). The solution presented in figure 9 is based on the utilization of the *ask* command. That NetLogo command executes a synchronization of each agent execution.

Another important observation is tied to attaching the graphical button to the *observer*. The use of this solution allows obtaining a solution of implementation with synchronization of the agents' execution. In that case, the *observer* will be the one that will initiate the stoping of the DisCSP application execution. In figure 9 the *update* procedure is attached and handled by the *observer*. These elements lead to the multi-agent system with synchronization of the agents execution (SEIS). If it's desired to obtain a system with asynchronous operation (SIEAS), will be used the second method of detection, which supposes another *update* routine. That new *update* routine will be attached to a graphical object of the *buton* type which is attached and handled by the turtle type agents.

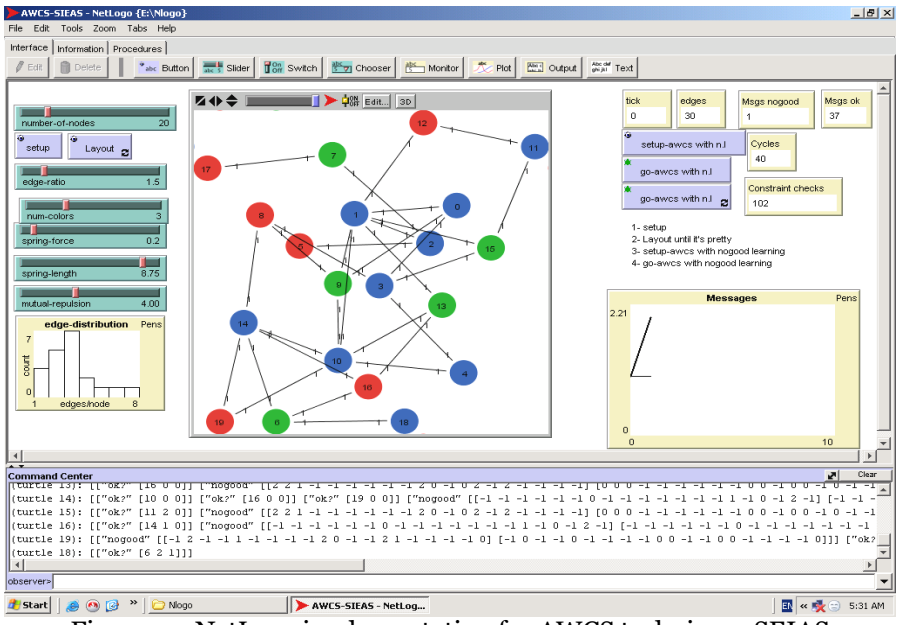


Figure 10. NetLogo implementation for AWCS technique- SEIAS

### P4. Monitorization of the evaluation parameters

The model presented in this chapter allows storing the costs for obtaining the solution. That thing can be done using some variables attached to the agents. For counting the flow of messages it can be used a variable proprietary to each agent (*messages-received_nogood,etc)*, variable that needs to be incremented in the moment of receiving a message. That variable is incremented in the routine of message manipulation *handle-message***.** Also, for measuring the work effort carried out by the agents can be used two variables nr_constraintc and c-ccks. Those variables store the costs necesary for each agent. Thus, those costs should be measured.

Application of the methodology presented previously allows the implementation and evaluation of any asynchronous search technique. In figure 10 is captured an implementation for the AWCS technique that uses uses the multi-agent SIEAS system.

## 4. CONCLUSIONS

In this article was analysed the NetLogo environment with the purpose of building a general model of implementation and evaluation for the asynchronous techniques such as

they could use the NetLogo environment as a basic simulator in the study of asynchronous search techniques.

In this article was proposed a general model of implementation and evaluation for the asynchronous search techniques. The proposed model supposed the identification of NetLogo objects necessary for implementing the asynchronous search technique (agents, messages, message queues, agents ordering) and of the interface of interaction with the user. In this article was proposed solutions for simulating the objects of any DisCSP application. Also, were proposed solutions for counting the costs for obtaining a solution using different measuring units. That thing will allow the evaluation of performances for asynchronous search techniques and eventual improvements for them Also, the model allows studying the behaviour of the agents for various techniques, studyind the costs for each agent.

As a general conclusion, we think that the model we achieved can be used for the study and analysis of the asynchronous techniques, the model allowing their complete evaluation. Students can use the models on the site [7] to study, to understand the functioning of the asynchronous search techniques and, perhaps, to extend them. Starting from those models, they can develop other versions of the asynchronous search techniques.

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# EDUCATIONAL SOFTWARE FOR ANALYSIS OF PARALLEL ALGORITHMS USING PRAM MODEL

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**Abstract**

This paper presents visual interactive software which shows through simulation the parallel access memory for PRAM model. The software was implemented in Java. It was also performed a comparative study between a classic sequential algorithm and a parallel algorithm in terms of execution times.

**Keywords:**

Algorithm visualization, parallel access memory, Java, PRAM model

## 1. INTRODUCTION

The purpose of the theoretical models for parallel computation is to give frameworks by which we can describe and analyze algorithms. These ideal models are used to obtain performance bounds and complexity estimates. One of the models that have been used extensively is the parallel random access machine (PRAM) model [1]. A PRAM consists of a control unit, a global memory shared by p processors, each of which has a unique index as follows: P1 , P2 , . . . , Pp . In addition to the global memory via which the processors can communicate, each processor has its own private memory.
Based on the different modes for read and write operations, the PRAM can be further divided into the following subclasses:

- EREW PRAM: Access to any memory cell is exclusive. This is the most restrictive PRAM model.
- ERCW PRAM: This allows concurrent writes to the same memory location by multiple processors, but read accesses remain exclusive.
- CREW PRAM: Concurrent read accesses are allowed, but write accesses are exclusive.
- CRCW PRAM: Both concurrent read and write accesses are allowed.

## 2. DESCRIPTION OF THE SOFTWARE

The target of this application is to help students in understanding the parallel and sequential algorithms. Another goal for this project is to show a comparative study between a classic sequential algorithm and a parallel algorithm in terms of execution times.

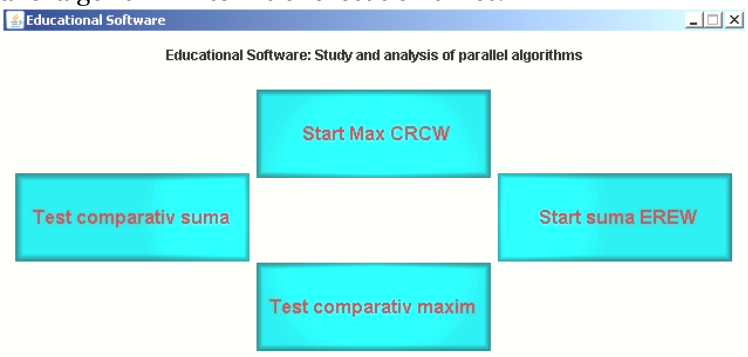



Figure 1. Main Menu

The application was implemented in Java as independent application. The application can easily convert in a Java applet. For simulation the It is made so that it possible for students and beginners to use the application. From the main menu that you can see in Figure 1 you can choose one of four options of the software:

- Description of the PRAM CRCW maximum search algorithm
- Description of the PRAM EREW sum algorithm
- A comparative study between the PRAM CRCW maximum search algorithm and the classic sequential.
- A comparative study between the PRAM EREW sum algorithm and the classic sequential variant.

By selecting any of these options from the application interface a new window will open which will contain each part of the application.

Buttons are simulations realized with the help of images created with the 3D Button program.

## 2.1. Maximum search CRCW Simulation

This is the main frame for the Maximum Search algorithm simulation. This presents the steps taken by the Maximum Search CRCW algorithm.

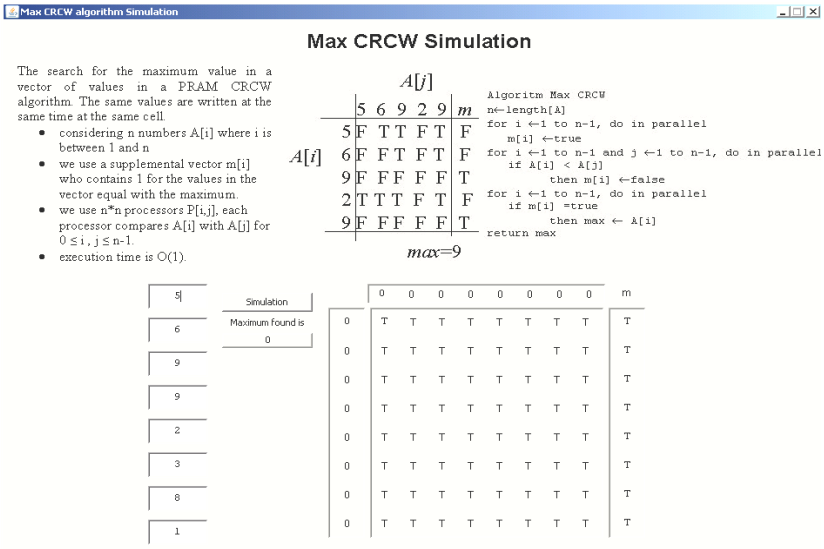



Figure 2. Maximum Search Simulation

The algorithm which searches for the maximum in a vector of values with the aid of the Maximum search CRCW (Concurrent Read Concurrent Write) algorithm is presented and simulated in our application.

The theory behind the algorithm is presented on the upper part. The simulation of the algorithm is made so that the user can input some 8 values for the vector. By pressing the Simulate button the process begins. First the top and left vectors are initialized with the values introduced by the user. Then the middle matrix is initialized with the start (F=False) value. The m vector is initialized also.

After the first phase the simulation of the algorithm is started. The middle matrix is obtained by the tests between A[i] and A[j]. Meanwhile the m vector is obtained. After the m vector is found, the maximum value of the vector is found: where m[i] is true, v[i] is the maximum.

## 2.2. Summing algorithm EREW Simulation

This is the frame which presents the simulation for the summing EREW algorithm.

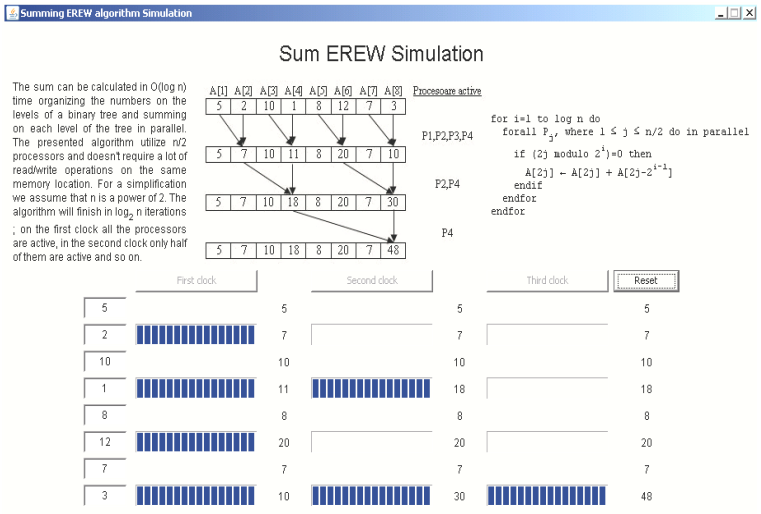



Figure 3. Summing algorithm Simulation

To simulate the summing algorithm in parallel the user must input some start values for the vector to be summed. To start the algorithm we first click the First Clock button. After the first clock of the simulation (the simulation is done by filling 4 progress bars showing that 4 processors are active) we can pass to the second clock of the simulation. In this clock, only half of the processors active in the previous clock are active (showed by only two progress bars). At the last clock only one processor is active. After this clock, the sum of all 8 values is in the last field on the down right part of the frame.

### 2.3. Comparative Study for the maximum search algorithms

In this frame we want to show the execution times for the classic sequential algorithm and the parallel CRCW algorithm. For this study we have made it possible for us to choose the length of the vector for the search and the maximum value of each value of the vector.

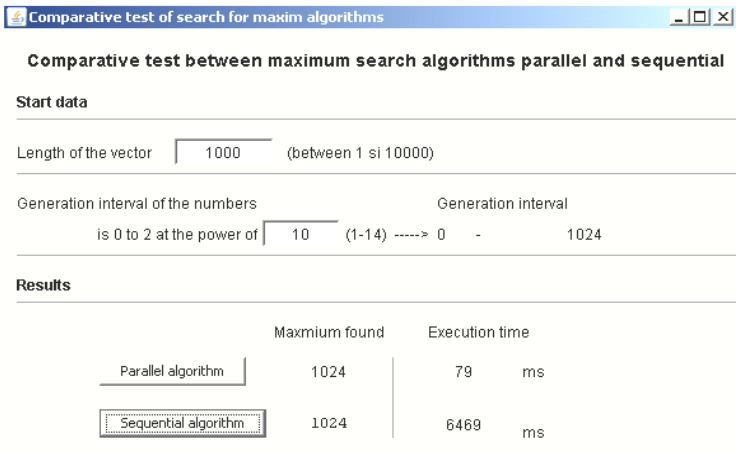



Figure 3. Comparative Study for the maximum search algorithms

To run the comparative test of the two algorithms the user must insert the length of the vector and the generation interval for the values (this generation interval is found between 0 and 2 at the power of the value entered). In case the introduced data is wrong the application will show an error message. If we will not introduce a number in one of the input box, the application will show the next error message.

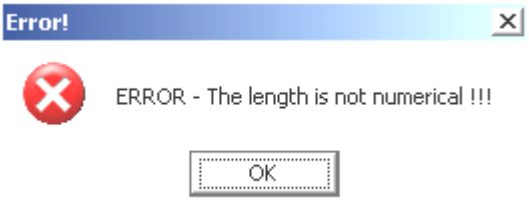



Figure 4. Error message

In case of a value lower of larger than the provided interval the application will show a attention message. In case the user didn't fill the start values and he whishes to execute the parallel or sequential algorithm the application will show another attention message.

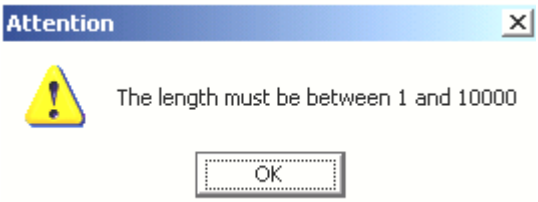



Figure 5. Attention message




Figure 6. Attention message

### 2.4. Comparative study for the summing algorithms

This frame presents a comparative study for the execution times of the summing algorithms, the sequential and the parallel one.

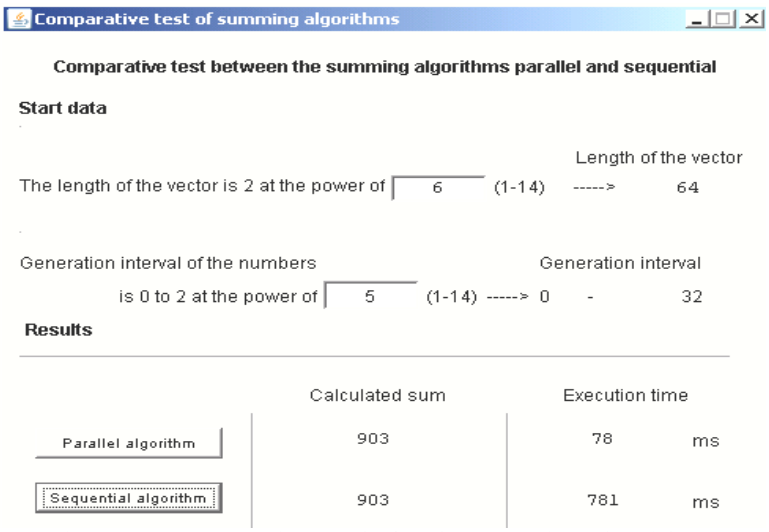



Figure 4. Comparative study for the summing algorithms

To start the comparative test between the two algorithms the user must fill in the initial data. If the values are not filled in, the application sends the user error or warning messages.

After the input parameters are filled in the two algorithms are executed and the application calculates and shows the execution times for the two algorithms. To verify if the two algorithms are working on the same set of numbers we can compare the two sums displayed. The results of some comparative tests are show in Table 1 for finding maxim algorithm and in Table 2 for

summing algorithm. The computer used for the test was an Intel Pentium Mobile, processor frequency 1,7 GHz, 1024 MB RAM, operating system Microsoft Windows Xp SP2.

Table 1 The run time for CRCW maximum search algorithm

| Input data | Nr. crt of test | Parallel algorithm | Sequential algorithm |
|---|---|---|---|
| Vector length: 4096 ($2^{12}$) Values interval: 0 – 256 (0 – $2^8$) | 1. | 1782 ms | 44344 ms |
| | 2. | 1622 ms | 44384 ms |
| | 3. | 1682 ms | 44664 ms |
| | 4. | 1712 ms | 47618 ms |
| | 5. | 1683 ms | 48530 ms |
| Vector length: 4096 ($2^{12}$) Values interval: 0 – 256 (0 – $2^8$) | 1. | 110 ms | 721 ms |
| | 2. | 130 ms | 771 ms |
| | 3. | 150 ms | 721 ms |
| | 4. | 121 ms | 741 ms |
| | 5. | 70 ms | 731 ms |

Table 2 The run time for EREW summing algorithm

| Input data | Nr. crt | Parallel algorithm | Sequential algorithm |
|---|---|---|---|
| Vector length: 128 ($2^7$) Values interval: 0 – 256 (0 – $2^8$) | 1. | 10 ms | 731 ms |
| | 2. | 10 ms | 771 ms |
| | 3. | 10 ms | 751 ms |
| | 4. | 15 ms | 721 ms |
| | 5. | 10 ms | 761 ms |
| Vector length: 1024 ($2^{10}$) Values interval: 0 – 512 (0 – $2^9$) | 1. | 30 ms | 6740 ms |
| | 2. | 20 ms | 6810 ms |
| | 3. | 10 ms | 6829 ms |
| | 4. | 40 ms | 6900 ms |
| | 5. | 31 ms | 6659 ms |

## 3. CONCLUSIONS

Analyzing the tests results it can be observe that form point of view of the execution time, the parallel algorithms are more efficient than the sequential algorithms, but the total cost of the parallel algorithm are higher in terms of processors numbers. Since a good sequential algorithm can sum the list of n elements and also find the maximum of the elements in O(n), these algorithms is not cost optimal.

However, the PRAM model is a very useful model for study the parallel access to the memory, and the present application can do this an interactive manner, so that the students will better understand these concepts.

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# EDUCATIONAL SOFTWARE METHODS AND STRATEGIES FOR DESIGNING ALGORITHMS BACKTRACKING, GREEDY METHOD AND DYNAMIC PROGRAMMING

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**Abstract**

This paper present visual interactive software which shows through simulation the main algorithms use in searching solutions in artificial intelligence. It was studies backtracking, greedy and dynamical programming algorithms. The software is multimedia educational software designed for acquisition and learning process and it can be seen as a modern method for teaching methodology. It was also perform a comparative study of these algorithms using some typical known problems.

**Keywords:**

Algorithm visualization, backtracking, dynamic programming, greedy algorithm

## 1. INTRODUCTION

The teaching art consists not only in the scientific strictness of exposing the subject matter to be studied, but also in including in this activity of all influence forms upon the student [1]. One of the main aspects of using computer for lessons is the development of the students creative thinking. An optimal mean in this case is the introduction in the computational training means of the interactivity elements. Educational software provides this important feature - it is interactive: it offers to the learner the opportunity to manipulate the model for achieving in a short time, a high volume of knowledge (more complex and stable).

This paper present not only one useful application to the study of solving algorithms with backtracking, greedy method and dynamic programming but also a comparative study of these algorithms in terms of executive time.

## 2. DESCRIPTION OF THE INFORMATICS SYSTEM

For informatics system design it was use a visual oriented object language, Borland C++ Builder. This environment is very useful because it generate a native code for Windows platform, which is the most used operating system.

Application interface is very simple. I have focused on the fact that all students and even beginners, in algorithms and programming tricks could use it. From the main menu, you can see in Figure 1, you can choose four paths of the project:

- Presentation of Backtracking method
- Presentation of Greedy method
- Presentation of Dynamic Programming
- A comparative study for these three algorithms earlier selected

By selecting any of these options from the application interface a new window will open which will contain the main menu for accessed algorithm.

The animation is realized using Xara 3D and starts the creation of the form.

Buttons are simulations realized with the help of images performed through program 3D Button. The effect of "push" the buttons is realized with Label type components, showing the explanatory text of the buttons.

Here are the main buttons for navigation. The name of each button will show the exact segment you want to make active. So, every time you click on *, from the book, you are accessing the" Theory" page where you'll find three more buttons. Each button is a links for another page, where you can find, depending on the button name, information about the accessed method.

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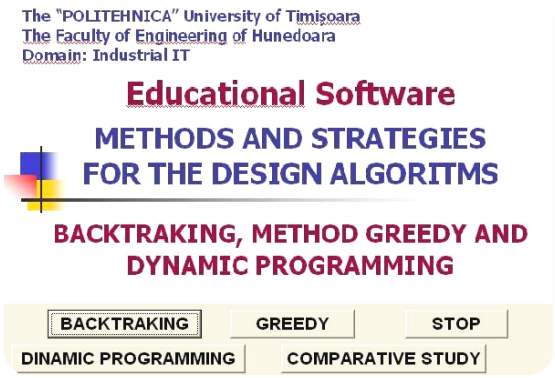


Figure 1. Main Menu

By running a click on Applications, you'll find applications, made to exemplify through images and algorithm of this procedure. Also, through the window on the right corner of the interface, you can learn what each button contains, simply passing the mouse over it.

### 2.1.Backtracking algorithm simulation

Backtracking is a general algorithm for finding all (or some) solutions to some computational problem, that incrementally builds candidates to the solutions, and abandons each partial candidate c ("backtracks") as soon as it determines that c cannot possibly be completed to a valid solution, [3].

Backtracking is an important tool for solving constraint satisfaction problems. It is often the most convenient (if not the most efficient) technique for parsing, for the knapsack problem and other combinatorial optimization problems. It is also the basis of the so-called logic programming languages such as Prolog use for artificial intelligence. Backtracking can be applied only for problems which admit the concept of a "partial candidate solution" and a relatively quick test of whether it can possibly be completed to a valid solution. When it is applicable, backtracking is often much faster than brute force enumeration of all complete candidates, since it can eliminate a large number of candidates with a single test.

For backtracking algorithm simulation it was use the following well known problems: the N queen's problem, the coloring maps problem, the horse jump on chessboard problem, and other problem that can be solve using backtracking. From these one, in this paper is present the map coloring problem.

The map coloring problem is a very well known problem and consists in finding the appropriate color to coloring a map so than two neighborhood regions on the map to have distinct colors. The graphical user interface for algorithm analyze in shown in fig. 3.

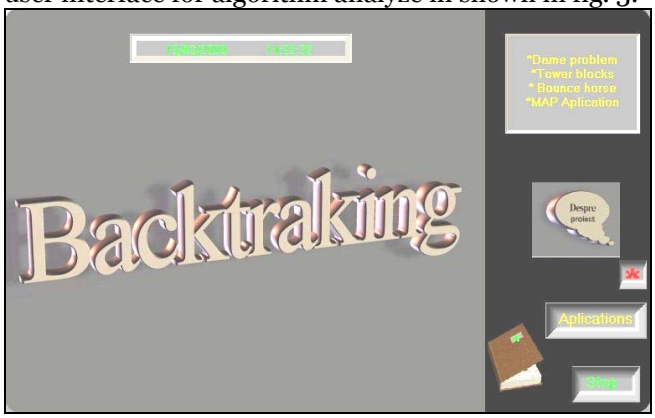


Figure 2. Main Menu Backtracking

The simulation allows to visualize the algorithm step by step or to visualize entire algorithm. For the first case the user can push the "Step by step" button after each step. This means that appear a new color for the current region on the map, after pushing the above mentioned button. At the same time the stack variation is updated by increasing or decreasing the top of stack. During the simulation the user can see the stack variation and the map partially colored. The test map can be load from a file (a *.bmp file). In a frame is show also the algorithm implemented in C++. After a solution is found, this is displayed in a separate frame.

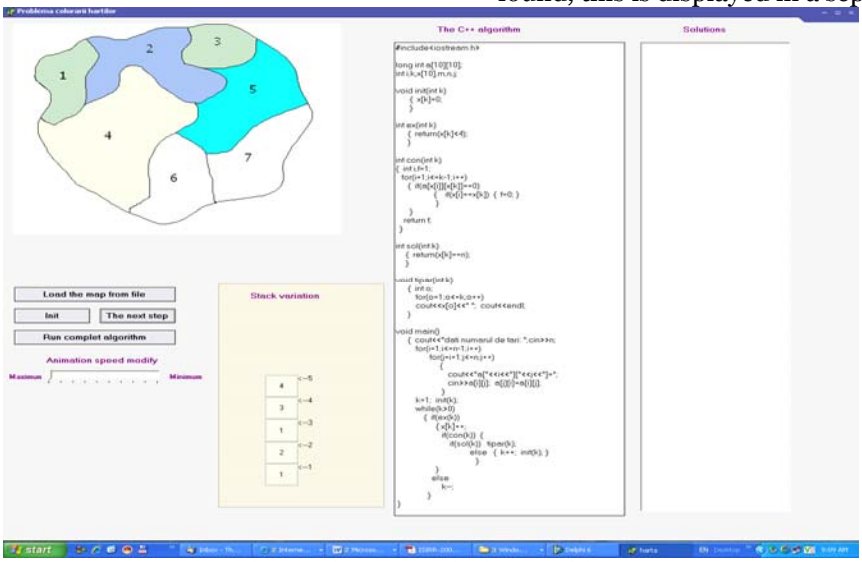


Fig. 3. The map coloring problem

### 2.2. Greedy algorithm simulation

A greedy algorithm is any algorithm that follows the problem solving meta-heuristic of making the locally optimal choice at each stage [4] with the hope of finding the global optimum. For example, applying the greedy strategy to the traveling salesman problem yields the following algorithm: "At each stage visit the unvisited city nearest to the current city". Greedy algorithms mostly (but not always) fail to find the globally optimal solution, because they usually do not operate exhaustively on all the data. Nevertheless, they are useful because they are quick to think up and often give good approximations to the optimum.

For Greedy algorithm simulation it was use the following well known problems: Dijkstra's Algorithm, Connecting cities with minimum cost, Prim's Algorithm, the Knapsack problem. These examples can be selected using a graphical user interface similar with the one presented in fig. 2.

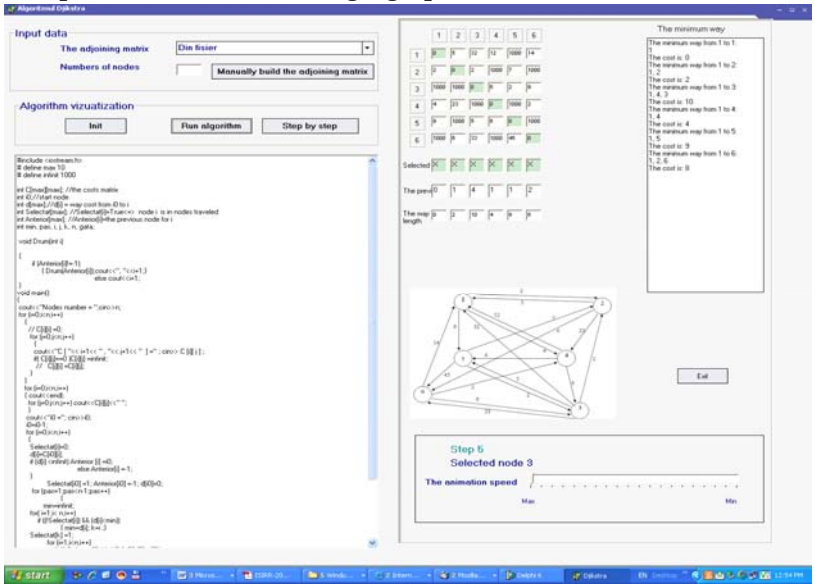



Fig. 4. The Dikstra's algorithm visualization

The Dikstra's algorithm visualization is exemplified in this paper. The graphical user interface is shown in fig 4.

In this simulation, the user can build the adjoining matrix for the graph manually or be loading from a file. As the previous presented simulation, the user can run the entire algorithm using a desired animation speed or the algorithm can be run step by step. During the simulation, the user can see the costs matrix updating, a vector with selected nodes and the current length way in each moment. Finally, in a frame on the GUI, all the ways from all the nodes to the selected start node are printed. The user can see also the algorithm implemented in C++ language.

### 2.3. Dynamical programming algorithm simulation

In computer science and also in mathematics, dynamic programming is a method of solving problems that exhibit the properties of overlapping subproblems and optimal substructure [5]. The method takes much less time than native methods. This method can be applied to many string algorithms including longest common subsequence, longest increasing subsequence, longest common substring. It can be also applied to many algorithmic problems on graphs can be solved efficiently for graphs of bounded treewidth or bounded clique-width by using dynamic programming on a tree decomposition of the graph. In this software was simulating the Roy – Floyd algorithm. This is a simple algorithm for determining dot-matrix graph roads. One execution of algorithm finds the shortest path between all pair vertices of the graph. In many practical situations the question is to determine a shortest way between two vertices of the graph. The graphical user interface is similar with the GUI for Djiskstra's algorithm simulation and provides the same options. Another simulation was made for maze problem.

## 3. CONCLUSIONS. COMPARATIVE STUDY

Comparative study was possible after using backtracking algorithms, greedy and dynamic programming of some representatives problems. The conclusions are presented below.

### 3.1. Backtracking-Dynamic programming

Solving problems by dynamic programming is done in polynomial time, because each optimal "more general" is calculated from optimum "more private" searching in polynomial time, and the calculated optimum time is not recalculated later but switched to calculating the optimum "more general".

Therefore the method of dynamic programming may be considered as an alternative to the backtracking method. It is clear that the problems which may be solved through backtracking may be solved by dynamic programming as well. If the backtracking method is used you can obtain an algorithm that can reach (in the most unfavorable case) exponentially. Dynamical programming is more efficient that Backtracking.

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If the dynamic programming method is used we can obtain a single optimal solution, unlike the backtracking method that generates all the optimal solutions.

### 3.2. Backtracking-Greedy

Although both methods offer solutions in the form of vector, the greedy method and backtracking method have the following differences:

- backtracking technique provides all the problem solutions, while greedy method is providing a single solution;
- greedy technique doesn't have a mechanism for going back (which is specific for backtracking method) that is why is impossible to achieve the global optimum.

Regarding the time running, Greedy algorithms are more efficient but it doesn't apply to whatever problem.

### 3.3. Greedy-dynamic programming

Both dynamic programming and greedy technique can be used when the solution to a problem is seen as the result of a sequence of decisions. The essential difference between greedy technique and dynamic programming is that the greedy method generates a single sequence of decisions, exploiting incompletely the optimality principle. In dynamic programming are generated more sub sequential decisions, taking in consideration the optimality principle, but considering only the best sub sequences, combining them in the final optimal solution. Although the total number of sequences of decisions is exponential, dynamic programming algorithms are often polynomial, the reduction of complexity due to the use optimality principle. Another important characteristic of dynamic programming is that it stores the optimum sub sequences, thus avoiding their recalculation.

Although the greedy algorithm does not guarantee obtaining the optimal solution, however it has the advantage that it is more efficient in terms of execution time and memory used than dynamic programming algorithm and the corresponding backtracking method.

Final conclusion is: when solving a problem by greedy method, execution time is polynomial (instant solution) for different input data. Solving through the backtracking method the execution time increases exponentially by the increase of input data's volume. For the dynamic programming method the execution in most cases is increasing polynomial with the input data. If recursively is used in solving a problem using dynamic programming, execution time increases exponentially with the input data.

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# EDUCATIONAL SOFTWARE FOR THE PRESENTATION OF HYPERBOLOID

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**Abstract**:
The informative society needs important changes in educational programs. The informational techniques needs a reconsideration of the learning process, of the programs, manuals structures, a reconsideration of the methods and organization forms of the didactic activities, taking into account the computer assisted instruction and self instruction. This paper presents a software package, which can be used as educational software.

**Keywords**:
Educational Software, Java, Hyperboloid, Distance Education.

## 1. INTRODUCTION

In the condition of informatics society whose principal source in the social–economic development is to produce and consumption the information, the complex and fast knowledge of the reality for rational, opportune, effective decisions is a desideratum which generate the necessity to form some superior level habituation in information manage for the whole population. The computers and their programs offer to the users powerful capabilities for the information manipulation: image and text visualize on the screen which can be manipulate later; memory storage of an important quantity of information, his accessing and selection of a part of them; possibility to realize a great volume of computation; possibility of equipment control and fast decisions; Computer Based Training [1]. This facilities offer to the microcomputers higher educational capabilities versus other technologies used in education and provide learning controlled based on many parameters: intellectual aptitude, level of knowledge, abilities, rhythm of work.

## 2. COMPUTER BASED TRAINING AS A DIDACTIC METHOD

The informatics society makes sensitive modification in education programs. In this scope, the school must prepare programmers, maintenance technicians, etc. In the same time it is necessary that the teacher make ready to use the computer in education process.

These informational techniques impose to reorganize the contents of the education process, of the programs, course books and manuals, to reconsider the methods and organization forms of didactic activities, which follow to be center on individualization of the teaching process [4].

The programmed teaching consist in information presentation in small units, logic structured, units that compose a program, the teaching program. The user will have possibility that after each sequence to have a knowledge about the measure of understanding the give information. The programmed teaching method organize the didactic action applying the cybernetic principles to the teaching-learning-evaluating activities level, considering like a complex and dynamic system, composed as an elements ensemble and inter-relations and develop his personal principles valid on the strategic level in any cybernetic organization form of teaching.

On the other hand, programmed teaching assume some principles which the teaching program must respect [6]:

- The small steps principle consists in progressive penetration, from simple to complex, in a subject content which logic divided in simple units series lead to minimal knowledge, which later will form an ensemble. This principle regards the subject division in contents/information units that give to user the chance to succeed in his teaching activities;
- The principle of personal rhythm of study regard mannerism observance and capitalization of each user of the program which will be able to make the sequences of knowledge learning or control, in a personal rhythm appropriate to his psycho-intellectual development, without time limits. The user can progress in the program only if he accomplished the respective sequence requirement;

- The active participation principle, or active behavior, regard user effort trend into selection, understanding and applying the necessary information in elaboration of a correct answer. On each step the user is liable to an active participation to resolve the step job;
- The principle of inverse connection, regard positive or negative inputs of user competence, refer to the success or breakdown in task performed;
- The immediate and directly control of the task work precision with the possibility to progression to the next sequence, in case of success;
- The repetition principle, based to the fact that the programs are based on return to the users initial knowledge.

The combined programming interposes the linear and branch sequence according to teaching necessities.

After linear and branch programming the computer aided generative teaching has appear, where the exercises are gradually present, with different difficulty steps and answers on the students questions.

The expert system consists of self-teaching training programs, tutorial strategies, and the usage of natural language, mixed initiative and some complex representation of knowledge usage [7].

The computer based programmed teaching realize learning process with a inputs flow – the command, an executive controlled system, an output flux – control and a control system functions which correct measure establish.

In such a system have tree stages of teacher perceive: teaching, evaluating and the feedback loop closing, the computer being present in all of tree stages.

## 3. HYPERBOLOID

A hyperboloid is a quadratic surface which may be one sheet or two sheets. The one sheet hyperboloid is a surface of revolution obtained by rotating a hyperbola about the perpendicular bisector to the line between the foci, while the two sheets hyperboloid is a surface of revolution obtained by rotating a hyperbola about the line joining the foci [2].

The one sheet hyperboloid is given in cartesian coordinates by [3]:

$$\frac{x^2}{a^2}+\frac{y^2}{a^2}-\frac{z^2}{c^2}=1. \tag{1}$$

The parametric equations of an one sheet hyperboloid can be written as [5]:

$$\begin{aligned} x(u,v) &= a\cdot\sqrt{1+u^2}\cdot\cos v;\\ y(u,v) &= a\cdot\sqrt{1+u^2}\cdot\sin v;\\ z(u,v) &= c\cdot u. \end{aligned} \tag{2}$$

The two sheets hyperboloid is given in cartesian coordinates by [8]:

$$\frac{x^2}{a^2}-\frac{y^2}{a^2}-\frac{z^2}{c^2}=1. \tag{3}$$

## 4. APPLICATION PRESENT

This paper presents a software package, which can be used as educational software to the course of analytical geometry for presentation of the hyperboloid. The application is implemented in Java, under Microsoft Windows operating system. The graphical user interface was structured in three parts:

- the theoretical presentation;
- the presentation of solved problems;
- the solution of representative types of problems.

From the application window it can selected by a main menu the following options:

- the determination of the first quadratic fundamental form of hyperboloid;
- the determination of the second quadratic fundamental form of hyperboloid;
- the graphic representation of hyperboloid;
- the plan tangent and the normal to the hyperboloid into a point.

In the figure 1 is represented hyperboloid of one sheet by using the following projections: ( α=-145, β=-30, γ=90), ( α=145, β=-30, γ=60), ( α=45, β=0, γ=145) and (α=-20, β=100, γ=150).

In the figure 2 is represented hyperboloid of two sheets by using the following projections: ( α=-145, β=-30, γ=90), ( α=45, β=150, γ=90), ( α=-60, β=60, γ=150) and (α=120, β=-120, γ=45).

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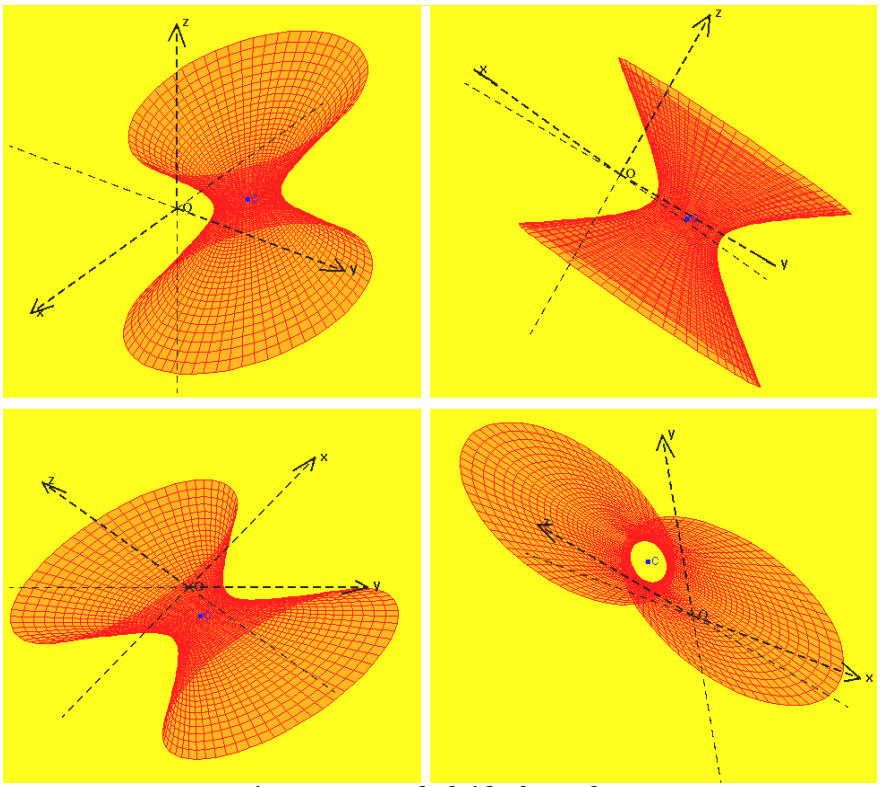


Figure 1. Hyperboloid of one sheet

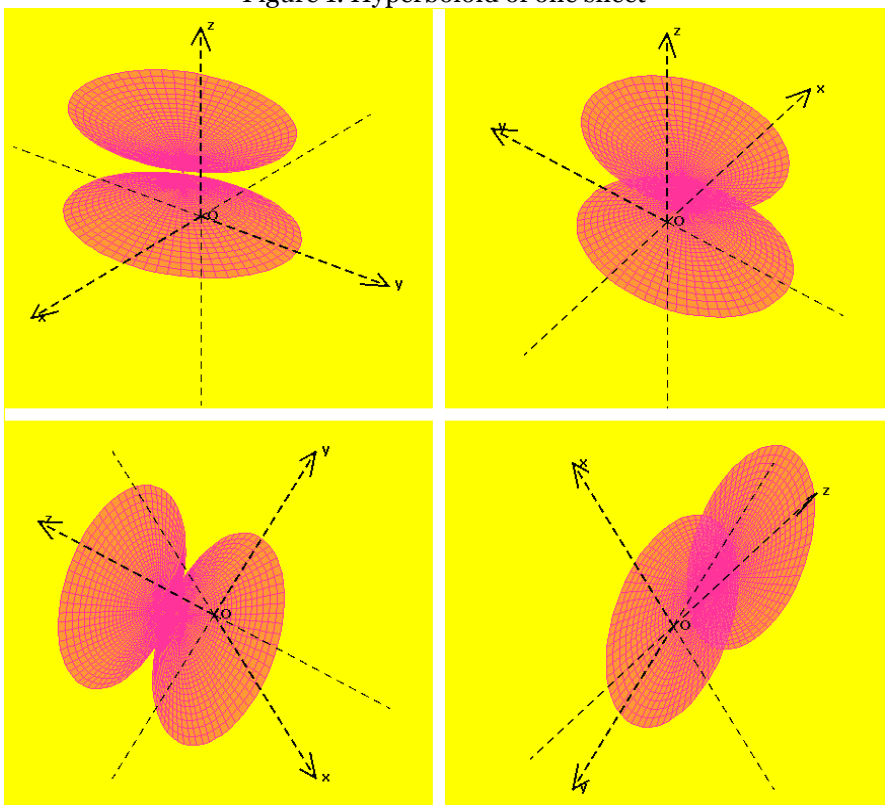


Figure 2. Hyperboloid of two sheets

The hyperboloid is draw by the following function:

```
public void desenare(Graphics2D g, int latime, int inaltime, Proiectie pr) {
    figura=new GeneralPath();
    Punct2D pct[][]=new Punct2D[61][61];
    pct=matrice(latime,inaltime,pr);
    int i,j;
    for (i=0;i<60;i++)
```

```
    for (j=0;j<60;j++) {
        GeneralPath fig=new GeneralPath();
        fig.moveTo((float)(pct[i][j].getX()),(float)(pct[i][j].getY()));
        fig.lineTo((float)(pct[i+1][j].getX()),(float)(pct[i+1][j].getY()));
        fig.lineTo((float)(pct[i+1][j+1].getX()),(float)(pct[i+1][j+1].getY()));
        fig.lineTo((float)(pct[i][j+1].getX()),(float)(pct[i][j+1].getY()));
        fig.closePath();
        if (culoare.equals(Color.black)) g.setColor(new Color(0,0,0,100));
        if (culoare.equals(new Color(155,65,30)))  g.setColor(new Color(155,65,30,100));
        if (culoare.equals(Color.green)) g.setColor(new Color(0,255,0,80));
        if (culoare.equals(Color.blue)) g.setColor(new Color(0,0,250,100));
        if (culoare.equals(new Color(155,55,150)))
        g.setColor(new Color(155,55,150,120));
        if (culoare.equals(Color.red)) g.setColor(new Color(255,0,0,110));
        if (culoare.equals(new Color(250,70,150)))  g.setColor(new Color(250,70,150,120));
        if (culoare.equals(Color.yellow)) g.setColor(new Color(255,0,0,70));
        g.fill(fig);
    }
    for (i=0;i<=60;i++) {
        figura.moveTo((float)(pct[i][0].getX()),(float)(pct[i][0].getY()));
        for (j=1;j<=60;j++)  figura.lineTo((float)(pct[i][j].getX()),(float)(pct[i][j].getY()));
    }
    for (j=0;j<=60;j++) {
        figura.moveTo((float)(pct[0][j].getX()),(float)(pct[0][j].getY()));
        for (i=1;i<=60;i++) figura.lineTo((float)(pct[i][j].getX()),(float)(pct[i][j].getY()));
    }
    g.setColor(culoare);
    g.setStroke(stil);
    g.draw(figura);
}
```

In the figure 3 is represented the plan tangent and the normal to a hyperboloid of one sheet by using the following projections: ( α=-145, β=-30, γ=90), ( α=-20, β=100, γ=150), ( α=-135, β=30, γ=120) and (α=-135, β=20, γ=120).

The plan tangent to a hyperboloid is draw by the following function:

```
public Plan3D plan_tangent(Punct3D P, double u, double v ) {
    double A,B,C1,D;
    if (caz==1) {
        A=-b*c*Math.cosh(u)*Math.cosh(u)*Math.cos(Math.toRadians(v));
        B=-a*c*Math.cosh(u)*Math.cosh(u)*Math.sin(Math.toRadians(v));
        C1=a*b*Math.sinh(u)*Math.cosh(u);
    }
    else {
        if (u>=0) {
            A=-b*c*Math.sinh(u)*Math.sinh(u)*Math.cos(Math.toRadians(v));
            B=-a*c*Math.sinh(u)*Math.sinh(u)*Math.sin(Math.toRadians(v));
        }
        else {
            A=b*c*Math.sinh(u)*Math.sinh(u)*Math.cos(Math.toRadians(v));
            B=a*c*Math.sinh(u)*Math.sinh(u)*Math.sin(Math.toRadians(v));
        }
        C1=a*b*Math.sinh(u)*Math.cosh(u);
    }
    D=-A*P.getX()-B*P.getY()-C1*P.getZ();
    return new Plan3D(A,B,C1,D);
}
```

The normal to a hyperboloid is draw by the following function:

```
public Dreapta3D normala(Punct3D P, double u, double v ) {
    double p,q,r;
    if (caz==1) {
        p=-b*c*Math.cosh(u)*Math.cosh(u)*Math.cos(Math.toRadians(v));
        q=-a*c*Math.cosh(u)*Math.cosh(u)*Math.sin(Math.toRadians(v));
        r=a*b*Math.sinh(u)*Math.cosh(u);
    }
    else {
        if (u>=0) {
            p=-b*c*Math.sinh(u)*Math.sinh(u)*Math.cos(Math.toRadians(v));
            q=-a*c*Math.sinh(u)*Math.sinh(u)*Math.sin(Math.toRadians(v));
```

```
            }
            else {
                p=b*c*Math.sinh(u)*Math.sinh(u)*Math.cos(Math.toRadians(v));
                q=a*c*Math.sinh(u)*Math.sinh(u)*Math.sin(Math.toRadians(v));
            }
            r=a*b*Math.sinh(u)*Math.cosh(u);
        }
        return new Dreapta3D(P,p,q,r);
}
```

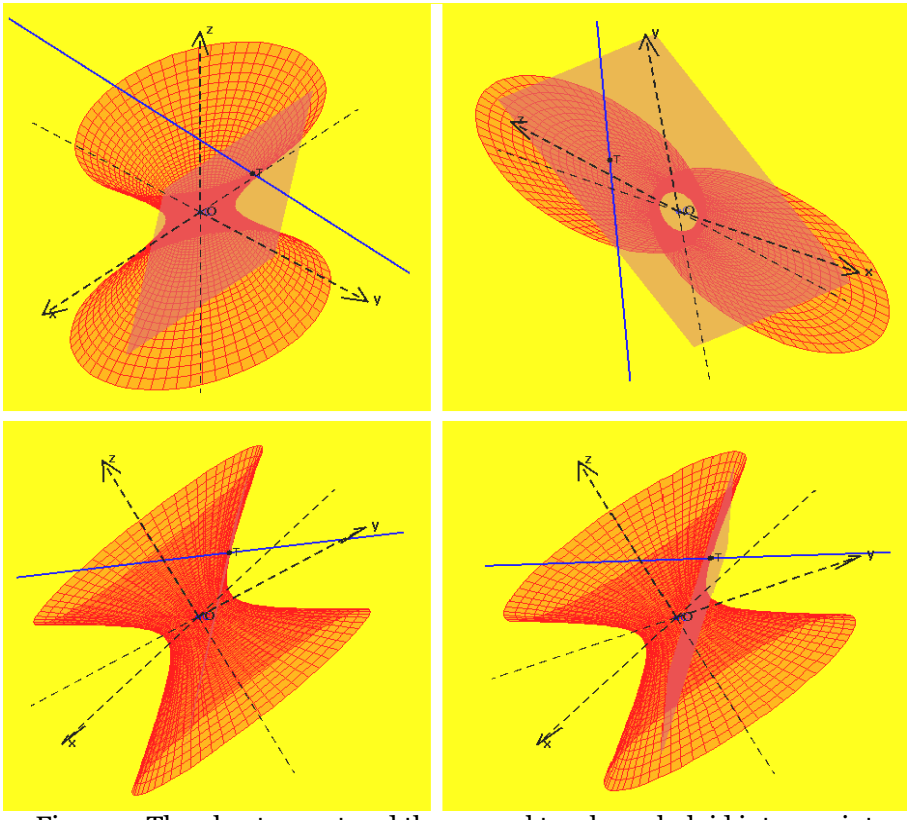


Figure 3. The plan tangent and the normal to a hyperboloid into a point

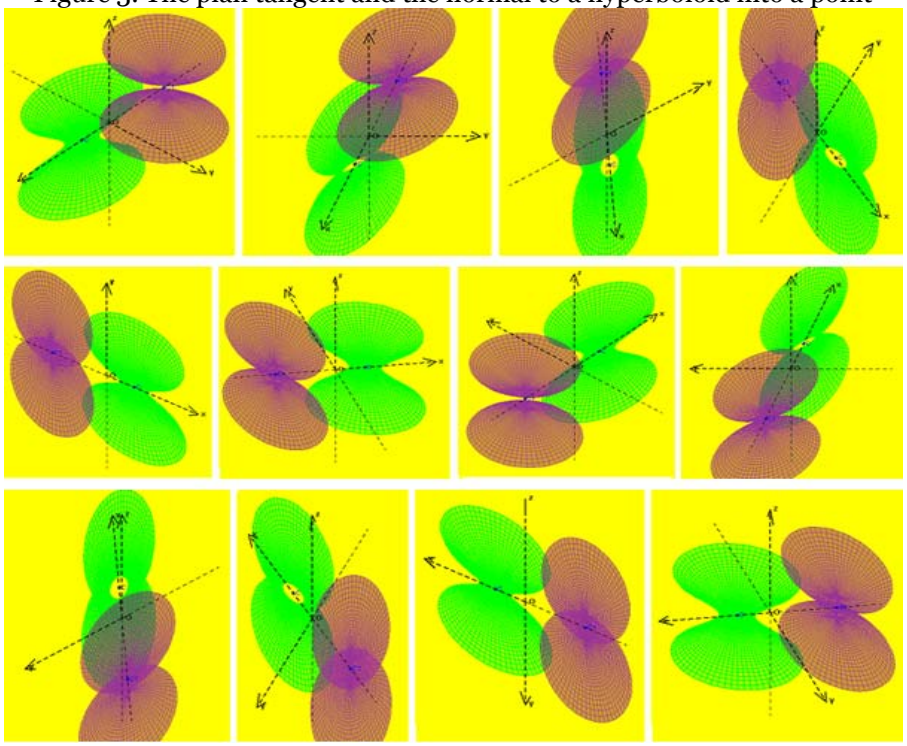


Figure 4. Animation achieved by rotation around the Oz axis

The interactive system allows the utilization of any orthogonal projection for representing the 3D geometric elements as bidimensional images in the projection plan. Specification of the desired projection is made by means of the three angles made by the three axis of the orthonormal benchmark from space with Ox axis from the projection plan.

After achievement of a 3D geometric construction there is the possibility to change the observation point by rotations around the Ox, Oy and Oz axis.

In the figure 4 is presented a sequence from the animation of a hyperboloid of one sheet and a hyperboloid of two sheets, animation achieved by rotation around the Oz axis. The presented sequence includes 12 bidimensional images obtained by using the following projections: (α=-145, β=-30, γ=90), (α=-115, β=0, γ=90), (α=-85, β=30, γ=90), (α=-55, β=60, γ=90), (α=-25, β=90, γ=90), (α=5, β=120, γ=90), (α=35, β=150, γ=90), (α=65, β=180, γ=90), (α=95, β=-150, γ=90), (α=125, β=-120, γ=90), (α=155, β=-90, γ=90) and (α=-175,β=-60, γ=90).

## 5. CONCLUSIONS

On this application, authors take into consideration the condition, which must accomplish a courseware, being made necessary steps. So, in elaboration and utilization of this application must take into consideration next criteria:

- To follow up the curriculum for a specific domain;
- To accomplish some teaching and learning strategy. In this kind of self-instruction and evaluation program it must find basic notions and representation and scanning notions. Animation and graphical modeling must represent the graphical construction way and also scanning of them;
- To exist the possibility to use parameterized variable, in conditions in which users have the possibility to input the variables value;
- To present a method in which the user can be informed about how can use graphical module, i.e. an interaction user-computer exist.

The presented application accomplishes these criteria, and for this we consider that is a good example of how educational software must be realized.

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# DESIGN OF SEQUENCE DIAGRAMS FOR IMPLEMENTATION OF A DYNAMICAL SOFTWARE FOR DOING GEOMETRICAL CONSTRUCTIONS

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**Abstract**:
This paper presents a software package, which can be used as educational software. The informatics system, including modern methods and techniques, will lead the subject which is using it to gain experience in understanding and managing the knowledge from geometry field and will offer the comfortable and efficient access to the newest information and knowledge. The investigation can be oriented towards reaching of some precise purposes or can be an exploration.

**Keywords**:
UML, Sequence Diagram, Educational Software

## 1. INTRODUCTION

Unified Modeling Language (UML) is a standardized general-purpose modeling language in the field of software engineering [1]. UML includes a set of graphical notation techniques to create abstract models of specific systems.

The Unified Modeling Language (UML) is an open method used to specify, visualize, construct and document the artifacts of an object-oriented software-intensive system under development. UML offers a standard way to write a system's blueprints, including conceptual components such as: actors, business processes, system's components and activities, as well as concrete things such as: programming language statements, database schemas and reusable software components.

UML combines the best practice from data modeling concepts such as entity relationship diagrams, business modeling (work flow), object modeling and component modeling. It can be used with all processes, throughout the software development life cycle, and across different implementation technologies. UML has succeeded the concepts of the Booch method, the Object-modeling technique (OMT) and Object-oriented software engineering (OOSE) by fusing them into a single, common and widely usable modeling language. UML aims to be a standard modeling language which can model concurrent and distributed systems. UML is not an industry standard, but is taking shape under the auspices of the Object Management Group (OMG). OMG has initially called for information on object-oriented methodologies, that might create a rigorous software modeling language. Many industry leaders have responded in earnest to help create the standard.

UML models may be automatically transformed to other representations by means of QVT-like transformation languages, supported by the OMG. UML is extensible, offering the following mechanisms for customization: profiles and stereotype.

UML is not a development method by itself, however, it was designed to be compatible with the leading object-oriented software development methods of its time. Since UML has evolved, some of these methods have been recast to take advantage of the new notations (for example OMT), and new methods have been created based on UML. The best known is IBM Rational Unified Process (RUP). There are many other UML-based methods like Abstraction Method, Dynamic Systems Development Method, and others, designed to provide more specific solutions, or achieve different objectives.

It is very important to distinguish between the UML model and the set of diagrams of a system. A diagram is a partial graphical representation of a system's model. The model also contains a "semantic backplane" — documentation such as written use cases that drive the model elements and diagrams.

UML diagrams represent two different views of a system model [2]:

- Static view: Emphasizes the static structure of the system using objects, attributes, operations and relationships. The structural view includes class diagrams and composite structure diagrams.

- Dynamic view: Emphasizes the dynamic behavior of the system by showing collaborations among objects and changes to the internal states of objects. This view includes sequence diagrams, activity diagrams and state machine diagrams.

UML models can be exchanged among UML tools by using the XMI interchange format.

## 2. SEQUENCE DIAGRAMS

A sequence diagram in Unified Modeling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order [3]. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called Event-trace diagrams, event scenarios, and timing diagrams.

A sequence diagram shows, as parallel vertical lines, different processes or objects that live simultaneously, and, as horizontal arrows, the messages exchanged between them, in the order in which they occur. This allows the specification of simple runtime scenarios in a graphical manner.

The UML 2.0 Sequence Diagram supports similar notation to the UML 1.x Sequence Diagram with added support for modeling variations to the standard flow of events.

If the lifeline is that of an object, it is underlined. Note that leaving the instance name blank can represent anonymous and unnamed instances.

In order to display interaction, messages are used. These are horizontal arrows with the message name written above them. Solid arrows with full heads are synchronous calls, solid arrows with stick heads are asynchronous calls and dashed arrows with stick heads are return messages. This definition is true as of UML 2, considerably different from UML 1.x.

Activation boxes, or method-call boxes, are opaque rectangles drawn on top of lifelines to represent that processes are being performed in response to the message (ExecutionSpecifications in UML). Objects calling methods on themselves use messages and add new activation boxes on top of any others to indicate a further level of processing.

When an object is destroyed, an X is drawn on top of the lifeline, and the dashed line ceases to be drawn below it (this is not the case in the first example though). It should be the result of a message, either from the object itself, or another.

A message sent from outside the diagram can be represented by a message originating from a filled-in circle ("found message" in UML) or from a border of sequence diagram ("gate" in UML).

UML 2 has introduced significant improvements to the capabilities of sequence diagrams [4]. Most of these improvements are based on the idea of *interaction fragments* which represent smaller pieces of an enclosing interaction. Multiple interaction fragments are combined to create a variety of *combined fragments*, which are then used to model interactions that include parallelism, conditional branches, optional interactions etc.

Some systems have simple dynamic behavior that can be expressed in terms of specific sequences of messages between a small, fixed number of objects or processes. In such cases sequence diagrams can completely specify the system's behavior. Often, behavior is more complex, e.g. when the set of communicating objects is large or highly variable, when there are many branch points (e.g. exceptions), when there are complex iterations, or synchronization issues such as resource contention [5]. In such cases, sequence diagrams cannot completely describe the system's behavior, but they can specify typical use cases for the system, small details in its behavior, and simplified overviews of its behavior.

## 3. PRESENTATION OF SEQUENCE DIAGRAMS UTILIZED TO IMPLEMENTATION OF A DYNAMICAL SOFTWARE FOR DOING GEOMETRICAL CONSTRUCTIONS

In the achievemnt of the interactive informatics system designed for studying geometry were aimed the following purposes:

- presenting of theoretical concepts and main results;
- interactive presentation of applications for each required subdomain;
- achievement of accurate drawings by replacing the pencil and ruler with the mouse.

By representing the diagrams related to the three steps: analysis, designing and implementation, the interactive informatics system will be described in a clear and concise manner. Utilization of the UML modelling language in the diagrams' achievement is featured by a rich syntactic and semantic rigour, and support for visual modeling.

The sequence diagram is used primarily to show the interactions between objects in the sequential order that those interactions occur. Much like the class diagram, developers typically think sequence diagrams were meant exclusively for them.

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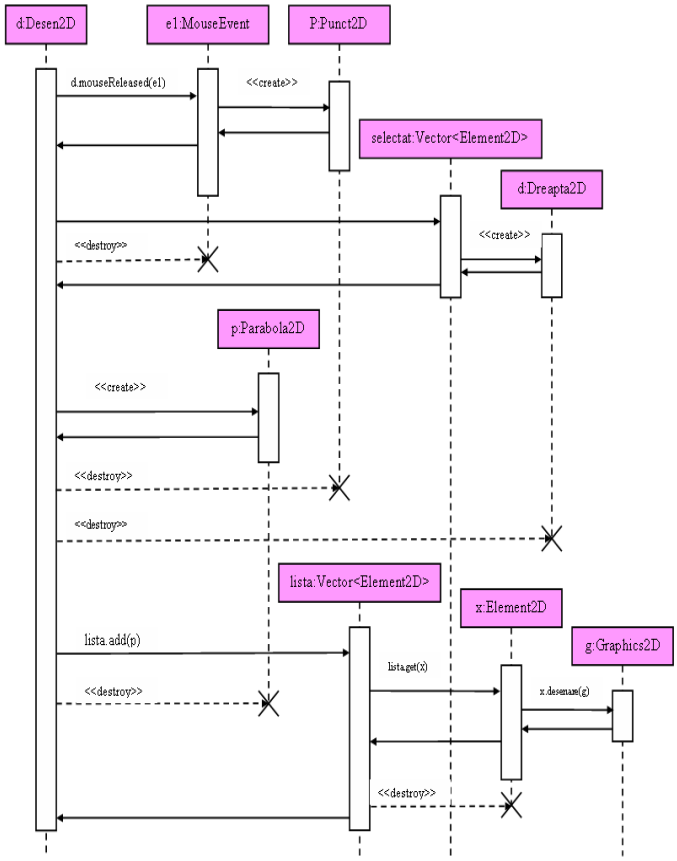



Figure 1. Sequence diagram for drawing a parabola

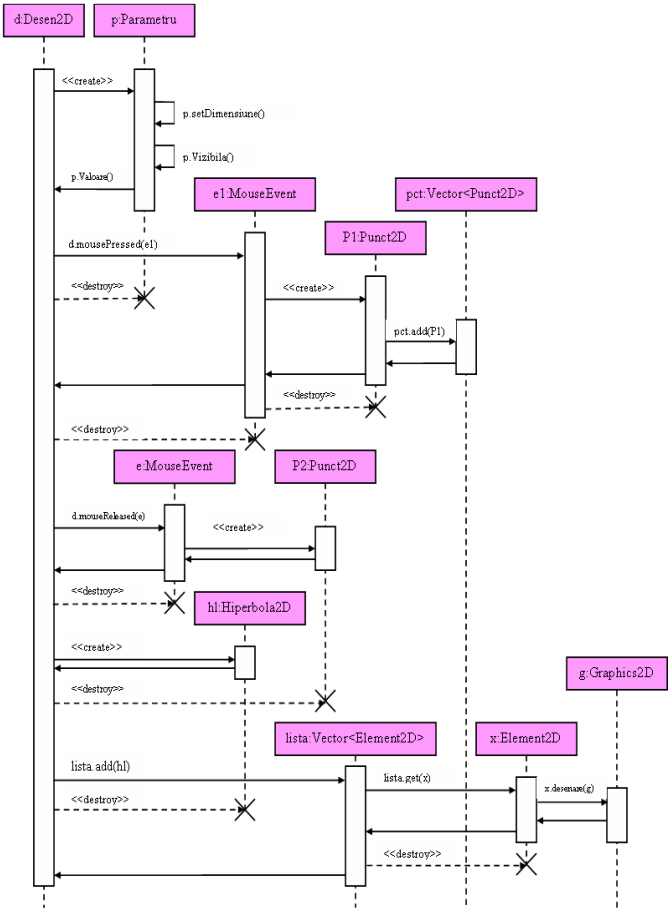



Figure 2. Sequence diagram for drawing a hyperbola

The diagram illustrates in figure 1 shows the interactions between objects, which have as purpose the drawing of a parabola. One can notice that there are interactions between nine objects, out of which the objects of *Vector<Element2D>*, *Desen2D* and *Graphics2D* type are already created, and the objects of *Element2D*, *Punct2D*, *Dreapta2D*, *MouseEvent* and *Parabola2D* type will instantiate during the interactions.

The diagram illustrates in figure 2 shows the interactions between objects, which have as purpose the drawing of a hyperbola. One can notice that there are interactions between eleven objects, out of which the objects of *Vector<Element2D>*, *Desen2D*, *Vector<Punct2D>* and *Graphics2D* type are already created, and the objects of *Element2D*, *Parametru*, *Punct2D*, *MouseEvent* and *Hyperbola2D* type will instantiate during the interactions.

The diagram illustrates in figure 3 shows the interactions between objects, which have as purpose the drawing the normal to a hyperbola. One can notice that there are interactions between nine objects, out of which the objects of *Vector<Element2D>*, *Desen2D* and *Graphics2D* type are already created, and the objects of *Element2D*, *Punct2D*, *Dreapta2D*, *MouseEvent* and *Hiperbola2D* type will instantiate during the interactions.

These objects are represented on Ox axis and, on Oy axis, are represented the messages ordered increasingly in time. At the beginning, the execution's control is undertaken by the object of *Desen2D* type which creates an instance of the *MouseEvent* class.

Now, the control is undertaken by this newly created instance that will allow to determining a point. Giving the control to the object of *Hiperbola2D* type, will verified if the created point belong to the hyperbola.

Giving back the control to the object of *Desen2D* type, further will be instantiated the object of *Dreapta2D* type, representing the normal to hyperbola, then will be destroyed the object of *Punct2D* type and the object of *Hiperbola2D* type.

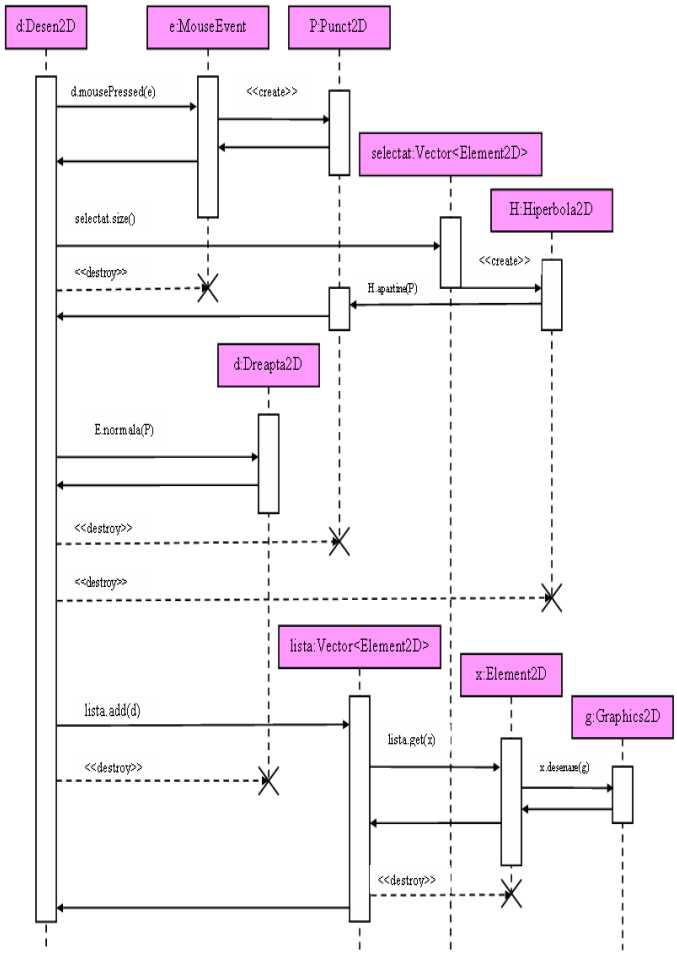



Figure 3. Sequence diagram for drawing a the normal to a hyperbola

Further, the execution's control is transmitted to the object of *Vector<Element2D>* type, in order to add the normal previously created in the list of 2D elements of the geometric construction, and then will be destroyed the instance of the *Dreapta2D* class. Finally, will be redrawn the geometric construction, which will include now also the normal to the previously created hyperbola by using the object of *Graphics2D* type.

## 4. CONCLUSIONS

The diagrams were achieved by an approach in a new manner, multidisciplinary, of the informatics application, including both the modern pedagogy methods, and the components specific to the discipline to be studied. Thus, was achieved the connection between the didactic actions and the purposes and objectives scientifically established, by elaborating of new methods and assimilating of new means, capable to increase the school efficiency, allowing the pupils and students to acquire the system required by knowledges and their application techniques in conditions as optimal possible.

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# STUDY OF LOW-SIGNAL AMPLIFIERS WITH FIELD-EFFECT TRANSISTORS

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**Abstract**:
In this work are presented the types of amplifier stages with field-effect transistors, as well as the diagrams of the low-signal amplifiers achieved with TEC-J for the three connection types: common-source, common-grid and common-drain. Also, using the EWB-Multisim 8 program, it was simulated the operation of the amplifier with TEC-J in common-source connection, the amplifier with TEC-MOS in common-drain connection and the cascode amplifier with two TEC-J transistors .

**Keywords**:
TEC transistor, Voltage amplification, Current amplification, Amplifier, Simulation, Multisim 8

## 1. INTRODUCTION

The models which describe the operation at small signal variations have in view a description of the transistors' behavior in applications of amplifier stages' type. In these applications, the transistors are polarized in the characteristics' area where these are almost horizontal lines; against the collector, the transistors are equivalent with a controlled current generator and behave linearly. In the respective circuits' operation, the effect of the charges accumulated in junctions or other regions of the transistors is the one of some capacitors which produce phase differences and dampings with frequency.

The small signal variations are the voltage and current variations situated within an interval relatively restricted around some continuous components, interval where the device's behavior can be described by linear equations. The device's equivalent diagram is composed by linear components, of which values depend generally to the operation static point (the continuous components of voltages and currents through the device). The voltage and current variations are small, but the time-variation speeds are not neglectable, thereby the accumulations of electric charges in the device should be taken in consideration .

## 2. TEC-J and TEC-MOS BEHAVIOR AT SMALL SIGNAL VARIATIONS

The operation static point should be in the saturation region of the drain current (Fig. 1). In this operation regime, the equation of the TEC-J transistor is:

$$I_D = I_{DSS} \cdot \left(1 - \frac{V_{GS}}{V_P}\right)^2 \tag{1}$$

$$dI_D = 2\, I_{DSS} \cdot \left(1 - \frac{V_{GS}}{V_P}\right) \cdot \left(-\frac{dV_{GS}}{V_P}\right) = 2\, I_{DSS} \cdot \sqrt{\frac{I_D}{I_{DSS}}} \cdot \left(-\frac{dV_{GS}}{V_P}\right) \tag{2}$$

Using the same convention to note the variations and the components $v_{GS} = V_{GS} + v_{gs}$ and $i_D = I_D + i_d$, we have the correspondence:

$$dI_D \to i_d \quad şi \quad dV_{GS} \to v_{gs} \tag{3}$$

$$i_d = -2\frac{\sqrt{I_D\, I_{DSS}}}{V_P} \cdot v_{gs} \tag{4}$$

The TEC-J transistor's slope is:

$$g_m = \left.\frac{i_d}{v_{gs}}\right|_{V_{DS}=constant} = -2\frac{\sqrt{I_D\, I_{DSS}}}{V_P} \tag{5}$$

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The higher the drain current, the higher the slope. The maximum slope of a TEC-J is obtained at $V_{GS} = 0$ and has the value:

$$(g_m)_{max} = |2\, I_{DSS} / V_P| \quad (6)$$

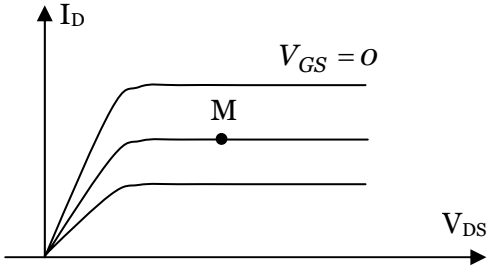



Fig. 1. TEC-J's operation point as amplifier

The small variations $v_{gs} > 0$ of the grid-source voltage produce the following effects:

- the drain current's increase due to the increase of the channel's conductance (the channels' area increases);
- the electric charge accumulated in the passing region of the grid-channel junction modifies in the source's region and, as result, is necessary a grid current to supply this modification $i_g' = C_{gs} \cdot \frac{dv_{gs}}{dt}$ where $C_{gs}$ is the barrier capacity of the grid-channel junction in the source's area;
- the drain-source voltage modifies (following the modification of the drain current), which leads to the modification of the electric charge acummulated in the passing region of the grid-channel junction in the drain's region; a grid current is necessary to supply this charge modification $i_g'' = C_{gd} \cdot \frac{dv_{gd}}{dt}$ where $C_{gd}$ is the barrier capacity of the grid-channel junction in the drain's area.

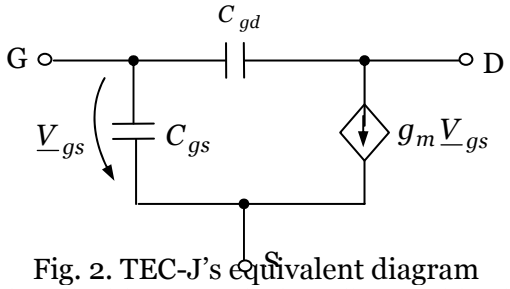



Fig. 2. TEC-J's equivalent diagram

TEC-MOS behavior is described by an equivalent diagram identical with the one from Fig. 2. Capacities $C_{gs}$ and $C_{gd}$ correspond to the TEC-MOS' sublayer grid capacities in the source's, respectively the drain's area. The TEC-MOS' equivalent slope is obtained starting from the transistor's equation in the drain current's saturation area.

$$I_D = k \cdot (V_{GS} - V_P)^2 \quad (7)$$

Is obtained the TEC-MOS transistor's slope:

$$g_m = 2\sqrt{k\, I_D} \quad (8)$$

## 3. AMPLIFIER STAGES

The amplifier stage is the simplest contructive block of an amplifier. It containes one or maximum two transistors which operate in controlled current source regime. For TEC, this corresponds to the drain current's saturation area. Against the drain, the transistor behaves as a current generator controlled by the voltage $\underline{V}_{gs}$. The three amplifier stages' types are based on the connections of the field-effect transistors:

- Common-source connection (Fig. 3);
- Common-grid connection (Fig. 4);
- Common-drain connection (Fig. 5).

The presented circuits include the resistances that ensure the transistors' polarization in the reminded regions. For the amplifier stages with TEC are presented, for exemplification, only the diagrams of the stages with TEC-J, but there are similar circuits also for TEC-MOS.

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In order to simplify the diagrams, in some cases it was chosen the option of polarization from two sources. In this case, the components' number from the diagram is smaller and the equivalent diagrams for small signal variations are simpler.

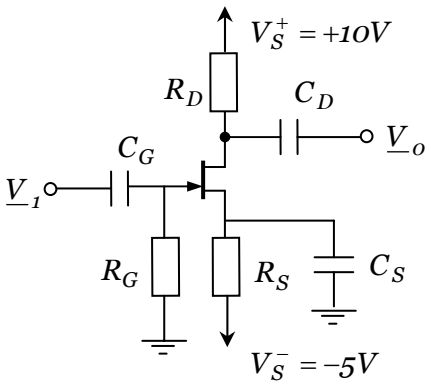



Fig. 3. Amplifier stage: Common-source

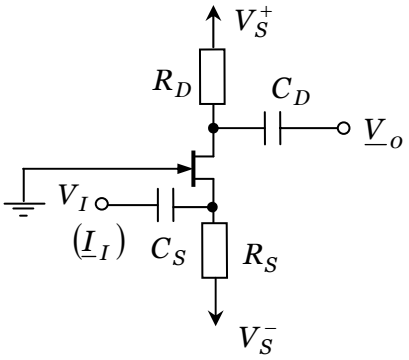



Fig. 4. Amplifier stage: Common-grid

Resistances $R_G$ , $R_S$ şi $R_D$ from the common-source amplifier stage (Fig. 3) ensures the TEC-J polarization in RAN. Capacitors $C_G$ and $C_D$ separate the input and output in d.c. from the TEC-J polarization and allow the coupling of the input and output signals, reason for which they are also called as coupling capacitors. The capacitor $C_S$ , also called as decoupling capacitor, is short-circuiting to earh in a.c. the source TEC-J, where from the diagram's name. The resistance $R_D$ has an important function also in a.c., as will be seen at amplification's calculation.

In the common-grid amplifier stage (Fig. 4), the TEC-J polarization in RAN is ensured by $R_S$ and $R_D$ and by the supply sources $V_S^+$ şi $V_S^-$ . The coupling capacitors $C_S$ and $C_D$ are separating in d.c. the amplifier stage from the rest of the circuit, and allow the input's and output's coupling to the circuit.

The common-grid amplifier stage: (Fig. 5), also called as repeater-on-source, is polarized from the supply sources through the resistances $R_G$ and $R_S$ . The input and output coupling is achieved with the coupling capacitors $C_G$ and $C_S$ .

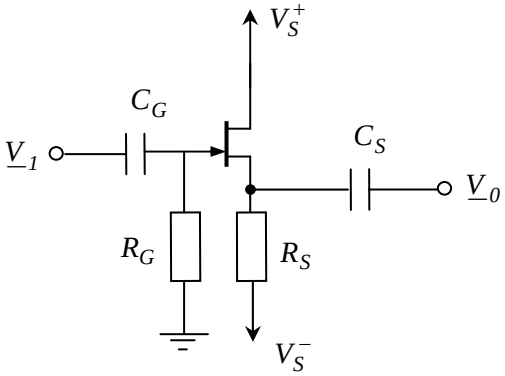



Fig. 5. Amplifier stage: Common-drain

In all diagrams, the coupling and decoupling capacitors ($C_G$, $C_D$, $C_S$) should have sufficiently high values, in order that their impedances at operating frequencies to be considered neglectable, respectively the voltage drops on the equivalent impedances don't matter. This condition is not only dependent by the capacitors' values and the signals' frequency, but also by the resistances from the circuit.

## 4. AMPLIFIERS WITH FIELD-EFFECT TRANSISTORS (TEC)

### 4.1. Amplifiers with field-effect transistor (TEC) in common-source connection

Study of an amplifier with TEC-J is very similar to the one of an amplifier with TEC-MOS, therefore here is presented only an amplifier with TEC-J. A typical diagram for such an amplifier is represented in fig. 7, and its model, in which for TEC-J are used the natural parameters, is given in fig. 8.

The role of the components $e_g, R_G, C_i, C_e, R_S$ from fig. 7 and 8 is the following: $e_g$ - signal source, which usually is of alternative signal; T - amplifying element; $R_G$ - equivalent internal resistance of the signal source; $R_{GR}$ and $R_D$ - the TEC-J's polarization resistors; $R_S$ - amplifier's charge (consumer); $C_i$ , $C_e$ - input capacitor which couples the signal mass at the amplifiers' input, respectively the output capacitor which couples the consumer's output to the charge.

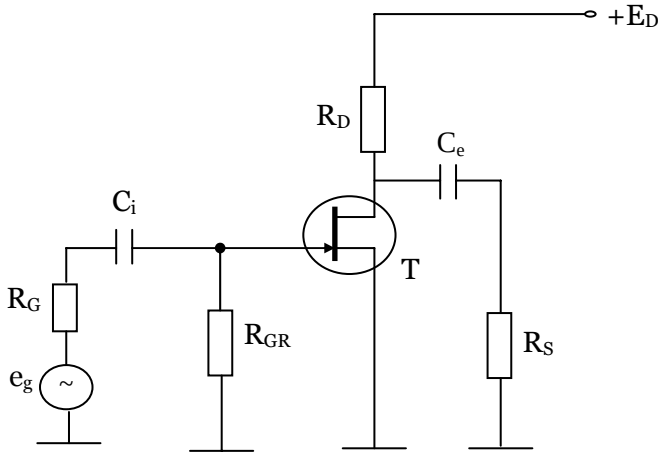



Fig. 7. Amplifier in common-source conection with TEC-J

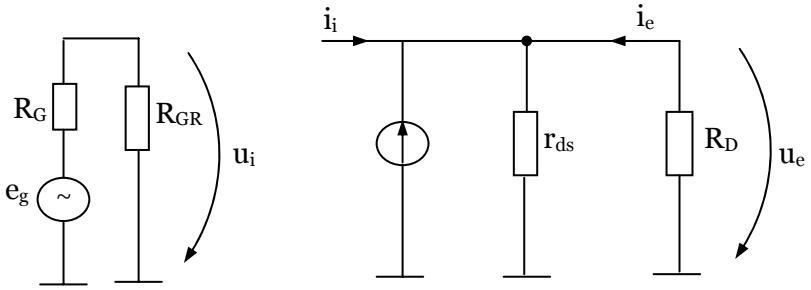



Fig. 8. Amplifier's low-signal equivalent circuit in common-source connection with TEC-J

Based on fig. 8, we have:

$$A_{us} = \frac{u_e}{u_i} = -\frac{g_m \cdot R_D}{1 + \frac{R_D}{r_{ds}}} \tag{9}$$

Because $r_{ds} << R_D$, the frequently used relation for the voltage amplification $A_u$ is:

$$A_{us} = -g_m \cdot R_D \tag{10}$$

and the current amplification $A_i$ is:

$$A_{is} = \frac{i_e}{i_i} \tag{11}$$

The current amplification is very high, but practically is less interesting because the TEC's control is made in voltage. However, a high $A_i$ leads finally to an amplification in power $A_p$ very high for a stage with TEC. For the input resistance $R_i$ and output resistance $R_e$, having in view the obvious neglects, are obtained:

$$R_{is} = R_{GR} \tag{12}$$

$$R_{es} = r_{ds} \tag{13}$$

### 4.2. Amplifiers with field-effect transistor (TEC) in common-drain connection (repeater-on-source)

The amplifier in common-drain connection (fig. 9) is useful in applications with requirements in accordance with its properties, i.e.:

- Output signal in phase with the input one;
- Very high input resistance;
- Low input capacity;
- Low output resistance;
- Output signal undeformed by high amplitude at output;
- Voltage amplification slightly subunitary.

Current amplification $A_i$ is very high:

$$A_{id} = \frac{i_e}{i_i} \uparrow \tag{14}$$

and the voltage amplification $A_u$ is expressed by the relation (15) and has the value closed to 1.

$$A_{ud} = \frac{g_m \cdot R_D}{1 + g_m \cdot R_D} \tag{15}$$

$$R_d = r_{ds} \,||\, R_{SU} \,||\, R_S \tag{16}$$

The stage's own input resistance is given practically by the value of $R_{GR}$ which should be chosen of an as high possible value, or, in some cases, equal with the value of the signal source's equivalent resistance $R_G$. The stage's own output resistance is low, having the value:

$$R_{ed} = \frac{1}{g_m + \frac{1}{r_{ds}}} \tag{16}$$

and the total one $R_{et}$:

$$R_{etd} \cong R_S \,||\, R_{SU} \tag{17}$$

The stage's total input capacity is:

$$C_{idt} = C_{gd} + (1 - A_u) \cdot C_{gs} \cong C_{gd} \tag{18}$$

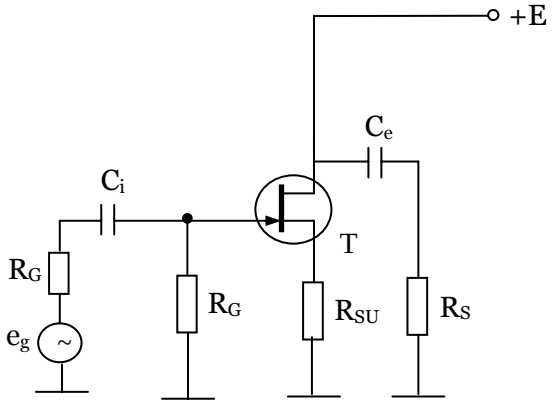



Fig. 9. Amplifier with TEC-J in common-drain connection

### 4.3. Amplifiers with field-effect transistor (TEC) in common-grid connection

The amplifier with TEC in common-grid connection (Fig. 10) is lesser used, and its main qualitative characteristics are the following:

- High output impedance;
- Low input impedance;
- Unitary current amplification;
- Low input → output transfer capacity;
- The output signal is in phase with the input one.

Under mathematical aspect, the circuit's voltage amplification is:

$$A_{ug} = \frac{(1 + g_m \cdot r_{dS}) \cdot R_S}{R_S + r_{dS} + (1 + g_m \cdot r_{dS}) \cdot R_S} \cong g_m \cdot (R_S \,||\, r_{dS}) \tag{19}$$

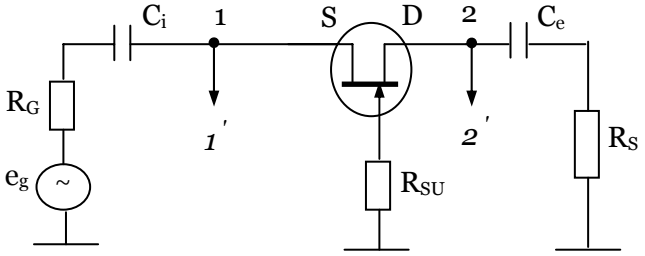



Fig. 10. Amplifier with TEC-J in common-grid connection

## 5. SIMULATION OF THE LOW-SIGNAL AMPLIFIERS' OPERATION WITH TEC USING EWB-MULTISIM 8

The amplifier with TEC-J in common-source connection is a classic one (Fig. 11). Resistors R1 and R3 achieve the automatic polarization, R3 introducing also a negative reaction in d.c. Resistor R2 represents the drain charge of the transistor T, and Rs is the amplifier's external charge.

Capacitors C1 and C2 achieve the galvanic separation of the amplifier from the signal source, respectively from the charge. The capacitor C3 decouples totally in a.c. the resistor R3 in order not to decrease the circuit's voltage amplification.

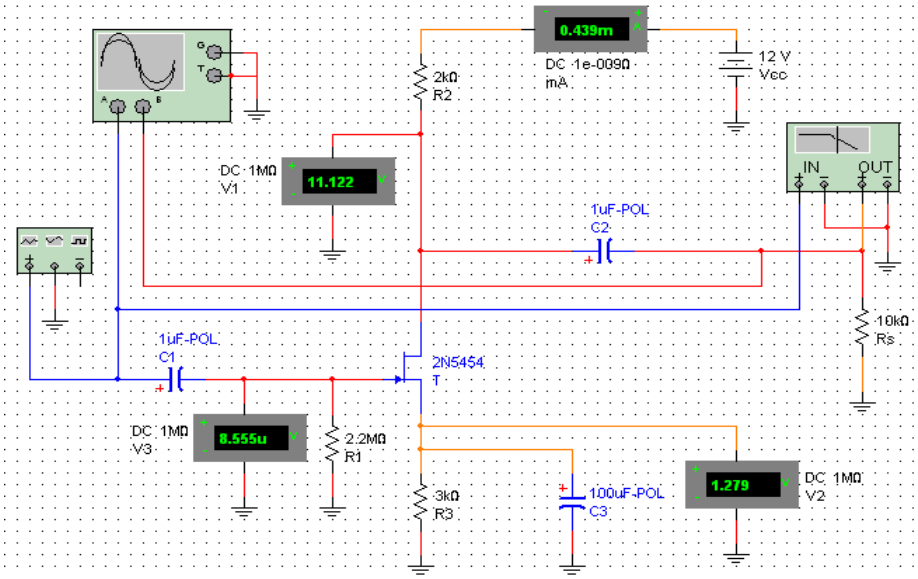



Fig. 11. The amplifier's simulation diagram with TEC-J in common-source connection

It's been achieved the simulation of this amplifier's operation for the following values of the electronic components from diagram: SV = 1 mV/10 kHz, Vcc = 12 V, T = 2N5454, R1 = 2,2 MΩ, R2 = 2 kΩ, R3 = 3 kΩ, C1 = C2 = 1 µF, C3 = 100 µF, Rs = 10 kΩ. Were measured: the the circuit's current consumption and the voltages in drain, the source and grid of the transistor T.

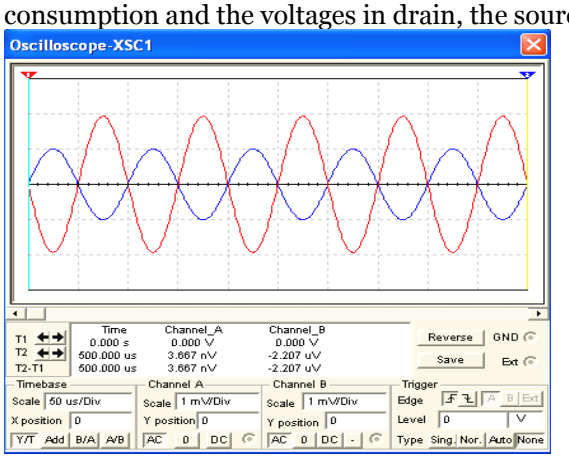



Fig. 12. Signals from the amplifier's input and output with TEC-J in common-source connection resulted further simulation

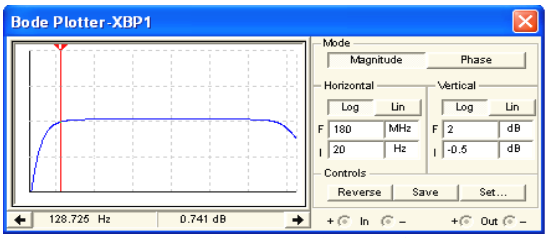



Fig. 13. Amplifier's amplitude-frequency characteristic with TEC-J in common-source connection resulted further simulation

Have been visualized on oscilloscope the signals from the amplifier's input and output with TEC-J in common-source connection (fig. 12). The amplitude–frequency characteristic of this amplifier, resulted further simulation, is presented in fig. 13.

The amplifier with TEC-MOS transistor, repeater-on-source with bootstrap reaction, (Fig. 14), represents an apart amplifier type, used especially as adaption circuit for signal sources with extremely high internal resistance. The bootstrap connection applies by the capacitor C2, which, by the the positive reaction source-grid which introduces it, increases the amplifier's input equivalent resistance (however very high in the presented case).

Resistors R1, R2 form the voltage divider from the grid of the transistor used for its polarization, and the resistor R3, of high value, has the role to ensure a high input resistance to the circuit. The resistor Rs contribute to establishing the drain current of transistor T, having in this case also the role of charge resistance.

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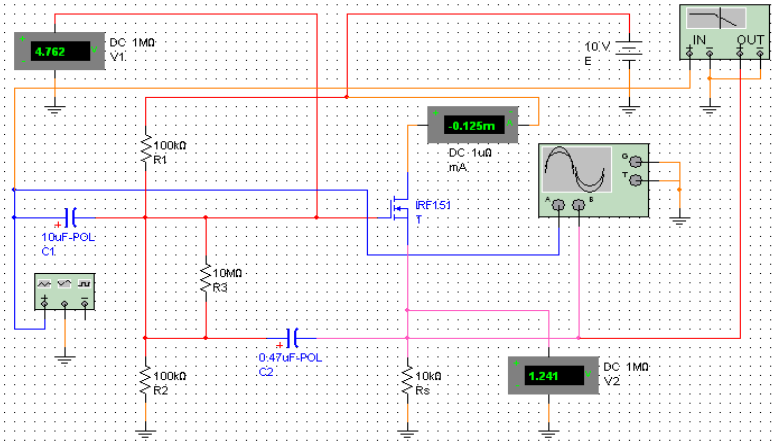



Fig. 14. Amplifier's simulation diagram with TEC-MOS in common-drain connection (repeater-on-source)

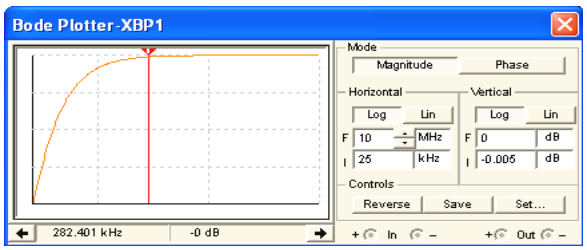



Fig. 15. The amplifier's amplitude–frequency characteristic with TEC-MOS in common-drain connection resulted further simulation

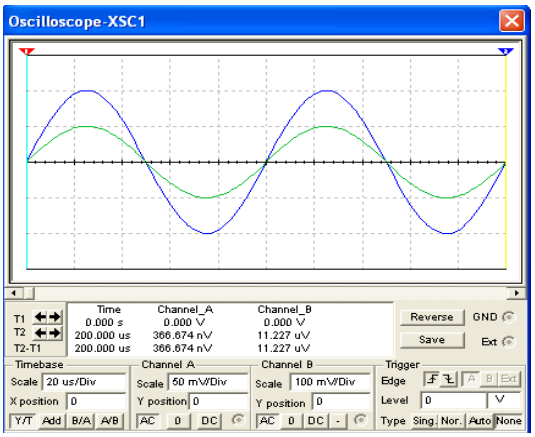



Fig. 16. Signals from the amplifier's input and output with TEC-MOS in common-drain connection resulted further simulation

It's been achieved the simulation of this amplifier's operation for the following values of the electronic components from diagram: SV = 100 mV / 10 kHz, E = 10 V, T = IRF151, R1 = 100 kΩ, R2 = 100 kΩ, R3 = 10 MΩ, C1 = 10 μF, C2 = 0,47 μF, Rs = 10 kΩ.

Was measured the circuit's current consumption, the grid voltage and the drain of transistor T. The amplitude–frequency characteristic of this amplifier, resulted further simulation, is presented in fig. 15.

Following the simulation, were visualized on oscilloscope the signals from the amplifier's input and output with TEC-MOS in common-drain connection (fig. 16).

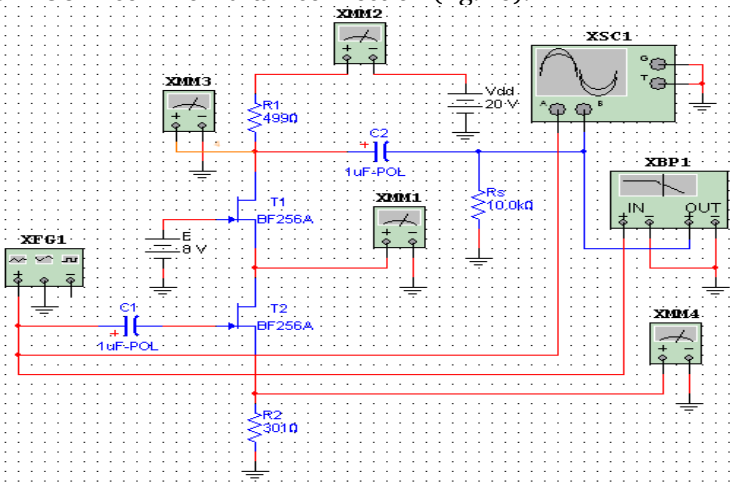



Fig. 17. Simulation diagram of the cascode amplifier with two TEC-J transistors

The cascode amplifier with two TEC-J transistors (Fig. 17) is used especially at high frequencies. Transistor T1 works in common-source connection and transistor T2 in common-grid connection, the coupling between the two transistors being direct. Thus, are ensured the equivalent input and output specific resistances and a high voltage amplification, comparable with the one of a classic amplifier

with two amplifier stages. Resistors R1 and R2 ensure the simultaneous polarization, convenient, of transistors T1, T2.

Capacitors C1, C2 achieve the galvanic separation between the amplifier and the SV signal source (XFG1 functions generator), respectively the charge Rs.

Was ahieved the simulation of this amplifier's operation for the following values of the electronic components from diagram: SV = 1 mV/10 kHz, E = 8 V, Vdd = 20 V, T1 = BF256A, T2 = BF256A, R1 = 499 Ω, R2 = 301 Ω, C1 = C2 = 1 μF, Rs = 10 kΩ.

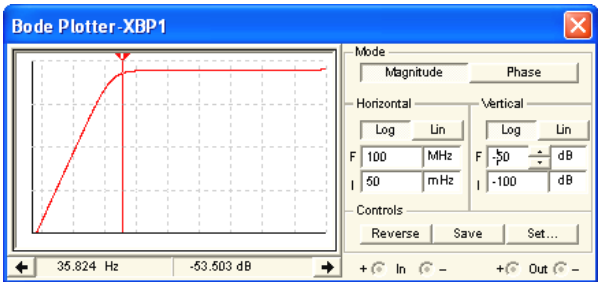



Fig. 18. The amplitude-frequency characteristic of the cascode amplifier with two TEC-J transistors

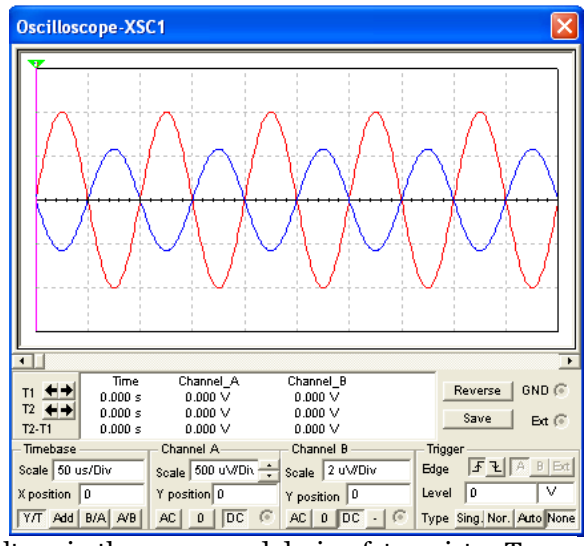



Fig. 19. Signals from the cascod amplifier's input and output with two TEC-J transistors

Was measured the circuit's consumption, the voltage in the source and drain of transistor T1, as well as the voltage in the source and drain of transistor T2. The amplitude–frequency characteristic of this amplifier, resulted further simulation, is presented in fig. 18.

In fig. 19 were visualized on oscilloscope the input and output signals of the cascode amplifier with two TEC-J transistors resulted further simulation.

## 6. CONCLUSIONS

Simulation of the low-signal amplifiers' operation with field-effect transistors has a very important role, being the intermediary step absolutely necessary between designing and achievement of the experimental model. Thus, the user can observe by simulation, without being necessary the practical achievement of the electronic circuit, the real behavior and can modify certain components in order to reach the desired result.

After the electronic diagram's achievement, by software can be performed an operational analysiss, as well as the behavior in different duty regimes – d.c., impulses, transitory and stationary regimes , behavior with frequencies, etc – by means of the own measurement and diagnosis systems, as well as the software's specific facilities.

The main advantage offered by the EWB–Multisim 8 simulation program consists in high flexibility as regards the structure modification of the analyzed electronic circuits and their duty regimes, fact which allows an analysis and a diagnosis within a much more reduced time interval of the electronic circuits than the case when these would be physically achieved, allowing in addition a facile and large storage of information about the circuit's operation between different implementation options.

One can notice the time savings and the possibility of further data processing, especially the graphic dependencies for different measures, by means of the EWB–Multisim 8 program.

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# SIMULATION OF SOME FAULTS IN THREE-PHASE ELECTRIC SYSTEMS USING THE PSCAD-EMTDC PROGRAM

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**Abstract**:
The main faults and abnormal regimes in the three-phase electric systems are short-circuit and phase interruptions, respectively overcurrents and system's stability loss.
Studying faults and abnormal operation regimes has a special practical importance, because these operation regimes produce malfunctions or even failures of the electric installation, if they are not removed on time.
In this work are analyzed few faults of three-phase electric systems by means of the PSCAD-EMTDC program.
Fault analysis with PSCAD can be used for protection relay coordination and for improving the system's performance and reliability.

**Keywords**:
Three-phase electric systems, Faults, Simulation, Reliability

## 1. INTRODUCTION

The most frequent faults in electric systems are short-circuiting. Short-circuits' appearance is caused by damaging the insulation or insulation space between phases, or between phase and ground, as result of the loads at rated voltage, or overvoltages that appear in electric installations [1,2].

Short-circuit can be: three-phase (or three-phase-to-earth), phase-to-phase (or phase-to-phase-to-earth) and single-phase (or phase-to-earth fault, produced in the grids with neutral directly grounded).

The three-phase short-circuit is also called as symmetrical fault, because the impedances on phases are equal. This short-circuits, by their consequences, represent the worst fault that might happen into an electric grid. From this reason, the three-phase short-circuit currents are taken as base when selecting the commutation electric devices and verifying them at thermal and electrodynamics stress, verifying the relay protection and automations etc [3-5].

The other short-circuits are called as asymmetrical faults. These are featured by the fact that the phenomena from each phase are produced differently. In these conditions, the phase impedances are unequal and the currents' three-phase system is asymmetrical. Determination of these currents is made by the symmetric components method.

In aerial electric grids, short-circuits are produced, in major cases, by external transitory causes: atmospheric discharges, indirect contact of some phases by foreign bodies etc. After a short time interval from disconnecting the faulty element, the causes might disappear and the insulation in the respective point resume to normal [6].

In these conditions, to prevent a long-term interruption of the consumers' power supply, are provided devices of high speed automatic reclosing (RAR), which connect after a preestablished time the disconnected supply circuits. Earth fault is not an immediate danger, because is not accompanied by big fault currents. However, earth fault of a phase determines the voltage increase of the healthy phases against ground. This increase leads to overstressing the insulation and the danger of its breakdown also in other point from the other phases. Thus, the fault is going to double-earth fault (bi-phase short-circuit to-earth) [7,8].

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Beside short-circuits, in the electric systems appear also other faults, such as interruption of a phase. The study of this fault is necessary for designing the parallel lines' protections and to verify if the influence of the negative-sequence components (that appear at a phase interruption) upon generators is within the permissible limits. In case of long-term operation of a line in two phases, is also necessary to verify the influence on the telecommunication lines [4,6].

The main abnormal regimes in electric systems are overcurrents and system's stability loss.

Overcurrents are caused by a short-circuit external to the protected element, or by appearance of some overloads. Overcurrents don't need an immediate disconnection of the protected element, but neither can be admitted on an undetermined period, because they are causing overheatings and, therefore, insulation's wear. Against overcurrents are provided delayed protections [4,6,8].

The system's stability loss can appear due to some short-circuits removed too late, or exceeding the permitted power transported through a line, which causes the dropping-out-of-step of the power plans operating in parallel [8].

Study of faults and abnormal operation regimes in three-phase electric grids has a special practical importance for protection relay coordination. The relay protection should ensure the installation's automatic disconnection when a fault or abnormal operation regime appears, dangerous for the installation. In case of faults and abnormal regimes which don't show an immediate danger, the relay protection is not controlling the installation's disconnection, but warns the appearance of the abnormal regime [9].

Automatic separation of the faulty installation from the rest of the electric system aims three objectives: to prevent the fault's increase, respectively extension of its effects by affecting other installations from the electric system and transforming the fault into a system emergency; to prevent the installation's damage where the fault appears, by rapid interruption of all possibilities to supply the fault; to reestablish a normal operation regime for the rest of the electric system, ensuring the consumer's supply continuity [10].

## 2. SIMULATION OF SOME FAULTS IN THREE-PHASE ELECTRIC SYSTEMS USING THE PSCAD-EMTDC PROGRAM

Calculation of some faults (short-circuits, phase interruptions, etc.) that appear during the three-phase systems' operation is a complicate procedure, needing to solve some equation systems with a great number of unknown quantities. To simplify the equations and the corresponding equivalent diagrams, can be used the symmetric components' method.

In case of a small circuit with linear elements, determination by normal analysis of the accurate solution is a problem easy to solve. Manual analysis of bigger circuits becomes, however, a very complex problem, being preferable the utilization of a simulation program.

Among the programs used in electric circuits' simulation can be enumerated: PSCAD-EMTDC, SPICE, OrCAD, Multisim.

PSCAD/EMTDC is a general-purpose time domain simulation program for multi-phase power systems and control networks. It is mainly dedicated to the study of transients in power systems. A full library of advanced components allows to precisely modeling interactions between electrical networks and loads in various configurations [11].

PSCAD is ideal for the analysis of electrical transients involving: assymmetrical faults, power line and cables, large non-linear industrial loads, protection relay coordination, arc furnace flicker, distributed power generator, rotating machines, embedded systems [11].

Further, are analyzed few faults of three-phase electric systems by means of the PSCAD-EMTDC program.

### 2.1 Short-circuit of a phase

Is admitted short-circuit of phase 1 into a circuit where the other two phases have equal impedances, and the voltage system is symmetric (Fig. 1). In simulation, short-circuit was modeled with a null impedance (phase 1 impedance).

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Switch $K_1$ is closed, and after a second it opens. The electric diagram implemented in simulation is presented in Fig. 1. Simulation results are presented in Fig. 2-4.

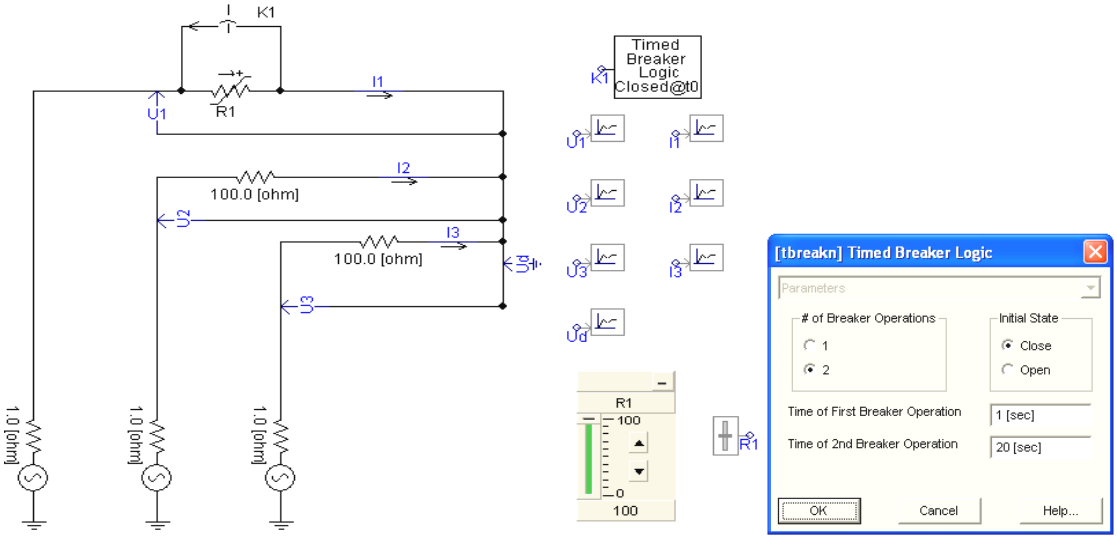



Figure 1. Electric diagram implemented in simulation. Switch $K_1$ configuration.

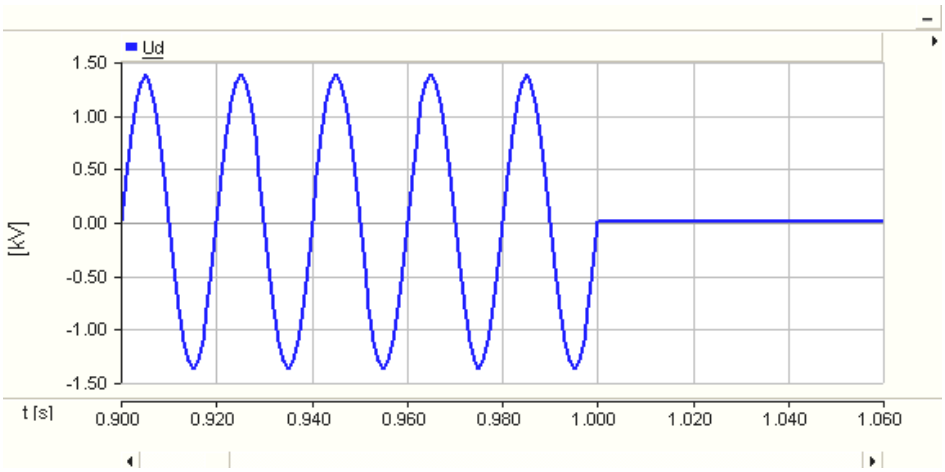



Figure 2. Simulation results. Neutral point displacement voltage.

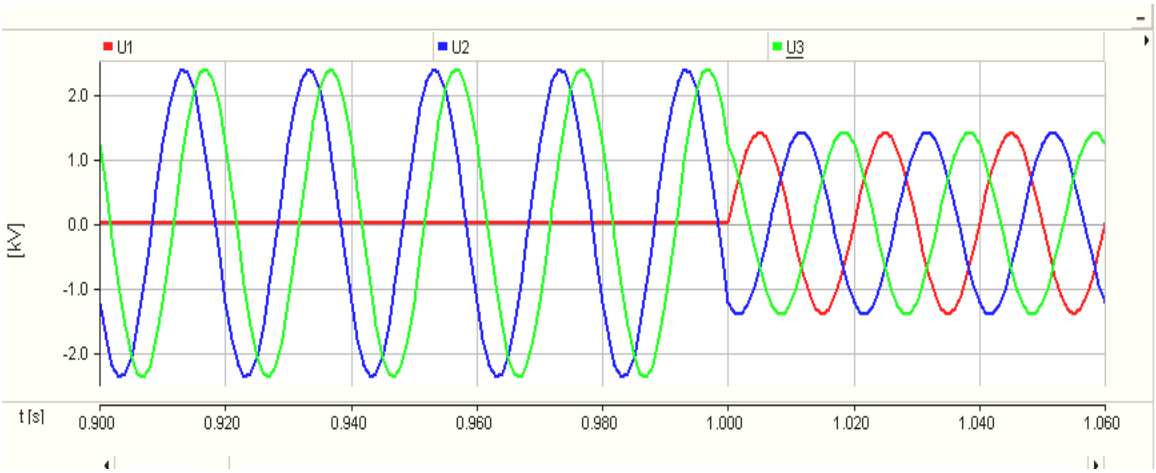



Figure 3. Simulation results. Voltages on receptor's phases.

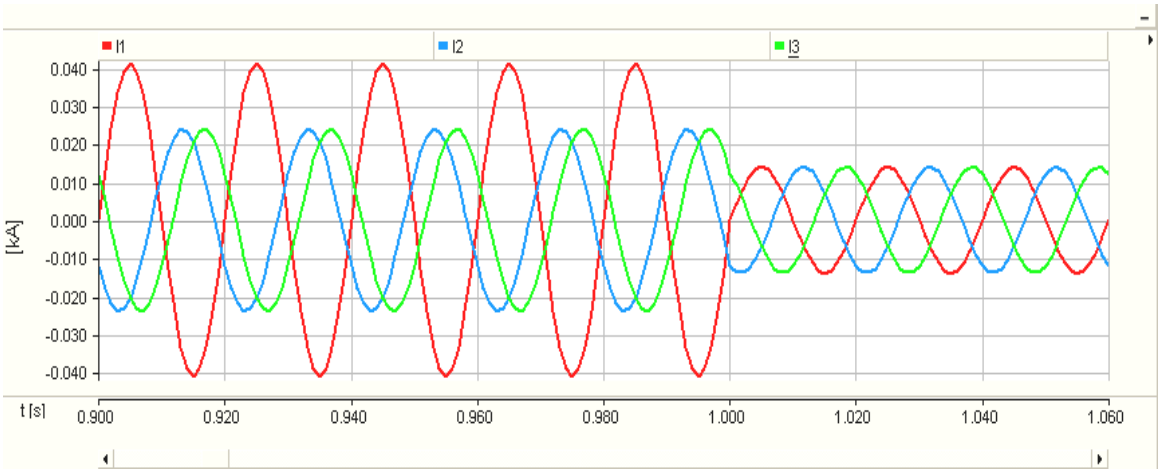



Figure 4. Simulation results. Currents absorbed from the grid.

It is found that voltages on phases 2 and 3 increase by $\sqrt{3}$ times during short-circuit of phase 1. As consequence, currents $I_2$ and $I_3$ increase (by $\sqrt{3}$ times) compared to rated currents. This currents are equal (as rms value) and dephased by $\pi/6$ radian. Short-circuit current $I_1$ increase very much (by 2,8 times) compared to rated current.

After 1 second, switch $K_1$ opens and the regime becomes symmetric (the receptor is balanced, and the supply voltage system is symmetric).

### 2.2 Interruption of a phase

Is admitted an interruption of phase 1 into a circuit where the three-phase receptor has the same impedances on phases, and the voltage system is symmetric. Interruptions on phases 1 were modeled with a static and infinite impedance.

Initially the switch $K_1$ is open and after a second switch $K_1$ closes. The electric diagram implemented in simulation is presented in Fig. 5. Simulation results are presented in Fig. 6 (voltages on receptor's phases and currents absorbed from the grid).

It is found that the voltage on the interrupted phase increases (by 1,5 times), and the voltages on other phases decrease (by $\sqrt{3}/2$ times) compared to rated voltages.

After 1 second the regime becomes symmetric because switch $K_1$ closes (the receptor is balanced, and the supply voltage system is symmetric).

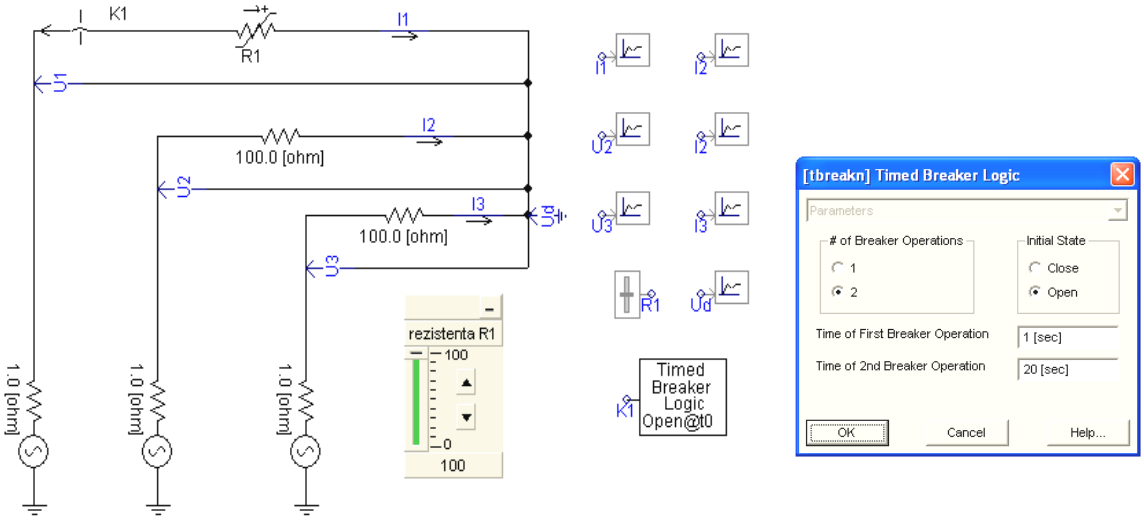



Figure 5. Electric diagram implemented in simulation. Switch $K_1$ configuration

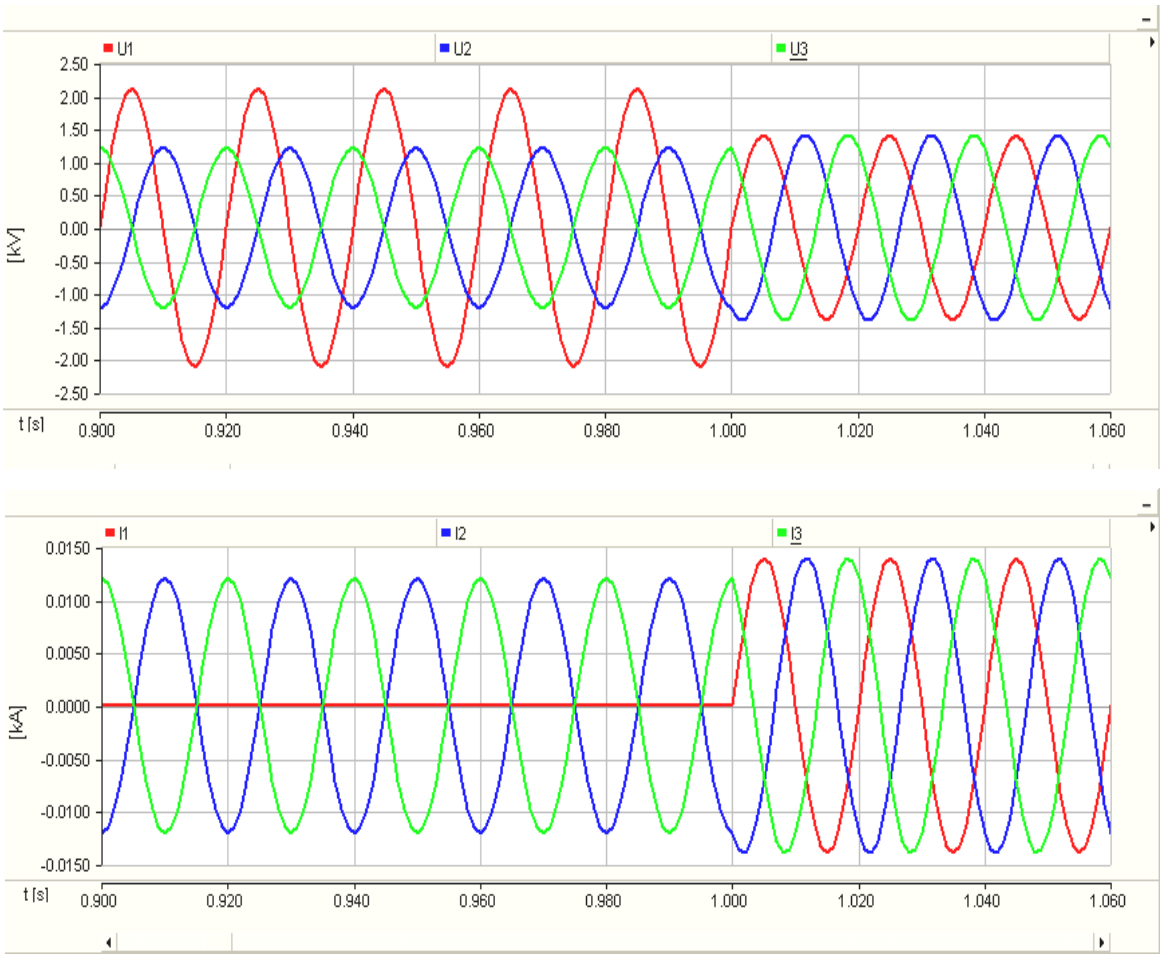



Figure 6. Voltages on receptor's phases and currents absorbed from the grid.

### 2.3 Short-circuit on phase 1 and interrupting phases 2 and 3

Interruptions on phases 2 and 3 were modeled with static and infinite impedances, and short-circuit on phase 1 was modeled with a null impedance.

During the first two seconds switch K1 is closed, and switches $K_2$ and $K_3$ are open. After 2 seconds, switch $K_1$ opens, and the other switches are closing. The electric diagram implemented in simulation is presented in Fig. 7, and simulation results are presented in Fig. 8, 9.

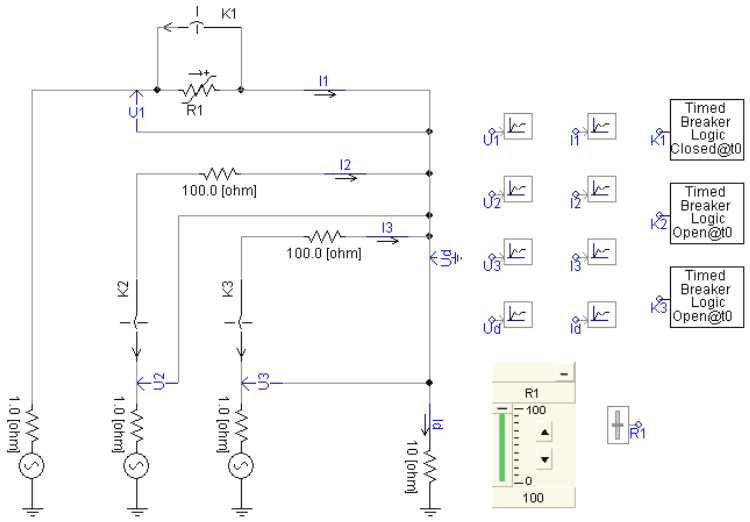



Figure 7. Electric diagram implemented in simulation.

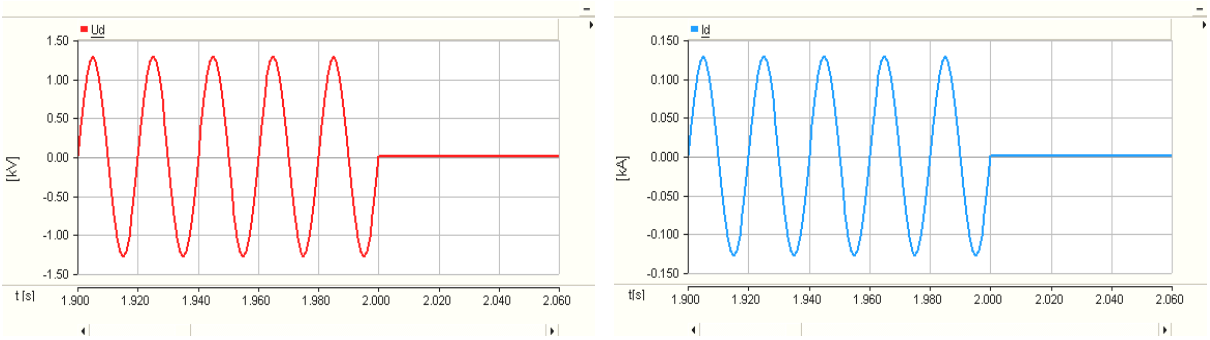



Figure 8. Neutral point displacement voltage and the neutral conductor current.

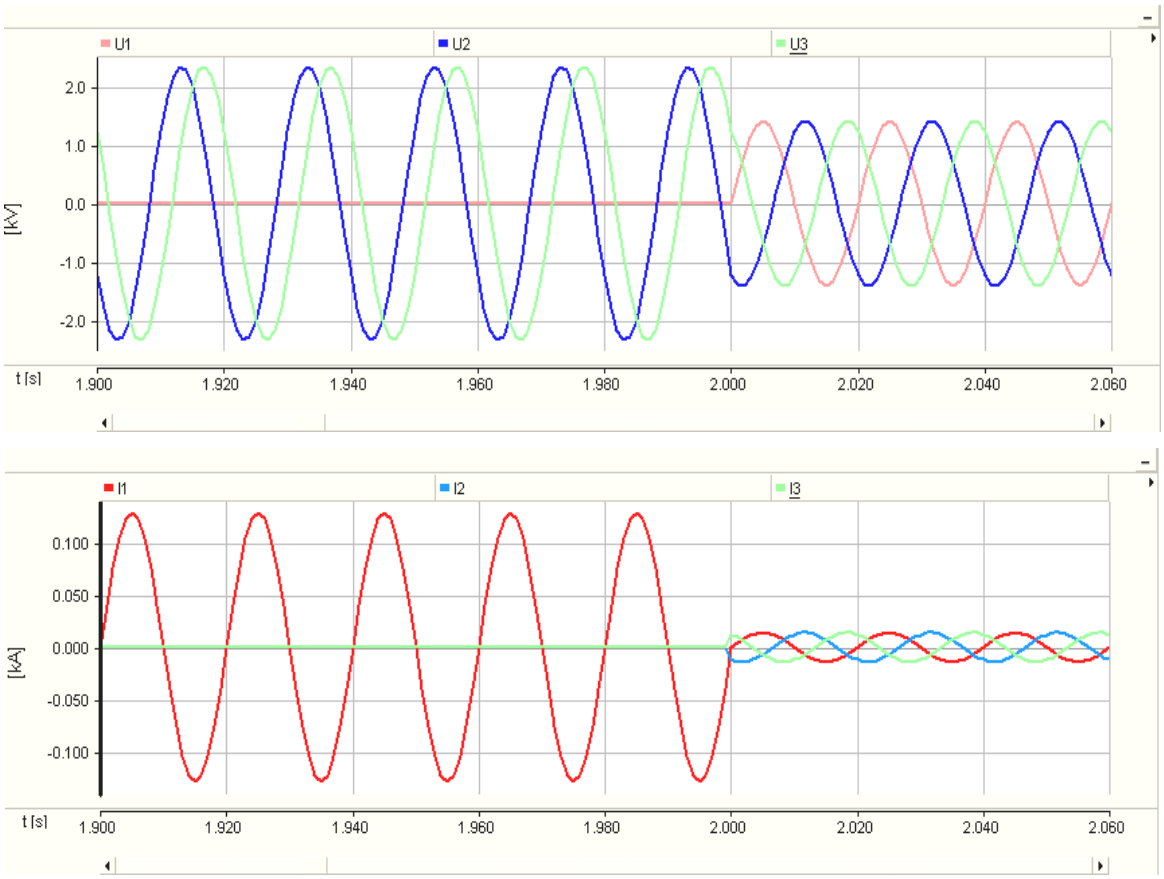



Figure 9. Voltages on receptor's phases and currents absorbed from the grid.

During the fault, the voltages on phases 2 and 3 increase (by $\sqrt{3}$ times). Current $I_1$ is very high (increases by 21 times compared to rated current), and currents $I_2$ and $I_3$ are null. After two seconds, when switch $K_1$ closes, and switches $K_2$ and $K_3$ open, the regime becomes symmetric.

### 2.4 Short-circuit in two phases and interrupting one phase

Is considered short-circuit in phases 2 and 3 (without earth) and phase 1 interrupted. Short-circuits were modeled with null impedances, and interruption on phase 1 was modeled with a static and infinite impedance.

During the first two seconds, switches $K_2$ and $K_3$ are closed, and switch $K_1$ is open. After this period, switches $K_2$ and $K_3$ open, and switch $K_1$ closes. The electric diagram implemented in simulation is presented in Fig. 10, and simulation results are presented in Fig. 11-13.

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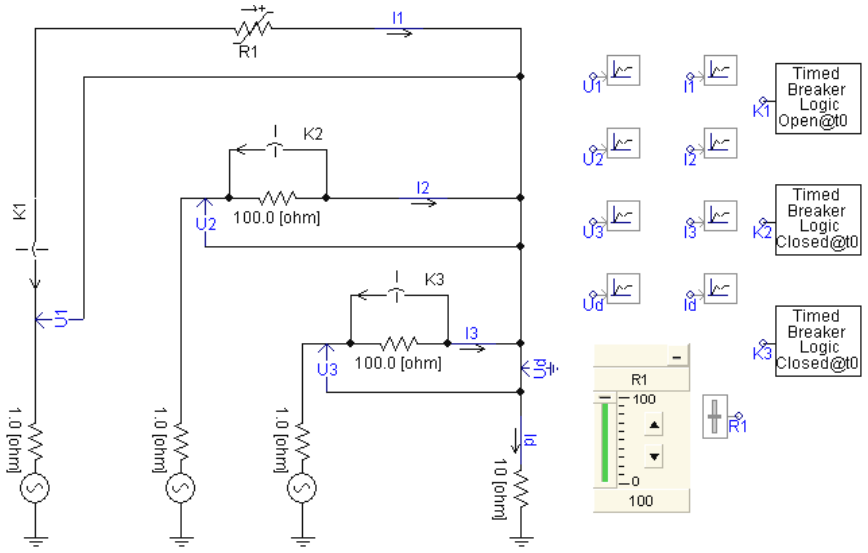



Figure 10. Electric diagram implemented in simulation.

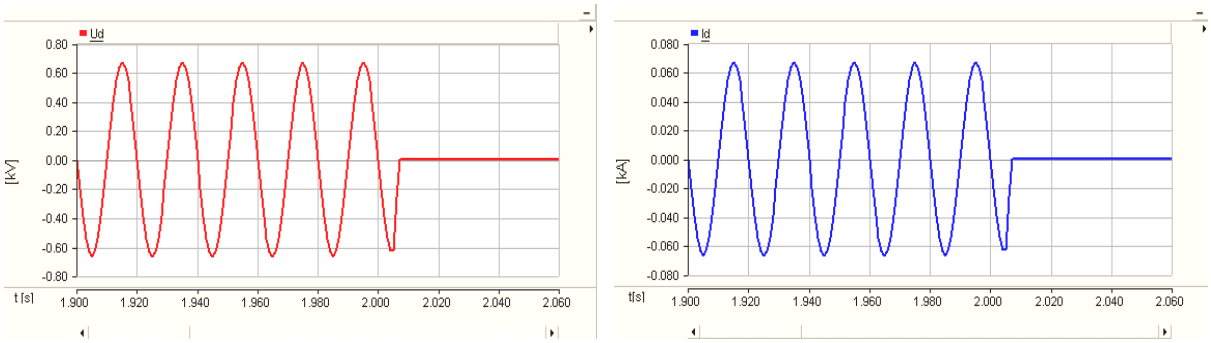



Figure 11. Neutral point displacement voltage and the neutral conductor current.

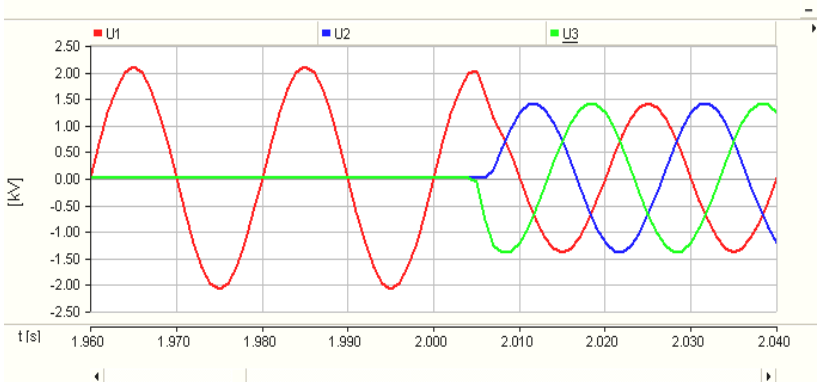



Figure 12. Voltages on receptor's phases.

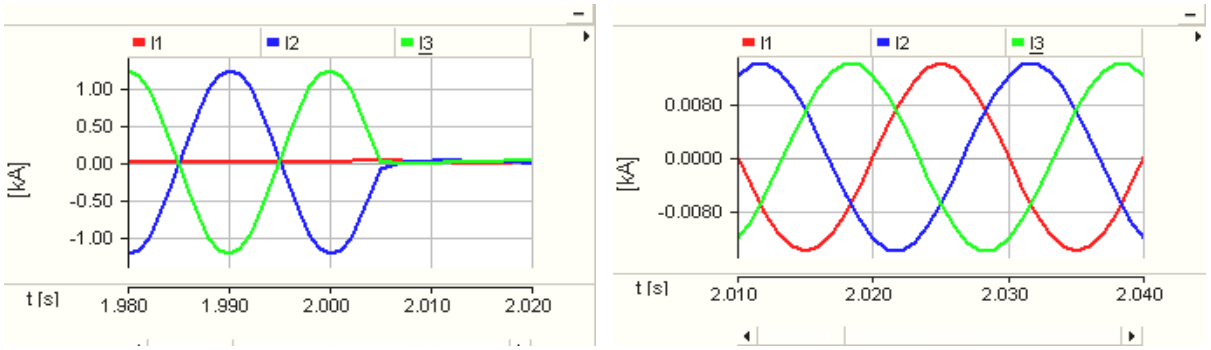



Figure 13. Currents absorbed from the grid.

During the fault the unbalance of system is very pronounced. Phase 1 voltage increases by 1,5 times compared to rated voltage. Current $I_1$ is null, but currents $I_2$ and $I_3$ are very high (increase by 80 times compared to rated currents) and in opposition on phase.

After 2 seconds, switch $K_1$ closes and switches $K_2$ and $K_3$ open. As consequence, the regime becomes symmetric.

## 3. CONCLUSIONS

Studying faults and abnormal operation regimes in three-phase electric systems has a special practical importance, because these operation regimes produce malfunctions or even failures of the electric installation, if they are not removed on time. Also, the study of faults and abnormal operation regimes are necessary for protection relay coordination.

In this work are analyzed few faults of three-phase electric systems by means of the PSCAD-EMTDC program.

PSCAD is a fast, accurate and easy-to-use simulator, being a very useful tool for analysis of asymmetrical faults.

A full library of advanced components allows to precisely modeling interactions between electrical networks and loads in various configurations. Users can easily interact with the components during the simulation because of the variety of control tools. The solution meters and the plotting traces are also visible and available during the simulation. Signals can be analyzed in real time.

The time steps interpolation technique combines accuracy and quickness; it allows the simulation to precisely represent the commutations of breakers and switches in the electrical model, for any model's size, up to extremely large models.

Fault analysis with PSCAD can be use for improving the system's performance and reliability.

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# EXPERMINETAL RESEARCH FOR IDENTIFYING INDUSTRIAL PROCESSES BY STATISTICAL METHODS

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**Abstract**:
This paper work refers to the results of an identification of the clinker furnace, by using statistic methods. We have obtained a mathematical model who describes the processes inside the furnace very accurately (more than 90%). Due to their complexity, the analytical shaping-up is impossible.
**Keywords**:
identification, clinker furnace, statistics, software.

## 1. INTRODUCTION

The analytical identification of the process during the fabrication of the concrete is difficult because this process is highly complex and they have helped us obtain some accurate mathematical methods who allow an effective conventional management.

According to the current evolution of the calculation techniques and of the process' management principles, the experimental identification based on statistic data is an alternative we should consider.

The most usual methods are the system, the linear, and the discrete models who enclose the effect of the random disturbance, such as in Figure no.1 [1].

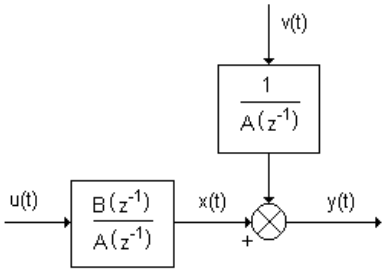



Figure no. 1

Synthetically speaking, z(t) is uptaken to this process (the parameter is the discreet time t). Because y(t) contains some noise (in addition), it is considered as such (it encloses a determination element x(t)). The statistic features of the output we have measured - y(t) - are determined by the statistic features of the noise z(t), or v(t), according to Figure no. 4.1. Due to the fact that the identification experiment does not use – for economic and engineering reasons – all the accomplishment of the noise, and/or either of the y(t) output, it does not acknowledge the identification methods of the output, because they need some statistic properties (hypothesis) which help them identify the PFD pattern. This is not possible after only one significant experiment (for off-line identification methods) or after continuous process, but they have the same properties (for on-line identification methods).

## 2. PROCESS PATTERN

This process is described in Figure no. 2.

The reason of this experimental identification is represented by the pattern of the operator controlled-segment [2], [3], and [4].

The process inside the furnace is steady, but the relation between the cooling grating and the furnace causes some vacillations of the temperature (heat) inside the furnace. The only way to eliminate this is to keep up a constant temperature of the combustion gas, by adjusting the energy flow. Therefore, the temperature of the combustion gas could be considered a process output variable.

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Besides that, one of the outputs should enclose information about the quality of the clinker. Because the quality of the clinker is measured (off-line) after the material gets out of the furnace, after a thorough analysis (for practical purposes) - after two hours -, it is difficult to use a quality control of the material. We have found out that the force of the motor that makes the furnace work is correlated to the temperature of the combustion area and the quality of the clinker. We could consider it is a second output for the process pattern we are about to identify.

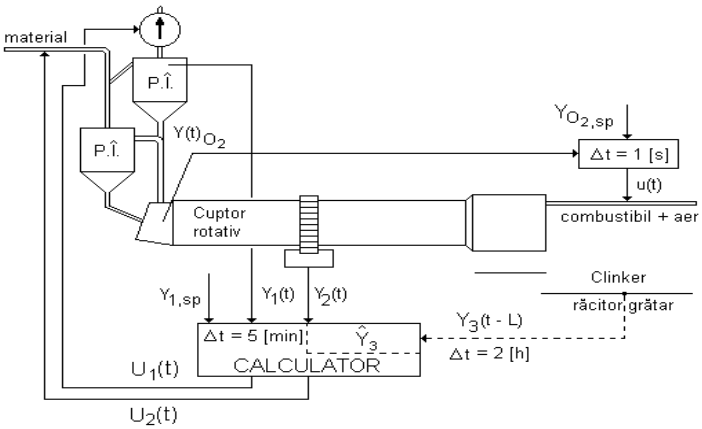



Figure no. 2

An important effect of the temperature transfer and of the chemical reactions inside the furnace is the combustible matter flow. This is the first control variable. The material flow is the second control variable.

Table 1

**DATA MEASURED AND CALCULATED**

| Speed oven nc [rot/min] | Engine speed nm [rot/min] | Computed Measuring torque M [kNm] | motor m [%] | Temperature measured Y1 | Power calculated Y2 | Fuel flow X1 | Material flow X2 | Y1 centered yc1 | Y2 centered yc2 | X1 centered xc1 | X2 centered xc2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,7 | 626,316 | 17671,5 | 45 | 355 | 269,432773 | 14 | 210 | 7,458 | 31,78077 | 0,4625 | -18,333 |
| 1,8 | 663,158 | 16493,4 | 42 | 350 | 237,5 | 13,75 | 225 | 2,458 | -0,152 | 0,2125 | -3,333 |
| 1,8 | 663,158 | 17278,8 | 44 | 347 | 248,809524 | 13,5 | 225 | -0,542 | 11,15752 | -0,0375 | -3,333 |
| 1,8 | 663,158 | 17278,8 | 44 | 347 | 248,809524 | 13,5 | 225 | -0,542 | 11,15752 | -0,0375 | -3,333 |
| 1,8 | 663,158 | 17278,8 | 44 | 347 | 248,809524 | 13,5 | 225 | -0,542 | 11,15752 | -0,0375 | -3,333 |
| 1,8 | 663,158 | 16100,7 | 41 | 347 | 231,845238 | 13,5 | 230 | -0,542 | -5,80676 | -0,0375 | 1,667 |
| 1,8 | 663,158 | 14529,9 | 37 | 350 | 209,22619 | 13,75 | 230 | 2,458 | -28,4258 | 0,2125 | 1,667 |
| 1,8 | 663,158 | 15708 | 40 | 347 | 226,190476 | 13,5 | 230 | -0,542 | -11,4615 | -0,0375 | 1,667 |
| 1,8 | 663,158 | 16100,7 | 41 | 347 | 231,845238 | 13,5 | 230 | -0,542 | -5,80676 | -0,0375 | 1,667 |
| 1,8 | 663,158 | 15708 | 40 | 347 | 226,190476 | 13,5 | 230 | -0,542 | -11,4615 | -0,0375 | 1,667 |
| 1,8 | 663,158 | 15708 | 40 | 347 | 226,190476 | 13,5 | 230 | -0,542 | -11,4615 | -0,0375 | 1,667 |
| 1,8 | 663,158 | 15708 | 40 | 347 | 226,190476 | 13,5 | 230 | -0,542 | -11,4615 | -0,0375 | 1,667 |
| 1,8 | 663,158 | 15708 | 40 | 348 | 226,190476 | 13,6 | 230 | 0,458 | -11,4615 | 0,0625 | 1,667 |
| 1,8 | 663,158 | 15708 | 40 | 348 | 226,190476 | 13,6 | 230 | 0,458 | -11,4615 | 0,0625 | 1,667 |
| 1,8 | 663,158 | 16100,7 | 41 | 348 | 231,845238 | 13,6 | 230 | 0,458 | -5,80676 | 0,0625 | 1,667 |
| 1,8 | 663,158 | 15315,3 | 39 | 349 | 220,535714 | 13,7 | 230 | 1,458 | -17,1163 | 0,1625 | 1,667 |
| 1,8 | 663,158 | 16100,7 | 41 | 347 | 231,845238 | 13,5 | 230 | -0,542 | -5,80676 | -0,0375 | 1,667 |
| 1,8 | 663,158 | 16493,4 | 42 | 347 | 237,5 | 13,5 | 230 | -0,542 | -0,152 | -0,0375 | 1,667 |
| 1,8 | 663,158 | 17671,5 | 45 | 346 | 254,464286 | 13,4 | 230 | -1,542 | 16,81229 | -0,1375 | 1,667 |
| 1,8 | 663,158 | 17671,5 | 45 | 345 | 254,464286 | 13,3 | 230 | -2,542 | 16,81229 | -0,2375 | 1,667 |
| 1,8 | 663,158 | 18064,2 | 46 | 345 | 260,119048 | 13,3 | 230 | -2,542 | 22,46705 | -0,2375 | 1,667 |
| 1,8 | 663,158 | 17671,5 | 45 | 345 | 254,464286 | 13,3 | 230 | -2,542 | 16,81229 | -0,2375 | 1,667 |
| 1,8 | 663,158 | 16493,4 | 42 | 348 | 237,5 | 13,6 | 230 | 0,458 | -0,152 | 0,0625 | 1,667 |
| 1,8 | 663,158 | 16493,4 | 42 | 347 | 237,5 | 13,5 | 230 | -0,542 | -0,152 | -0,0375 | 1,667 |
| Arithmetic average | | | | 347,5417 | 237,6525 | 13,5375 | 228,3333 | | | | |

There are other possible variables, but the first two are the most important and the identification process sticks to them.

We have measured it every 5 minutes and we have found out 24 values of the following elements (Table no. 1):

- combustion gas temperature- $Y_1(t)$, in [°C];
- the coupling to the motor shaft - m [%] – is used for calculating the training force - $Y_2(t)$.

All the values are written in percentage of the nominal coupling;

- the revolution of the furnace - $n_c$, in [rot/min] – is used for calculating the training force;
- the combustible matter flow - $X_1(t)$, in [$m^3$/h];
- the material flow - $X_2(t)$, in [t/h].

## 3. THE PROPER SHAPING UP

The proper shaping-up has been performed according to the CMP criterion – using two retrogressive methods – linear and non-linear II-type.

a) *Linear retrogressive*

If we use a linear subordination of the output size, according to the input sizes, we have :

$$Y_1 = A_{11}X_1 + A_{12}X_2 + B_1 , \quad (1)$$

$$Y_2 = A_{21}X_1 + A_{22}X_2 + B_2 . \quad (2)$$

where:

$$X = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} X_{1,1} X_{1,2} \dots X_{1,24} \\ X_{2,1} X_{2,2} \dots X_{2,24} \end{bmatrix}; Y = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} Y_{1,1} Y_{1,2} \dots Y_{1,24} \\ Y_{2,1} Y_{2,2} \dots Y_{2,24} \end{bmatrix} \quad (3)$$

Input data Output data

The mathematical pattern is the following:

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} B_1 \\ B_2 \end{bmatrix} \quad (4)$$

By using the method of the smallest squares, the constant values are:

- for output size $Y_1(t)$:

$A_{11} = 11,04$ $A_{12} = -0,1055$ $B_1 = 222,2$

The precision indicator of the regress pattern is: $R^2 = 0,9866$

- for input size $Y_2(t)$:

$A_{21} = -85,92$ $A_{22} = -3,784$ $B_2 = 2265$

The precision indicator of the regress pattern is: $R^2 = 0,8266$

Thus, the pattern is:

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} 11.04 & -0.1055 \\ -85.92 & -3.784 \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 222.2 \\ 2265 \end{bmatrix} \quad (5)$$

b) *II- degree polynomial regress*

If we use a II-type non-linear subordination of the output size, according to the input sizes, we have:

$$Y_1 = C_{11}X_1 + C_{12}X_2 + C_{13}X_1^2 + C_{14}X_2^2 + C_{15}X_1X_2 + C_{10} \quad (6)$$

$$Y_2 = C_{21}X_1 + C_{22}X_2 + C_{23}X_1^2 + C_{24}X_2^2 + C_{25}X_1X_2 + C_{20} \quad (7)$$

The mathematical pattern is:

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} C_{13} C_{14} C_{15} \\ C_{21} & C_{22} C_{23} C_{24} C_{25} \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ X_2 \\ X_1^2 \\ X_2^2 \\ X_1X_2 \end{bmatrix} + \begin{bmatrix} C_{10} \\ C_{20} \end{bmatrix} \quad (8)$$

By using the method of the smallest squares the constant values are:

- for output size $Y_1(t)$:

$C_{11} = -27,36$ ; $C_{12} = 1,628$ ; $C_{13} = 2,8$ ; $C_{14} = 0,001288$ ;

$C_{15} = -0,1642$ ; $C_{10} = 273,6$

The precision indicator of the regress is: $R^2 = 0,9988$

- for output size $Y_2(t)$:

$C_{21} = -298$ ; $C_{22} = 170,9$ ; $C_{23} = 62,97$ ; $C_{24} = -0,1891$ ; $C_{25} = -6,506$ ; $C_{20} = -16317$

The precision indicator of the regress is: $R^2 = 0,8576$

Thus, the pattern is:

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} -27.36 & 1.628\ 2.78\ 0.001288 & -0.1642 \\ -298 & 170\ .962\ .97 & -0.1891\ -6.506 \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ X_2 \\ X_1^2 \\ X_2^2 \\ X_1X_2 \end{bmatrix} + \begin{bmatrix} 273\ .6 \\ -16317 \end{bmatrix} \quad (9)$$

In order to make the calculations we have used the Matlab for Windows software, which allows us:

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- to see the graphics of the sizes, according to two methods : PLOT and BAR;
- to estimate the process by the method of the smallest squares, using two regress patterns : linear and non-linear II-type regress;
- to use the data by two methods: interpolar cubic shift, where the insertion steps are: 1, 0.5, 0.4, 0.3, 0.2, 0.1 şi 0.05, and the insertion based on the Fourier fast transformation method is valid for 30, 60, 90, 120, 150, 180 and 200 insertion points. We can see the insertion curves on the monitor.

The main software is called « ie.m » and is able to perform a graphic interface with buttons – selected optionally; we could use the calculation methods of the above mentioned functions.

Figure no. 3 and 4 refer to the results of the shaping-up by two methods. The continuous line describe the data we have measured, meanwhile the dotted line refers to the determined methods.

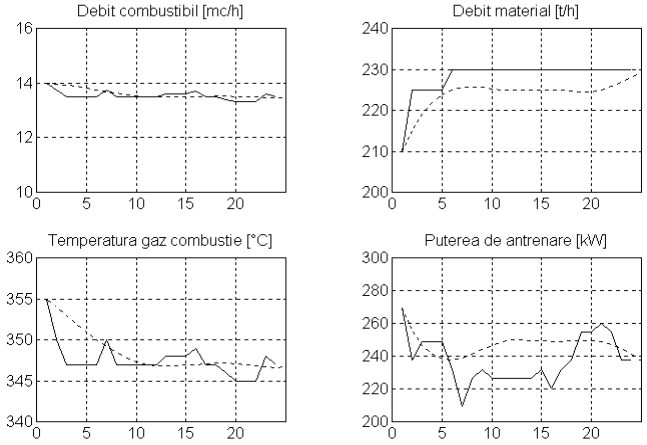



Figure no. 3 Cubic shift insertion of 0.2 step

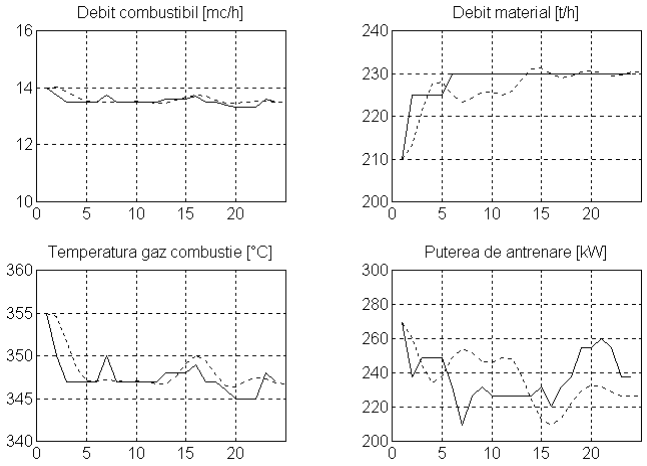



Figure no. 4 60-points FFT insertion

## 5. CONCLUSIONS

This paperwork describes the mathematical method based on statistic methods for a clinker furnace. The accuracy of the model is very high, as far as the statistic indicators have proved it. This method is relatively simple and it has been used in experiments. We have come up with the MATLAB calculation software, but we are not able to describe them in this paperwork for space reasons.

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# AUTOMATIC DETERMINATION OF THE MINERAL COMPOSITION OF THE PORTLAND CEMENT CLINKER

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**Abstract**:
This paperwork points out software for the automatic determination of the mineral composition of the cement clinker. Although they have rather similar oxide composition, the mineral structure may be rather different and it influences the quality of the cement. Therefore, the software we suggest allows the fast determination of the mineral composition and any method of improvement, according to the required properties of the Portland cement.

**Keywords**:
cement, mineral composition, clinker, software.

## 1. INTRODUCTION

According to the balance diagrams [1], we are able to calculate the basic composition of the clinkers. This calculation is possible if the cement turns solid in case of both termic-dynamic and non termic-dynamic balance.

In case of the complete balance solid state, the product does not turn glassy. In fact, there is no termic-dynamic balance in case of the solid state, and if we consider that possibility, the mineral composition we calculate according to that hypothesis is a potential composition – it is possible only if the chemical composition is not equal to the real mineral composition (of those minerals that make up the composition).

a) Presuming that the clinkers are situated in the termical balance sub-system $C_3S$-$C_2S$-$C_3A$-$C_4AF$ ($M_{Al} > 0,64$), Bogue has determined that we could calculate the mineral elements according to the following formula:

$$\begin{aligned} \%C_4AF &= 3,04\%Fe_2O_3 \\ \%C_3A &= 2,65\%Al_2O_3 - 1,69\%Fe_2O_3 \\ \%C_3S &= 4,07\%CaO - 7,60\%SiO_2 - 6,72\%Al_2O_3 - 1,42\%Fe_2O_3 \\ \%C_2S &= 8,60\%SiO_2 + 5,06\%Al_2O_3 + 1,07\%Fe_2O_3 - 3,05\%CaO \end{aligned} \quad (1)$$

b) For the clinkers in the termic balance sub-system $C_3S$-$C_2A$-$C_4AF$-$C_2F$ ($M_{Al} < 0,64$), the result is based on Bogue's analogical argument. Thus:

$$\begin{aligned} \%C_4AF &= 4,76\%Al_2O_3 \\ \%C_2F &= 1,70\%Fe_2O_3 - 2,65\%Al_2O_3 \\ \%C_3S &= 4,07\%CaO - 7,60\%SiO_2 - 4,48\%Al_2O_3 - 2,84\%Fe_2O_3 \\ \%C_2S &= 8,60\%SiO_2 + 3,36\%Al_2O_3 + 2,14\%Fe_2O_3 - 3,05\%CaO \end{aligned} \quad (2)$$

c) For the intermediary case of the clinkers belonging to the $C_3S$-$C_2A$- -$C_4AF$ ($M_{Al}$= 0,64), we have:

$$\begin{aligned} \%C_4AF &= 3,04\%Fe_2O_3 \\ \%C_3S &= 4,07\%CaO - 7,60\%SiO_2 - 5,70\%Fe_2O_3 \\ \%C_2S &= 8,60\%SiO_2 - 4,30\%Fe_2O_3 - 3,05\%CaO \end{aligned} \quad (3)$$

The relations according to Bogue are particular and they use some coefficients specific to the termical balance sub-systems:

$$\begin{aligned} &C_3S\text{-}C_2S\text{-}C_3A\text{-}C_4AF \text{ with } M_{Al} > 0,64 \\ &C_3S\text{ -}C_2A\text{-}C_4AF\text{- }C_2F \text{ with } M_{Al} < 0,64 \end{aligned} \quad (4)$$

$C_3S$ -$C_2A$-$C_4AF$ with $M_{Al}$ = 0,64

These relations are not valid for other termic balance sub-systems. Considering all these facts, we have come up with software who determines the composition for each stage of the clinker, for both mineral composition of the dust and the termic balance sub-system. We made the software by generalizing the following example which was based on the weight survey. We are going to describe it in the following.

## 2. THE SO-CALLED SOFTWARE

```
software CompClincher;
uses Crt, Graph, UApp;
const Mc = 56; Ma =102; Ms =60; Mf =160;
Var
  CaO, Al2O3, SiO2,Fe2O3 :  Real;
  SCaO, SAl2O3, SSiO2, SFe2O3 :  String;
  Paragenesis : String;
  M :array[1..4] of real; N:array[1..4,1..4] of Byte ; X:array[1..4] of real;
  B:array[1..4] of real; A:array[1..4,1..4] of real;

procedure Init;
 begin
   Title('Determination of the portland cement clinker for each stage');
   DefineBtn(  0,  10,  55, 620, 393, 0, 0, '', '', Off);
   { define the main menue buttons }
   DefineBtn( 10,  10,  26,  60,  19,  2,  1, 'Info',
    'General information about the software', Off);
   DefineBtn( 11,  75,  26,  60,  19,  2,  1, 'Calculation',
    'Determination of the stage composition ', Off);
   DefineBtn( 12, 570,  26,  60,  19,  2,  5, 'Exit',
    'Stop the software', Off);
   SCaO:='';
   DefineInp(1,100,100,320,30,50,'% CaO ',SCaO);
   SAl2O3:='';
   DefineInp(2,100,130,320,30,50,'% Al2O3 ',SAl2O3);
   SSiO2:='';
   DefineInp(3,100,160,320,30,50,'% SiO2 ',SSiO2);
   SFe2O3:='';
   DefineInp(4,100,190,320,30,50,'% Fe2O3 ',SFe2O3);
   Paragenesis:='';
   DefineInp(5,100,220,320,30,200,'Paregenesis ',Paragenesis);
 end;

procedure Info;
 begin
 end;

procedure Calculation;
Var I,J,K,L: Integer; S:String[10]; Code,MM,Poz :Integer; T:Real;
    Sform: array[1..4] of  string[15]; SS:string; Sf: array[1..4] of  string[15];
begin
   Drawinp(1); Drawinp(2); Drawinp(3); Drawinp(4); Drawinp(5);
   Inp(1); Inp(2); Inp(3); Inp(4); Inp(5);
   Val(SCaO,CaO,Code); Val(SAl2O3, Al2O3,Code); Val(SSiO2,SiO2,Code); Val(SFe2O3,Fe2O3,Code);
   for i:=1 to 4  do
    for j:=1 to 4 do
      N[i,j]:=0;
   Insert('-',Paragenesis,length(Paragenesis)+1);
   K:=1;
   for i:=1 to 4 do
    begin
        while (Paragenesis[k]<>'-')  do
        begin
         if Paragenesis[k]='C' then
           begin
            Inc(k);
            if (Paragenesis[k]>='A') and (Paragenesis[k]<='S') or (Paragenesis[k]='-') then
              N[i,1]:=1
             else
              begin
               if (Paragenesis[k+1]>='0') and (Paragenesis[k+1]<='9') then
                 begin
                   S:=Copy(Paragenesis,k,2); Inc(K);
                 end
                 else
```

```
                S:=Copy(Paragenesis,k,1);
              Val(S,N[i,1],Code);
              Inc(K);
            end;
          end;
        if Paragenesis[k]='A' then
         begin
          Inc(k);
          if (Paragenesis[k]>='A') and (Paragenesis[k]<='S') or (Paragenesis[k]='-') then
            N[i,2]:=1
          else
           begin
            if (Paragenesis[k+1]>='0') and (Paragenesis[k+1]<='9') then
             begin
               S:=Copy(Paragenesis,k,2); Inc(K);
             end
             else
               S:=Copy(Paragenesis,k,1);
            Val(S,N[i,2],Code);
            Inc(K);
           end;
          end;
         if Paragenesis[k]='S' then
         begin
          Inc(k);
          if (Paragenesis[k]>='A') and (Paragenesis[k]<='S') or (Paragenesis[k]='-') then
            N[i,3]:=1
          else
           begin
            if (Paragenesis[k+1]>='0') and (Paragenesis[k+1]<='9') then
             begin
               S:=Copy(Paragenesis,k,2); Inc(K);
             end
             else
               S:=Copy(Paragenesis,k,1);
            Val(S,N[i,3],Code);
            Inc(K);
           end;
          end;
    if Paragenesis[k]='F' then
         begin
          Inc(k);
          if (Paragenesis[k]>='A') and (Paragenesis[k]<='S') or (Paragenesis[k]='-') then
            N[i,4]:=1
          else
           begin
            if (Paragenesis[k+1]>='0') and (Paragenesis[k+1]<='9') then
             begin
               S:=Copy(Paragenesis,k,2); Inc(K);
             end
             else
               S:=Copy(Paragenesis,k,1);
            Val(S,N[i,4],Code);
            Inc(K);
           end;
          end;
        end;
        Inc(k);
  end;
 for I:=1 to 4 do
    M[I]:=N[I,1]*Mc+N[I,2]*Ma+N[I,3]*Ms+N[I,4]*Mf;
 B[1]:= CaO/Mc;
 B[2]:= Al2O3/Ma;
 B[3]:= SiO2 /Ms;
 B[4]:= Fe2O3 /Mf;
 for I:=1 to 4 do
     begin
       A[i,1]:=N[1,i]/M[1]; A[i,2]:=N[2,i]/M[2]; A[i,3]:=N[3,i]/M[3]; A[i,4]:=N[4,i]/M[4];
     end;
Mm:=4;
 for k:=1 to mm do
 begin
  if a[k,k]=0 then
   begin
    j:=k+1;
    while (j<=mm) and ( a[j,k]=0) do j:=j+1;
    if j<=mm then
```

```
      begin
       for l:=k to mm do
       begin
         t:=a[k,l]; a[k,l]:=a[j,l]; a[j,l]:=t;
       end;
       t:=b[k];
       b[k]:=b[j];
       b[j]:=t;
      end
      else
       begin
       Outtextxy(100,500,'The system cannot be solved by Gauss' method');
       Halt;
      end;
    end;
    for i:=k+1 to mm do
     begin
       for j:=k+1 to  mm do
       a[i,j]:=a[i,j]- a[k,j]*a[i,k]/a[k,k]; b[i]:=b[i]-b[k]*a[i,k]/a[k,k];
     end;
  end;
  x[mm]:=b[mm]/a[mm,mm];
  for k:=mm-1 downto 1 do
   begin
    t:=0;
    for j:=k+1 to mm do t:=t+a[k,j]*x[j] ;
    x[k]:=(b[k]-t) /a[k,k];
   end;
  j:=0;
  k:=1;
  poz:=1;
  for i:=1 to length(Paragenesis) do
    if Paragenesis[i] <>'-' then   Inc(j)
     else
       begin
        Sform[k]:=copy(Paragenesis,poz,j);
        poz:=i+1;
        Inc(K);
        j:=0;
       end;
  Str(x[1]:6:3,Sf[1]);
  Str(x[2]:6:3,Sf[2]);
  Str(x[3]:6:3,Sf[3]);
  Str(x[4]:6:3,Sf[4]);
  SS:='';
  DefineInp(10,90,260,350,30,0,'The stage composition of the clinker is:',SS);
  DrawInp(10);
  SS:=SF[1];
  DefineInp(6,100,300,320,30,100,'% '+Sform[1]+'  ',SS);
  DrawInp(6);
  SS:=SF[2];
  DefineInp(7,100,330,320,30,100,'% '+Sform[2]+'  ',SS);
  DrawInp(7);
  SS:=SF[3];
  DefineInp(8,100,360,320,30,100,'% '+Sform[3]+'  ',SS);
  DrawInp(8);
  SS:=SF[4];
  DefineInp(9,100,390,320,30,100,'% '+Sform[4]+'  ',SS);
  DrawInp(9);
  WaitEsc;
end;

procedure Run;
  begin
    { Start main menu }
    MainSel := 10;
    repeat
      ClearClient;
      HMenu(10, 12, MainSel);
      case MainSel of
        10: Info;
        11: Calculation;
      end;
    until MainSel = 12;
  end;

procedure Done;
```

```
 begin
   EndGraph;
   DoneButtons;
 end;

begin
 Init;
 Run;
 Done;
end.
```

## 3. CALCULATION EXAMPLE

Considering a quaternary mix with the composition 66,7% CaO; 21,4% $SiO_2$; 6,9% $Al_2O_3$; 5% $Fe_2O_3$ and knowing that this mixture belongs to the paragenesis $C_3S$-$C_2S$-$C_3A$-$C_4AF$ – in case it reaches a balance – we have to establish the stage composition of the clinker.

During the crystallizing processes, the weight of the mixture is constant. When we perform the weight survey for each of the four oxides, we have:

$$\begin{cases} m_{CaO_{iniþial}} = m_{CaOdinC_3S} + m_{CaOdinC_2S} + m_{CaOdinC_3A} + m_{CaOdinC_4AF} \\ m_{SiO_{2iniþial}} = m_{SiO_2dinC_3S} + m_{SiO_2dinC_2S} \\ m_{Al_2O_{3iniþial}} = m_{Al_2O_3dinC_3A} + m_{Al_2O_3dinC_4AF} \\ m_{Fe_2O_{3iniþial}} = m_{Fe_2O_3dinC_4AF} \end{cases} \quad (5)$$

Considering that:

$$\begin{aligned} M_{C_3S} &= 3\cdot 56 + 60 = 228 \\ M_{C_2S} &= 2\cdot 56 + 60 = 172 \\ M_{C_3A} &= 3\cdot 56 + 102 = 270 \\ M_{C_4AF} &= 4\cdot 56 + 102 + 160 = 486 \end{aligned} \quad (6)$$

And that: x = $\%C_3S$; y = $\%C_2S$; z = $\%C_3A$ şi u = $\%C_4AF$, we have:

$$66{,}7 = x\frac{3\cdot 56}{228} + y\frac{2\cdot 56}{172} + z\frac{3\cdot 56}{270} + u\frac{4\cdot 56}{486}$$

$$21{,}4 = x\frac{60}{228} + y\frac{60}{172} \quad (7)$$

$$\left.\begin{aligned} 6{,}9 &= z\frac{102}{270} + u\frac{102}{486} \\ 5 &= u\frac{160}{486} \quad \Rightarrow u \end{aligned}\right\} \Rightarrow z \quad (8)$$

$$x + y + z + u = 100$$

After the calculation, we have:

$$\begin{aligned} u &= 15{,}19\ \%C_4AF \\ z &= 9{,}83\ \%C_3A \end{aligned} \quad (9)$$

If we replace the „u" and the „z" from the first equation, we have:

$$\begin{cases} x + y = 74{,}98 \\ \frac{60}{228}x + \frac{60}{172}y = 21{,}4 \end{cases}$$ and we calculate:

$$\begin{aligned} x &= 55{,}56\ \%C_3S; \\ y &= 19{,}42\ \%C_2S \end{aligned} \quad (10)$$

The software runs if we take the following steps:

**Step 1.** – *Open dialogue window* made of:

- the name of the software: "Determining the composition of the portland cement clinker for each stage";
- the menu bar with the buttons: "Info", "Calculation" şi "Exit";

- the windows for introducing the primary data: %CaO, %Al2O3, %SiO2, %Fe2O3 and Paragenesis;

**Step 2.** – *Introduce data* – with the help of the keyboard;

**Step 3.** – *Data processing* – it begins when we press the "Calculation" key, by selecting the right key from the menu bar. The algorithm is based on the example we have already discussed about, and it turns it into a general rule. Thus, it should:

a) – identify the paragenesis we have used and make another matrix N[i,j], i = 1 ... 4, j = 1 ... 4, where the coefficients of the oxides correspond to the mineral elements;

b) – calculate the molecular weight of each stage:

$$M[i] = N[i,1]*Mc + N[i,2]*Ma + N[i,3]*Ms + N[i,4]*Mf, \quad i = 1 \dots 4 \qquad (11)$$

c) – calculate the free elements (%oxide/ oxides' molecular weight) and the coefficients of the unknown quantities of the equation system:

$$B[i] = x[1]*A[i,1] + x[2]*A[i,2] + x[3]*A[i,3] + x[4]*A[i,4], \quad i = 1 \dots 4 \qquad (12)$$

where:

$$A[i,1] = N[1,i]/M[1]; \; A[i,2] = N[2,i]/M[2]; \; A[i,3] = N[3,i]/M[3]; \; A[i,4] = N[4,i]/M[4]; \qquad (13)$$

d) – solving the equation system by Gauss' method;

e) – posting the results;

**Step 4.** – *Closing the working window* by pressing the "Exit" key or introducing new data and performing a new calculation.

## 5. CONCLUSIONS

The method and the software we have discussed about in this paperwork allow us to determine the mineral composition of the Portland cement clinker faster. According to the properties of the cement we would like, we can get some useful information about the composition we need for the clinker. Therefore, we can get a finite good of a higher constant quality.

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# MODELING OF THE ENERGY ENTITIES FUNCTIONING USING THE MARKOV CHAINS METHOD

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**Abstract**:
In this paper the authors present a functioning of the energy entities modelling method using Markov chains. It is modelled the functioning of an electric supply loop for a 0.4kV voltage consumer by successive reducing of the electric supply scheme and taking into consideration the two possible states for each loop element: failure and repair rates.

**Keywords**:
Markov chains, state transition rates matrix, failure rate, repair rate

## 1. INTRODUCTION

The Markov processes represent a particular case of the stochastic processes, whose characteristically property is that they have no memory. The final states of the systems that are modelled by Markov chains are connected only with the transition probability from an *i* state (at *t* time) to a *j* state (at *t+1* time) and they have no connection with the initial state. The evolution of a Markov process is influenced only by its current state. If a Markov process has a finite number of states, then it is a Markov chain.

In energy systems field this modelling method is used only when the independence of the containing elements assumption cannot be admitted.

In this paper the behaviour of the elements is modelled by an exponential distribution function of the stochastic variable, described by the relation:

$$f(t) = \lambda \cdot e^{-\lambda t} \quad , \tag{1}$$

The probability density is given by the relation:

$$F(t) = 1 - e^{-\lambda t} \quad , \tag{2}$$

## 2. PROBLEM FORMULATION

The evolution in time of an energy entity through the various states that can appear after the failure and repairing of the containing elements can be assimilated with a continuous time Markov chain [1]. The determining of the state probabilities for a given reference period is made by solving the differential equations system, written in the following matrix form:

$$P'(t) = P(t) \times Q \quad , \tag{3}$$

where

$P(t)$ represents the state transition functions matrix at $t$ moment.

Q represents the state transition rates matrix.

The state transition functions $p_{ij}$ are the elements of the state transition functions matrix. They depend only on the difference between two moments of time and they have the properties:

$$p_{ij} \in [0,1] \quad , \tag{4}$$

$$\sum_{j=1}^{m} p_{ij} = 1 \quad , \tag{5}$$

The state transition functions are used in directly form very rarely. A continuous time Markov chain is usually characterized by the state transition rates [2, 6]. In functioning of the energy entity

modeling is using the state transition rates matrix $Q=[q_{ij}]$, $i,j=1,2....$ with the following property:

$$\sum_{j=1}^{m} q_{ij} = 0 \quad , \tag{6}$$

The Q matrix form is given by the relation:

$$Q = \begin{vmatrix} q_{11} & q_{21} & \dots & q_{n1} \\ q_{12} & q_{22} & \dots & q_{n2} \\ \dots & \dots & \dots & \dots \\ q_{1n} & q_{2n} & \dots & q_{nn} \end{vmatrix}, \tag{7}$$

The elements $q_{ij} \geq 0$ of the state transition state matrix Q indicate the probabilities that the system to pass from *i* state in *j* state, $i,j=\overline{1,n}$ ,where *n* is the number of the possible states for the studied installation. As it is shown in [1], is using the following notations for the reliability parameters in energy installations:

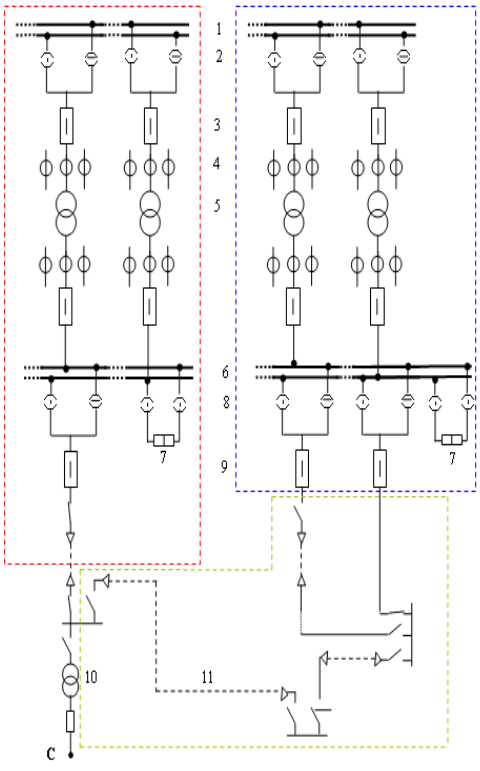
$\lambda$ [h$^{-1}$] is the failure rate of an energy entity element

$\mu$ [h$^{-1}$] is the repair rate of an energy entity element

$\nu$ [h$^{-1}$] is the replacement rate of an energy entity element.

In situation when the system passing from *i* state in *j* state is made by failure of an element with $\lambda$ failure rate, then $q_{ij}=\lambda$.

In situation when the system passing from *i* state in *j* state is made by repairing of an element with $\mu$ repair rate, then $q_{ij}=\mu$.




In situation when the system passing from *i* state in *j* state is made by repairing of an element with $\nu$ replacement rate, then $q_{ij}=\nu$.

Taking into consideration a system composed by *n* elements, each element having two possible states (failure and repairing), the total number of the possible states of the installation is $2^n$. From here is resulting that to determine the state probabilities $P_i$, $i=\overline{1,n}$ is necessary to solve an $2^n$ equations system.

If the reference time is ample $(t\to\infty)$, the (1) differential equations system becomes an algebraic equations system written in the following form:

$$P \times Q = 0 \quad , \tag{8}$$

The functioning of the electric supply scheme modelling implicates the reducing of its structure.

Fig.1. Electric supply scheme where C consumer is connected
Legend fig. 1: 1-110kV electric line, 2-110kV disconnector, 3-110kV circuit breaker, 4-110kV current transformers, 5-110/20kV power transformers, 6-20kV electric bar 7-20kV transversal couple, 8-20kV disconnector 9-20kV circuit breaker, 10-20/0,4kV power transformer 11-20kV underground cable

After successive reducing of the scheme in fig.1, the authors obtained the block diagram in fig.2. The situation is analysed taking into consideration the followings:

- the containing elements of the scheme can be failed only when the entity is functioning.
- the state with all three failed elements is not existing, because the element no.3 cannot fail if the elements no.1 and no.2 are failed, and also, the elements no.1 and no.2 cannot fail if the elements no.3 is failed.

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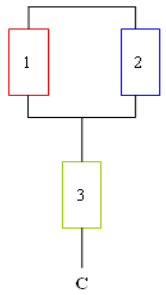



Fig.2. Block diagram obtained by reducing the electric scheme

Table 1

| Possible states | Functioning elements | Failed elements |
|---|---|---|
| 1 | 1, 2, 3 | - |
| 2 | 2, 3 | 1 |
| 3 | 1, 3 | 2 |
| 4 | 1, 2 | 3 |
| 5 | 3 | 2, 1 |
| 6 | 2 | 3, 1 |
| 7 | 1 | 2, 3 |

In table 3 are presented all possible states of the entity.

The set of a Markov chain possible states, together with the state transition state matrix Q are defining an oriented graph. The points of this oriented graph represent the system states. If the $q_{ij}$ rate is different from 0 value, then it is existing an oriented arc from *i* state to *j* state [6]. The figure 3 represents the Markov chain transition graph for the studied entity.

Taking into consideration that the studied system has 7 different states and the Markov chain transition graph (fig.3), the Q matrix is given by the relation:

$$Q=\begin{vmatrix} -\lambda_1-\lambda_2-\lambda_3 & \lambda_1 & \lambda_2 & \lambda_3 & \lambda_3 & 0 & 0 \\ \mu_1 & -\mu_1 & 0 & 0 & 0 & 0 & 0 \\ \mu_2 & 0 & -\mu_2-\lambda_1-\lambda_3 & 0 & \lambda_1 & 0 & \lambda_3 \\ \mu_3 & 0 & 0 & -\mu_3-\lambda_1-\lambda_2 & 0 & \lambda_1 & \lambda_2 \\ 0 & \mu_2 & \mu_1 & 0 & -\mu_1-\mu_2 & 0 & 0 \\ 0 & \mu_3 & 0 & \mu_1 & 0 & -\mu_1-\mu_3 & 0 \\ 0 & 0 & \mu_3 & \mu_2 & 0 & 0 & -\mu_2-\mu_3 \end{vmatrix} \quad (9)$$

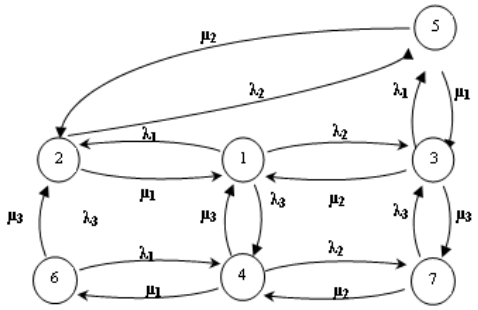



Fig.3. Markov chain transition graph

In order to solve the equation system (8), to avoid the unique banal solution, one of the system equations is replaced with the condition $\sum_{i=1}^{n} P_i = 1$ (the sum of the states probability on one line of the matrix is 1). It means that system states realise a complete events set.

The equation system (8) becomes:

$$\begin{cases} P_1 \cdot q_{11} + P_2 \cdot q_{21} + \ldots + P_7 \cdot q_{71} = 0 \\ P_1 \cdot q_{12} + P_2 \cdot q_{22} + \ldots + P_7 \cdot q_{72} = 0 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ P_1 \cdot q_{17} + P_2 \cdot q_{27} + \ldots + P_7 \cdot q_{77} = 0 \end{cases} \quad (10)$$

$P_i$ represent the elements of the state transition functions matrix. The solution of the equations system (10) is the state vector $P=[P_1 \ldots P_7]$. Replacing the state transition rates $q_{ij}$ with the failure and the repair rates, the equations system (10) becomes:

$$\begin{cases} -P_1(\lambda_1+\lambda_2+\lambda_3)+P_2\mu_1+P_3\mu_2+P_4\mu_3=0 \\ P_1\lambda_1-P_2\mu_1+P_5\mu_2+P_6\mu_3=0 \\ P_1\lambda_2-P_3(\mu_2+\lambda_1+\lambda_3)+P_5\mu_1+P_7\mu_3=0 \\ P_1\lambda_3-P_3(\mu_3+\lambda_1+\lambda_2)+P_6\mu_1+P_7\mu_2=0 \\ P_3\lambda_1-P_5(\mu_1+\mu_2)=0 \\ P_4\lambda_1-P_6(\mu_1+\mu_3)=0 \\ P_3\lambda_3+P_4\lambda_2-P_7(\mu_2+\mu_3)=0 \\ P_1+P_2+P_3+P_4+P_5+P_6+P_7=0 \end{cases} \quad (11)$$

## 3. PROBLEM SOLUTION

After the electric scheme from figure 1 is reduced and using the reliability parameters (failure rate $\lambda$ and repair rate $\mu$) for the containing components (electric bar, disconnectors, circuit breakers, transversal couples, current transformers, power transformers, underground lines) [1], it can be computed the reliability indicators from block diagram presented in figure 2.

Table 2

| | Element 1 | Element 2 | Element 3 |
|---|---|---|---|
| $\lambda[h^{-1}]$ | $0.63 \cdot 10^{-4}$ | $0.0126 \cdot 10^{-4}$ | $0.045 \cdot 10^{-4}$ |
| $\mu[h^{-1}]$ | $129.94 \cdot 10^{-4}$ | $140.52 \cdot 10^{-4}$ | $699 \cdot 10^{-4}$ |

The values of the failure rate $\lambda$ and repair rate $\mu$ for the element from figure 2 are presented in table 2.

## 4. OBTAINED RESULTS

The solution of the equation system (11) is the probability state vector $P = [P_1 ... P_7]$:

$P_1 = 0.995$; $P_2 = 0.0048$; $P_3 = 0.0001135253$; $P_4 = 0.000064$;

$P_5 = 0.000000432$; $P_6 = 0.00000031$; $P_7 = 0.000000005$ (12)

The probability state vector serves in determining the reliability indicators:

- success probability

$$P = \sum_{i \in S} P_i = 0.995 \quad (13)$$

- unsuccessful probability

$$Q = \sum_{i \in R} P_i = 1 - P = 0.005 \quad (14)$$

- medium success duration in 1 year (8760 h)

$$M[\alpha(T)] = P \times T = 8716.2h \quad (15)$$

- medium unsuccessful duration in 1 year (8760 h)

$$M[\beta(T)] = Q \times T = 43.8h \quad (16)$$

- failure total number in 1 year (8760 h)

$$M[\nu(T)] = \left[ \sum_{i \in S} \left( P_i \times \sum_{j \in R} q_{ij} \right) \right] \times T = 394{,}17 \quad (17)$$

- medium functioning time

$$M[T_f] = \frac{M[\alpha(T)]}{M[\nu(T)]} = 22222h \quad (18)$$

- medium unfunctioning time

$$M[T_d] = \frac{M[\beta(T)]}{M[\nu(T)]} = 14{,}28h \quad (19)$$

In relations (12)-(19) there were noted: S-success states set, $P_7 = 0.000000005$ and R- unsuccessful states set

## 5. CONCLUSION

The computing of the state probabilities based on solving the equation system (8) is useful in all cases when it's making a quantitative analysis of the energy installation reliability, indifferent if the containing elements of the system are dependent or independent. The advantages of the Markov chain modelling are:

- the energy system that is analysed can be modelled with dependent elements.
- It can be analysed each possible state of the system, using Markov chain transition graph, and the reliability parameters ($\lambda$, $\mu$ and $\nu$)
- the resulting data, reliability indicators can give important informations about the system functioning.

This modelling method is limited in situations when implicates a lot of calculation, the reason for reducing the computing scheme. In situation when the results do not demand accuracy, it is indicated to use the binomial method, in witch the element can be considered independent.

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# DETERMINATION OF THE CURRENT HARMONICS INTRODUCED IN THE GRID BY THE D.C.-SUPPLIED CONSUMERS

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**Abstract**:
This work is presenting a determination mode of the current harmonics for a supply circuit of a d.c. motor, to which the loading is adjusted by another identical motor, connected as generator. Their determination is achieved by direct measurement with an energy analyzer CA8334.

**Keywords**:
current harmonics, single-phased power rectifier, distortion factor

## 1. WORK'S PRESENTATION

For the current harmonics' study it was achieved a circuit of relatively reduced power using a d.c. motor of 750 W coupled directly with another motor, identically with the first one, which is connected as generator, to which the loading can be adjusted by means of a slide rheostat. The electric circuit's diagram (fig. 1) allows the adjustment of the motor's supply voltage using a single-phased autotransformer.

Will be analyzed the current harmonics for three different loading situations of the generator, respectively three values for the slide potentiometer, at three different supply voltages. Determinations of the current harmonics, as well as the THD factor, are made with a three-phased energy analyzer CA8334 which alows the calculation of these parameters as follows:

1 sec RMS values for voltage and current

$$V_{rms}[i]=\sqrt{\frac{1}{NechSec}\cdot\sum_{n=0}^{NechSec-1}V[i,n]^2} \quad (1)$$

where: $V_{rms}$ single rms voltage $i+1$ phase; $Vavg[i]=Vrms[i]$

$$U_{rms}[i]=\sqrt{\frac{1}{NechSec}\cdot\sum_{n=0}^{NechSec-1}U[i,n]^2} \quad (2)$$

where: $U_{rms}$ compound rms voltage $i+1$ phase $Uavg[i]=Urms[i]$

$$Arms[i]=\sqrt{\frac{1}{NechSec}\cdot\sum_{n=0}^{NechSec}A[i,n]^2} \quad (3)$$

where: $Arms[i]$ - Effective current phase $i+1$; $Aavg[i]=Arms[i]$

Calculation of harmonic bins :

By FFT (16 bits) 1024 samples on 4 cycles without windowing (CEI 1000 –4-7). From real and imaginary parts, each bin calculated on each phase Vharm, Uharm and Aharm in proportion to the fundamental value and the angles Vph, Uph, and Aph between each bin and the fundamental.

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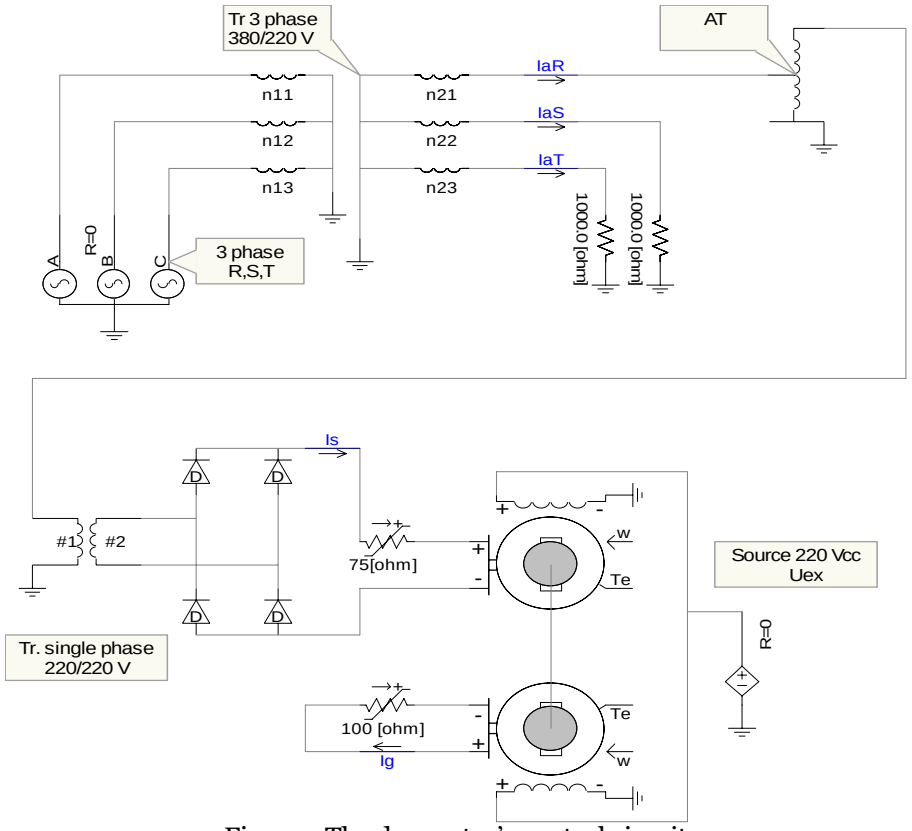



Figure 1 The d.c. motor's control circuit

This calculation is done with the following principle: Module in %: $\mathrm{mod}_k = \frac{c_k}{c_1} \times 100$

angle in degree: $\varphi_k = \arctan\left(\frac{a_k}{b_1}\right)$

With
$$\begin{cases} c_k = |b_k + ja_k| = \sqrt{a_k^2 + b_k^2} \\ b_k = \frac{1}{512} \sum_{s=0}^{1024} F_s \times \sin\left(\frac{k\pi}{512} s + \varphi_k\right) \\ a_k = \frac{1}{512} \sum_{s=0}^{1024} F_s \times \cos\left(\frac{k\pi}{512} s + \varphi_k\right) \\ c_0 = \frac{1}{1024} \sum_{s=0}^{1024} F_s \end{cases} \quad (4)$$

$c_k$ is the amplitude of frequency $f_k = \frac{k}{4} f_1$, $F_s$ is sampled signal, $c_0$ is the DC component, $k$ is the ordinal number (spectral bin).

Calculation of the distortion factor (DF):

There are calculated two global values which give the relative quantity of harmonics: total harmonic distortion (THD) against the fundamental and the distortion factor (DF) and DF against the effective value (RMS).

$$Vthd[i] = \frac{\sqrt{\sum_{n=2}^{50} Vharm[i,n]^2}}{Vharm[i,1]}; \; Uthd[i] = \frac{\sqrt{\sum_{n=2}^{50} Uharm[i,n]^2}}{Uharm[i,1]}$$
$$Athd[i] = \frac{\sqrt{\sum_{n=2}^{50} Aharm[i,n]^2}}{Aharm[i,1]} \quad (5)$$

$$Vdf[i]=\frac{\sqrt{\frac{1}{2}\sum_{n=2}^{50} Vharm[i,n]^2}}{Vrms[i]};\ Udf[i]=\frac{\sqrt{\frac{1}{2}\sum_{n=2}^{50} Uharm[i,n]^2}}{Urms[i]}$$

$$Adf[i]=\frac{\sqrt{\frac{1}{2}\sum_{n=2}^{50} Aharm[i,n]^2}}{Arms[i]} \qquad (6)$$

Multiplying the voltage's harmonics factor with the current's harmonics factor, results the power's harmonics factor. Differentiating the voltage's harmonic phase angle with the current's harmonic phase angle, results the power's phase angle.

- different ratios

$$PF[i]=\frac{W[i]}{VA[i]} \text{ power factor, phase } i+1$$

$$\cos(\varphi[i])=\frac{\sum_{n=0}^{NechSec-1} VF[i,n]\cdot AF[i,n]}{\sqrt{\sum_{n=0}^{N\sec-1} VF[i,n]^2}\cdot\sqrt{\sum_{n=0}^{N\sec-1} AF[i,n]^2}} \qquad (7)$$

Cosinus angle between the voltage's fundamental and the phase current $i+1$

$$PF\,3=\frac{PF[0]+PF[1]+PF[2]}{3} \qquad (8)$$

Total power factor various types of energy

$Wh[0,i]=\sum_{T\,\mathrm{int}}\frac{W[i]}{3600}$ Active energy consumed $i+1$ phase;

$VARhL[0,i]=\sum_{T\,\mathrm{int}}\frac{VAR[i]}{3600}$ for $VAR[i]\geq 0$ Reactive inductive energy consumed $i+1$ phase;

$VARhC[0,i]=\sum_{T\,int}\frac{VAR[i]}{3600}$ for $VAR[i]\leq 0$ Reactive capacitive energy consumed $i+1$ phase.

| Motor loading | Is [A] | Ig [A] | IaR[A] | THD[%] |
|---|---|---|---|---|
| min | 2.4 | 1.2 | 2.1 | 14.6 |
| med | 3.1 | 1.8 | 3 | 15.1 |
| max | 4.1 | 2.5 | 3.8 | 15.5 |

There are obtained the amplitude values of the harmonics of rank 3,5,7,9, 11..... and the THD factor calculated for there values of the harmonics. In the first stage, are determined the current harmonics and the THD for the situation when the insulation transformer is missing (Tr single-phase). The results will be written in a table (table 1) and, for exemplification, there are presented two graphics with the harmonics' values and the THD's value for a medium loading (fig. 2), respectively for a maximum loading (fig. 3).

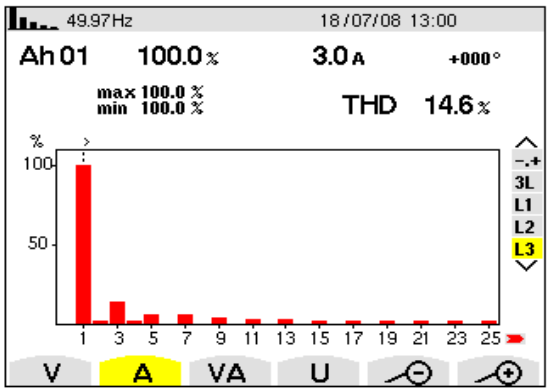



Fig. 2 Harmonics spectrum for a loading of 50%

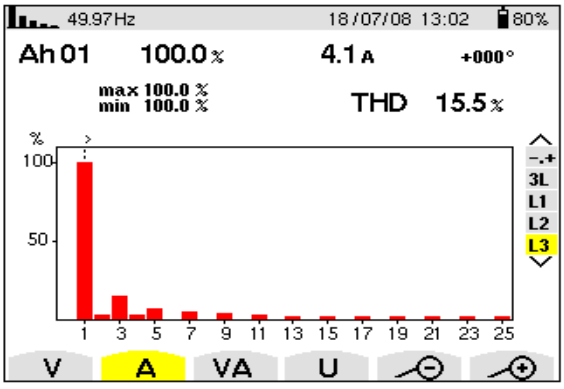



Fig. 3 Harmonics spectrum for a loading of 100%

Table 2

| Voltage [V] | Motor loading | Is [A] | Ig [A] | THD [%] |
|---|---|---|---|---|
| 50 | min | 0.8 | 0.5 | 13.2 |
| | med | 0.9 | 0.65 | 14.8 |
| | max | 1.1 | 1 | 16.3 |
| 100 | min | 5.9 | 1.5 | 6 |
| | med | 6.7 | 1.8 | 5.9 |
| | max | 7.9 | 2.75 | 3.5 |
| 150 | min | 8.4 | 1.55 | 4.8 |
| | med | 9 | 2 | 4.7 |
| | max | 10.4 | 2.7 | 4.6 |

In the circuit is introduced the insulation transformer (Tr single-phase), and are rerunned the measurements for the supply voltages of the d.c. motor of 50 V, 100 V, 150 V at loading of the generator with minimum, medium and maximum load. The values are written in the table (table 2) and for the supply voltage of 100 V will be presented two distinct situations, at a medium loading of 50 % from the value of the generator's loading potentiometer (fig. 4 ) respectively maximum, 10% from 75 Ω (fig.5).

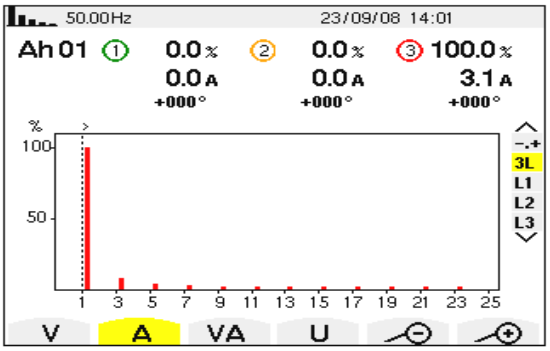



Fig. 4 Harmonics spectrum for a loading of 50% with insulation transformer

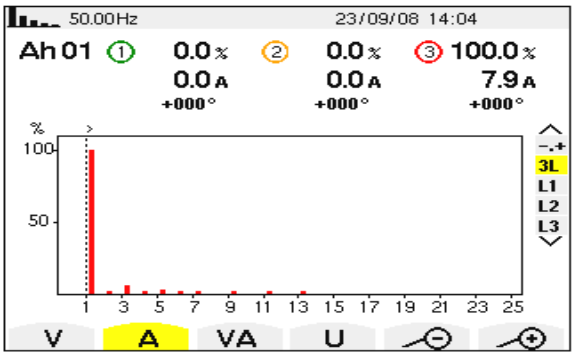



Fig. 5 Harmonics spectrum for a loading of 100% with insulation transformer

## 2. CONCLUSIONS

In case of the circuit without insulation transformer from fig. 2 and fig. 3 can ne noticed a relatively small reduction of the distortion factor regarding the load currents at medium and maximum loading.

In case of the circuit with insulation transformer from fig. 4 and fig. 5, beside the pronounced THD's reduction, is noticed also a more pronounced reduction between the situation of medium loading and maximum loading of the d.c motor.

It can be easily noticed the reduction of the distortion factor in case of introducing the insulation transformer. Although the harmonics' values are relatively reduced related to the fundamental, is obtained a relatively high THD factor, especially at small load currents. By increasing the load current, the harmonics' effective value is not realy reducing. The finding of the THD's reduction is due to the relative reduction of the ration between the harmonics' values and fundamental. Reduction of THD is achieved by using of passive filters at small rank harmonics, completed by a power active filter.

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# ANALYSIS OF A DOUBLE-WAVE ACCURACY RECTIFIER'S OPERATION WITH OPERATIONAL AMPLIFIERS

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**Abstract**:
In this work is studied the operation of a double-wave accuracy rectifier achieved with operational amplifiers LM741 at frequencies that exceed their cut-off frequency, using the Multisim simulation program. Is aimed the quality and accuracy of the obtained signal, having in view the damping introduced by the operational amplifiers' operation.

**Keywords**:
double-wave accuracy rectifier, operational amplifier.

## 1. WORK'S PRESENTATION

The double-wave rectifier can be obtained by serial connecting of a single-wave rectifier and a summation instrument. Diagram of a single-wave accuracy rectifier which rectifies the positive semi-periods of the input voltage is given in fig. 1. Because it's about small signals, the voltage between the two inputs of the operational amplifier is not neglected anymore, but instead are neglected the OA's input currents and the reverse current through the diode is blocking state.

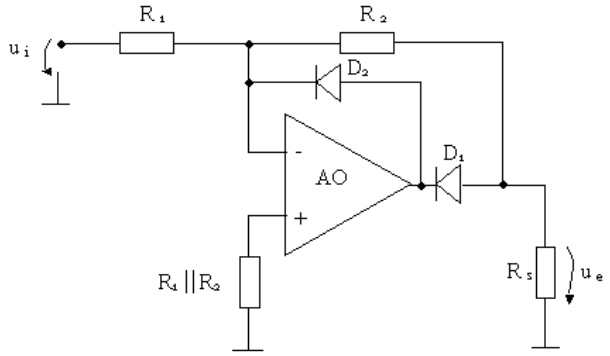



Figure 1. Operation diagram on positive alternance

Output voltage for the positive semi-period of the input voltage is:

$$u_e = -\frac{u_i\frac{R_2}{R_1}+\frac{u_{d1}}{\frac{R_1}{R_1+R_2}A_u}}{1+\frac{1}{\frac{R_1}{R_1+R_2}A_u}} \cong -u_i\frac{R_2}{R_1} \qquad (1)$$

At the circuit's output is obained an identical voltage as time-variation form, and reversed as phase. For the negative semi-period of the input voltage $u_i$ diode $D_1$ is blocked and diode $D_2$ conducts all the current coming from the input (fig. 2). In this case, for the output voltage is obtained the relation:

$$u_e = -u_i\frac{R_s}{R_2+R_s} \cong \frac{u_{d2}}{A_u}\cdot\frac{R_s}{R_2+R_s} \cong 0 \qquad (2)$$

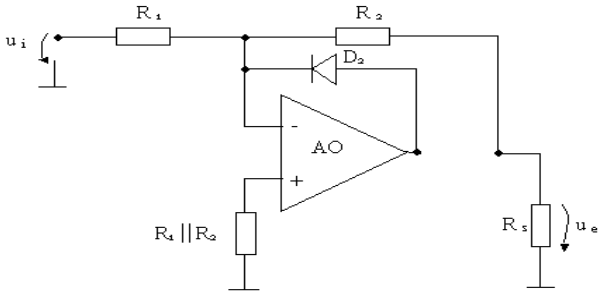



Figure2. Opertation diagram on negative alternance

Is found that, during the negative semi-period of the input voltage, at output is obtained a voltage almost null.

The diagram of the double-wave rectifier is using such a rectifier, out of which outpt is connected a summation instrument with AO (fig. 3).

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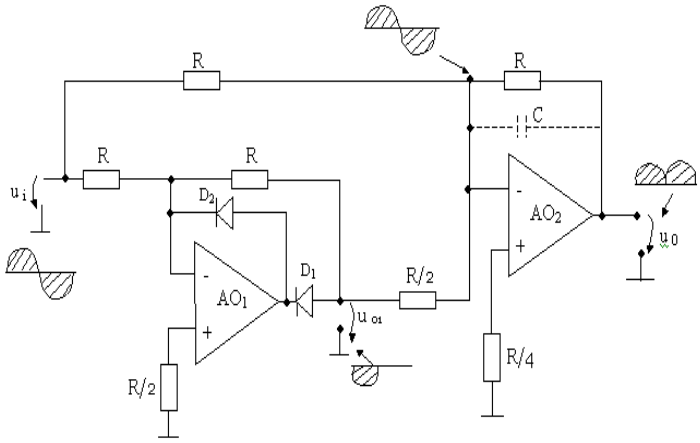



Figure 3. Diagram of the double-wave accuracy rectifier

For the first semi-period (positive) of the input signal, the volatge $u_{e1}$ is negative and, in this case, at the summation device's inputs are brought voltages with equal amplitudes, one positive and one negative, amplified differently. The positive voltage has the amplification 1 and the negative one has the amplification 2, at the summation instrument's output being obtained the positive alternance of the signal $u_i$. For the negative alternance of the signal $u_i$ is obtained $u_{e1} = 0$ and at the summation instrument's input is brought only the negative alternance of the signal $u_i$, for $u_{e2}$ being obtained the alternance reversing and amplification 1.

As result, at output is obtained the input signal's rectification, this without being amplified. If it's desired its amplification, the resistances from the diagram will be modified in the ratio aimed to be obtained.

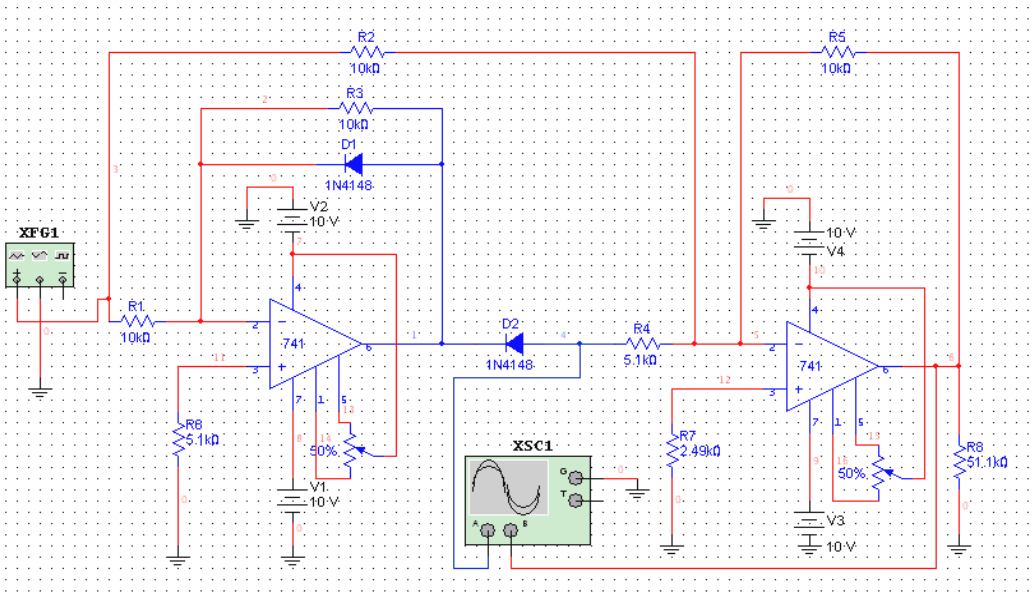



Figure 4. Electronic diagram of the accuracy rectifier

In order to check the rectifier's operation, it was used a generator of sinusoidal signal with amplitude of 275mV and adjustable frequency (fig. 4). The signal was recorded by means of a digital oscilloscope, which allowed the data acquisition in the memory of a PC system.

Are presented three distinct situations, corresponding to all frequencies of 1 KHz (fig. 5.a), 10KHz (fig. 6.a) and respectively 50KHz (fig. 7.a), with the wave forms related to each frequency in part. For each frequency in part are presented the parameters corresponding to the wave forms presented above (fig. 5b, fig. 6b, fig. 7b).

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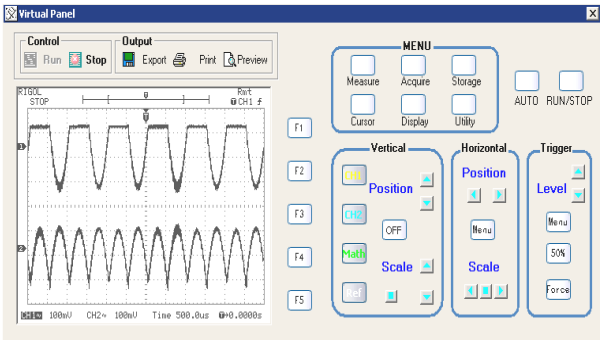
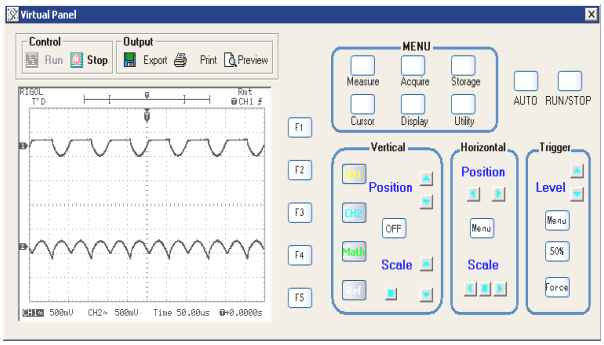






Figure 5.
a) wave forms corresponding to frequencies of 1 kHz;
b) parameters corresponding to the wave forms for 1kHz



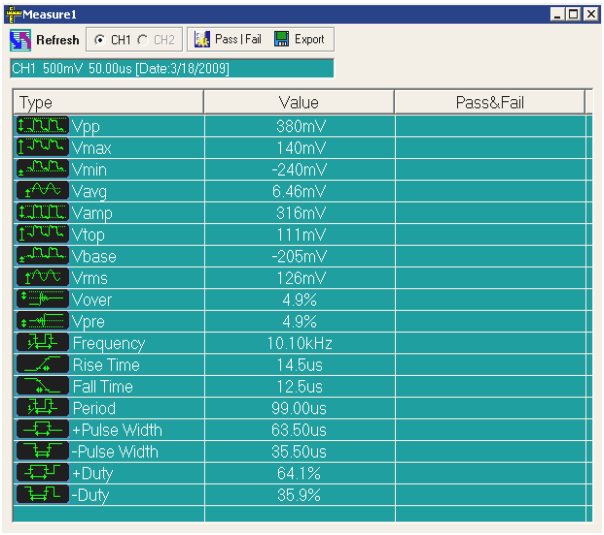




Figure 6.
a) wave forms corresponding to frequencies of 10 kHz;
b) parameters corresponding to the wave forms for 10kHz

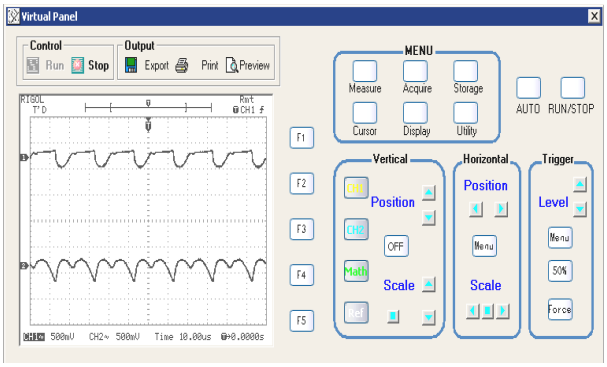






Figure 7.
a) wave forms corresponding to frequencies of 10 kHz;
b) parameters corresponding to the wave forms for 50kHz

## 2. CONCLUSIONS

Further the experimental verification of the double-wave rectifier, is found a correct operation within a relatively large frequency band, reaching to approximately 50KHz. One can notice that at the end of the negative semi-period is not reaching to zero, but to a value a

little superior, which cannot be compensated, because also the other value related to the positive alternance would be reduced identically. Once by increasing the frequency, is found a distorsion of the output signal, especially due to the parasite capacities that occur in the circuit, which makes it to integrate the signal brought at input, reaching up to ramp-signal at very high frequencies.

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# VIBRATIONS INFLUENCE OVER THE METALLIC ALLOYS CRYSTALLIZATION

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**ABSTRACT:**
Metal materials casting is influenced favorably under the mechanical vibrations influence applied over the liquid alloy bath. Vibrations producing methods may be different, by using mechanical vibrations, or pneumatic, hydraulic or electrical. The mechanical vibrations in the particular case we've studied are obtained by means of an element that is in translation for a wide range of forces and frequencies up to 75 Hz.
The aluminum-silicone and aluminum-copper alloys are among the most used nonferrous cast alloys.
The present study (paper) presents the main phenomena occurring under the mechanical vibrations influence over the alloys especially the dendrites break and the superficial strain influence over the germinate particles.

## 1. INTRODUCTION

Crystallization, as any other process (chemical or physico- chemical) is studied from the static and kinematicl point of view. The statics structures the balance relationships between the crystals, the solution they are formed from. The statics deals with the solubility of the phase that is pure, in the presence of other phases, with the kinds of crystals balance and their composition.

The kinematics is specific to the speed the processus takes place at, it characterizes the speed taken by the processus to deploy, respectively the mechanism of germination and solidification of the metallic alloys. In connection with this fact, you have to examine the main factors that influence the germination, the break of the dendritic branches, the influence of the superficial tensions of the germinated particles, all under the vibrations influence over the metallic alloys.

## 2. DOCUMENTARY STUDY

The processus of crystallization from metallic melts has two stages: formation of crystallization germs and their growth.

The kinematics of the crystallization processus may be characterized mainly by two ratings: speed of germs formation and speed of crystals growth. To have a clearer image over the processus mechanism, each and every of these ratings have to be examined separately, as well as the influence of various factors over the speed needed by these processus to deploy. The vibrations influence is a research factor. Further on we shall refer to the vibrations influence (mechanical vibrations) over the germination and crystallization of cast alloys.

The strong connection between the germs formation and their development, the impossibility to separate exactly these stages, makes difficult the study of the crystallization processus. This explains the fact that neither of the theories proposed over the formation of crystallization germs and their growth cannot be considered complete for stating clear all the particularities of this heterogeneous processus so complex.

A high oversaturation of the melt favors, evidently, also the occurrence of the forms of dendritic growth. Indeed, the inflow of the substance that crystallizes from the solution is achieved easiest towards the crystal peaks, that is why the growth speed of the crystal peaks supersedes by far the growth speed of the edges and sides, which finally leads to the formation of the dendritic crystal having arborescent shape. In the dendrites growth, the substance that crystallizes (gets solid) can fill gradually the clearance between the branches, that is why the final shapes of the dendritic growth can be of a great variety, from compact crystals to those resembling to a hedgehog, function of the nature of the

melt and of the growth conditions. Out of the conditions that favor the germination, besides the nature of the melt, a very significant influence is generated by the influence of the vibration with frequency (pulses) amplitude and acceleration as its main parameters. Lately, the acceleration is a working parameter since it can be measured and controlled easier. It is worth being mentioned that the connection between the frequency (f), pulsation ($\omega$), amplitude (A), speed (v) are in well defined relationships, this is the reason why one can work unitarily with each of them. By vibrating the melt, a uniform affluence of the solution that crystallizes at various faces is ensured, by this annihilating the influence of the concentration currents, which favors the formation of crystals with a regular shape.

The action of accelerating the vibration over the germs formation becomes more and more efficient by increasing the crystals speed that gets lower gradually.

It is established that the mechanic erosion of the crystals, as a sequence of rubbing between each other, as well as to the molds (matrix) sides, increases with the mechanic vibration intensification. The crystals obtained thus have a round shape with rounded corners and edges, and finally increases sudden the quantity of the fine fractions.

## 3. ANALYSIS, INTERPRETATION - EXPERIMENTAL PART

The expression of the compact state by the density of the metallic material melt has a significant importance because it influences the structure and features of the material obtained. The discontinuities that may occur when the alloy gets solid are due to the phenomenon of contraction, characteristic to the majority of the alloys, together with a strong decrease of the solubility of the gases within the melt at the crystallization temperature.

Obtaining a compact metallic material is guaranteed if the penetration speed v of an alloy in the capillaries of the biphasic zone is equal to the contraction speed $v_{contr.}$:

$$V_{contr} = \alpha \cdot m \cdot R \text{ [m/s]} \quad (1)$$

where: $\alpha$ - contraction coefficient of the alloy when it gets solid;

m – relationship between the volume at the liquid state within the biphasic zone and the volume of this zone;

Under common circumstances, the speed v is expressed thus:

$$v = \frac{r^2}{8\eta} \cdot \frac{P_e + P_m - P_g + \frac{2\sigma}{r} \cdot \cos\theta}{l} \text{ [m/s]} \quad (2)$$

r - radius of the capillary [m/s]; $P_e$ – external pressure [Pa]; $P_m$ - metal static pressure [Pa]; $P_g$ - pressure of the gas in the capillary [Pa]; $\sigma$ - alloy superficial tension [N/m]; $\theta$ - humectation (moistening) angle [rad]; $\eta$ - alloy dynamic viscosity [Pa·s]; l – length of alloy penetration into the capillaries [m].

From the equality between the relations (1) and (2) it results:

$$\frac{r^2}{8\eta} \cdot \frac{P_e + P_m - P_g + \frac{2\sigma}{r} \cdot \cos\theta}{l} = \alpha \cdot m \cdot R \quad (3)$$

Where from:

$$l = \frac{r^2 \cdot \left( P_e + P_m - P_g + \frac{2\sigma}{r} \cdot \cos\theta \right)}{8\eta \cdot \alpha \cdot m \cdot R} \quad (4)$$

The mechanical oscillations decrease the superficial tension $\sigma$ at the liquid solid interface, the humectation angle $\theta$ and renders to the alloy an initial speed $v_i = A \cdot \omega$.

Under the vibrations physical action, the biphasic zone gets fragmented, thus lowering the capillaries length that must be run by the liquid alloy in order to fill the clearances provoked by the contraction and increasing thus the flow speed of the liquid alloy in these clearances, improving the conditions of supplying the micro cavities. Thus the overall volume of the micro blisters (shrinkage cavities) and the macro blisters concentrate at the top (large opening angle and low penetration depth fig.1), reducing the volume of the liquid alloy for the crop ends, phenomena that can be explained if it is considered that the alloy solidification under the influence of the mechanical oscillations takes place according to the following mechanism:

- the inertial forces generated by the vibrations render into pieces the solid phase in course of getting constituted and disperses it into the liquid alloy placed in front of the solidification front;

- the liquid alloy penetrates between the broken and dislocated fragments; it determines a temperature rise in the crust of solidified alloy, thus improving the conditions of thermal transfer at the interface alloy mould;
- the descendent circulation of the solid phase fragments and their storage at the bottom of the mould leads to the concentration of the macro blisters and porosities diminishing.

a) 

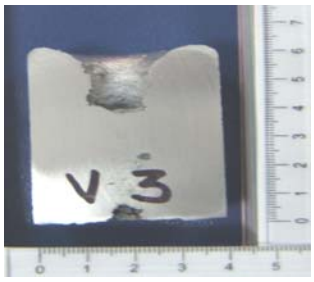
b) 


Fig. 1 Aspect of blisters without vibration and with vibration

blisters volume $O_3$= 9,5cm³; $V_3$=6,5cm³
blisters height h $O_3$= 34mm; $V_3$=24mm
blisters diameter d $O_3$=22mm; $V_3$=24mm
relation h/d $O_3$=1,5 $V_3$=1
relation blisters volume /sample vol.; $O_3$= 3,15; $V_3$=2,16
sample volume 301,44cm3 ;

Note: for the vibrated sample (V3) the blister height decreased versus the non vibrated sample (O3).

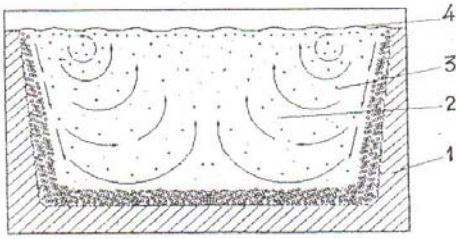



Fig. 2. Diagram of the movement of the fluxes in the liquid and solid phase in the solidification process
1 – crystallizer side walls, 2 - liquid phase, 3 - solid particles in the flux, 4 - crust

The general movement diagram of the liquid and solid phase flow in the conditions of applying the action of the mechanical vibration in the solidification procesus is shown in figure 2.

In the course of the observations it was established that oriented fluxes (circulation currents) are formed in the area next to the melted mass surface.

By means of these fluxes the most minute particles of the crystals that are broken are taken away within the volume of the melted mass, and the larger ones are precipitated at the bottom. The dendrites destruction mechanism, the diagram of the dendrite cell that develops in the solid- liquid area and temperatures distribution in it is shown in figure 2.

The growth of the thinnest branches of the second degree dendrite takes place in the surrounding liquid phase, figure 3.a, and between the peaks of these derivations the dendritic structure is sufficiently open for the liquid phase outlet. As long as the solidification advances, the dendritic cell derivations get thicker, and the liquid phase within it is in the state of small movement. The temperature along the length of each dendrite is modified from the liquid temperature $T_{lic}$ (according to the axe of the clearance between the dendrites) up to the temperature of the solid mass $T_{sol}$ at its basis. By applying vibrational force on the vibrant table on which the mould is mounted a phenomenon is produced: the liquid phase mixes and the dendrite branches are destroyed figure 3.b.

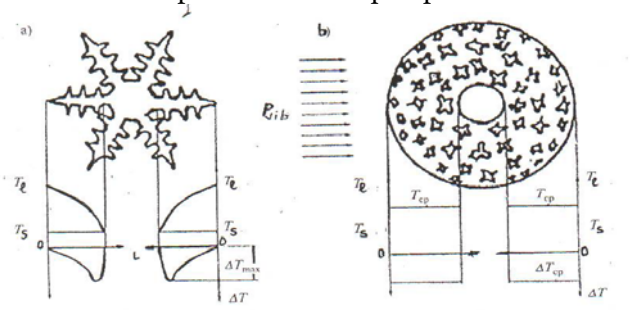



Fig.3. Conditions of growth of the dendrites axes in state of rest and in the conditions of pressure exertion $P_{vib}$ over the melted mass.
a) dendrite growth in the melted mass;
b) breaking of the dendrite branches when applying the mechanical vibrations

The temperature within the solidification interval is established at the average values over the entire mould cross-section, and in the clearance available between the dendrites crystallization germs occur, that, afterwards, under the action of the mechanical vibrations, move within the volume of the unsolidified part of the alloy. Each one of these disintegrations (breakings) of dendrites is serving the crystallization centre in the melted mass volume. Thus, the under cooling around each breaking is considerably higher than within the surrounding liquid. The amount of this under cooling is equal to:

$$\Delta T_B = \left(\sigma_{l-s} \cdot T_{lic}\right) / r \cdot \rho \cdot q_{crist} \qquad (5)$$

where: $\sigma_{l-s}$ - superficial extend at the limit between phases [N/m² ];
$T_l$ - melted mass liquid temperature [°K];
r - broken dendrite radius [m];
$\rho$ - melted mass density [kg/m³];
$q_{crist}$ - crystallization temperature of the melted mass [°K].

Out of the equation (5) it can be seen that the lower the radius of the broken dendrite is the higher the under cooling is around it. That is why, by increasing the vibration frequency, the destruction of the dendrite branches, the under cooled liquid volume and the melted mass crystallization speed increase incessantly.

The characteristic peculiarity of ingot forming under the mechanical vibrations action is the small constant thickness of the crust on the vertical, lateral sides (surfaces) of the ingot. This fact ensures the constant, intense exhaustion of the crystallization heat and the incessant growth of the horizontal area thickness of the crystals that fall down. After the solidification is finished, the even crystalline dispersed structure is obtained over the entire ingot cross-section that is characteristic for the crystallization of the alloys volume. In the research process the variant of the moulded part complete solidification duration has been studied function of the alloy overheating under usual circumstances and by applying the mechanical oscillations.

## 4. CONCLUSIONS

The solidified part of the dendrite represents a solid body and in it longitudinal waves occur (of strain/elongation and compression), that create variable pressures and that determine the elastic deformation, respectively the occurrence of fragmenting strains. The critical force at which the crystal gets fragmented is given by the relation:

$$F_{cr} = p_{max} \cdot \pi \cdot r^2, [N];$$

The break of the dendritic branches is possible, having in view their low withstand at high temperatures. Due to the vibrations, the speed the alloy moves with from the biphasic zone in front of the solidification front is much higher, which determines an intense fragmenting of the dendritic branches. The solid particles movement speed depends upon:

- solidified crust thickness;
- alloy kinematic viscosity;
- melting temperature;
- dimensions of the part;
- conditions of the heat exchange;
- oscillations energy, respectively the acceleration, their amplitude and frequency.

The physical-mechanical treatment, applied to the liquid sate alloy intensifies the vibrations layers at the edges, which produce side currents, hydro-dynamic phenomena at the limit between the solidified layer and the mould side walls, the speed increases and the solidification time decreases. Among the most important technological effects of applying the mechanical vibrations within the solidification process we can list: homogenization and finishing of the structure, molded material getting compact, alloy degassing, segregations contraction, separation of the nonmetallic inclusions and growth of the capacity of achieving a high quality alloy as well as improving certain mecano-physical characteristics.

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# FEW TEORETIC ELEMENTARY NOTIONS REQUIRED FOR CHARACTERIZATION OF METAL MELT AND APRECIATION OF BEHAVIOR AT INTERFACE DURING CASTING

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**ABSTRACT:**
Surface tension is one of the properties of metal melt, which depends on two other properties, cohesion and adhesion. Atomic-scale phenomena can be regarded as if atoms or molecules within a substance are spaced sufficiently small, then each of them is surrounded by a field of forces, which form a system equivalent to zero. Forces are forces of cohesion, named "Van der Waals" forces.

## 1. INTRODUCTION

To separate atoms or molecules of the same type, some others must consume a mechanical work, it carry the name mechanical work of cohesion. The force that opposes atoms separation or molecules of that substance reported at length shall be known as surface tension (σ). Adhesion is the force of attraction between atoms or molecules that are in different phases. It is characterized by the work that needs to be done to separate the two phases in contact with the surface contact unit. The properties of surface flows have an important role, which include both surface tension and inter-phase and moistening phenomena.

## 2. DOCUMENTARY STUDY

Understanding the nature of surface tension in metals and alloys requires a profound study of this phenomenon. When two phases, for example liquid and gas are in direct contact, between them it forms a very thin separation layer, called the interface or inter-phase or phase separation. The interface properties differ from those of phases in contact. In this area the number of atoms and distribution functions of their energy is changing continuously, from the value which they have in melt, to the one which they have outside the melt. While atoms are leaving the surface, entering in liquid or evaporating outside the liquid, other atoms are replace. Stationary time of atoms at the liquid surface is very short, but it's longer than the remaining sibotaxis groups of atoms inside the liquid. At the melt surface occur a flux of collectivized electrons, which tend to get of the environment, but positive ions pull them back into the melt.

Metal melt surface are covered by a thin layer of liquid with negative loads, under which by a certain depth of atomic radius order, it's located a layer with compensating positive electrical loads. The two layers form a double layer with a thickness of interaction radius of an atom order. This double layer acts as a electrical condenser as a barrier, preventing, at least partially, the outgoing of electrons molten metal.

An atom in the melt, under the double layer, at a distance greater than the range of inter-atomic forces is surrounded by a field of forces, which together with its own forces form a system equivalent to zero. It has an effect of mutual annihilation of the forces of interaction between atoms, which allows free movement, as there is cohesion between them.

So the forces of interaction between atoms which belong to melt and the gas from the interface, will be much smaller than the forces of interaction between atoms on the surface of the liquid and the liquid inside.

If we consider a point particle (N) at a depth (X) less than the radius of the sphere of action of inter-atomic forces (r), figure 1, all atoms which are located in the EGF ABFE sector, will draw down N atom, while atoms in the ABCD and CHD sector, N atom will be attract upwards.

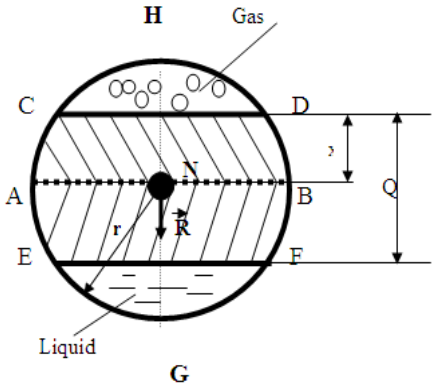



Figure 1. Schematic representation of double layer Q, between liquid and gas phases

The ABCD and ABFE being equal, it can be assumed that the atoms contained in these, cancel each other so that the atom N is drawn down only in the liquid by atoms in the EGF because the forces of interaction between atoms in liquid are much higher than those between atoms in the gas CDH. It follows that the resultant $\vec{R}$ of forces acting between atoms in liquid and gas and the atom N is facing towards the liquid, being normal to the surface of separation.

Because at the apparent liquid surface, are located a very large amount of atoms N, acting on their resultant R of the interaction forces, normal to the surface and directed into the liquid, they act as an elastic membrane which surrounds the liquid and exercise forces on it, which, reported to the surface pressure is the internal liquid.

Energy between the two contact surfaces of the different phases shall be known as the Gibbs energy, and the change at constant temperature and pressure, reported to the surface between both phases shall be known as inter-facial surface tension or tension Gibbs.

Consequence that the attraction of atoms from metal melt surface, produces forces directed towards the inside, is that the surface free energy is greater than the one from inside. The absence of this excess energy, surface separation would not be stable, would degrade at the lowest energy state of fluctuation, the two phases in contact would disperse to another one.

To form a surface should be consumed a mechanical work needed to bring the atoms of the liquid on the surface, the same thing for the surface growth. Consuming a mechanical work it's decreasing the surface free energy.

## 3. ANALYSIS, INTERPRETATION - EXPERIMENTAL PART

If we note (σ) generalized force corresponding to the surface (S), then the mechanical work (dW) required for modification iso-thermic surface area will be:

$$dW = -\sigma \cdot dS \quad (1)$$

On the other hand this mechanical work is equal to the decrease of the surface free energy (dE, Gibbs energy change), so:

$$dE = \sigma \cdot dS \quad (2)$$

$$\text{or} \qquad \sigma = \left( \frac{dE}{dS} \right)_{T,p,ni} \quad [J/m^2] \quad (3)$$

If we express mechanical work used to increase the surface (dS), as the acting force (dF) or displacement (d ℓ), then:

$$dW = dF \bullet d\ell = -dE = -\sigma \bullet dS \quad (4)$$

This is another way of expression the surface tension, being force tangent to the surface, reported at length.

For a system being in energy balance, the free energy should be minimal. For a given volume which can have different values of the area, the lowest value being that of the spherical surface, because surface tension is constant, then the free energy will take different values, it will be minimal if the separation of the volume given will be minimal. This property explains why drops of liquid in a gas tend to form spherical, the surface having the smallest separation.

Pure liquids, composed of identical atoms or molecules, have generally a constant surface tension, which is established very quickly after the surface forming. For compound liquid, to reach equilibrium, it is necessary to pass a greater time interval.

Surface tension of a phase is defined as surface tension on the surface in the vacuum phase, while the surface tension of the interface phase in contact with those other phase voltage is inter-facial.

The inter-facial surface tension (σi), the limit of separation between a liquid and its vapour, in equilibrium is equal to the difference between the absolute surface tension liquid (σ ℓ) and its vapour (σv):

$$\sigma_i = \sigma_\ell - \sigma_v \quad (5)$$

Knowing the values of (σi) and (σ ℓ) we could determine the absolute surface tension liquid (σv).

The same can be said in general, when we have two phases in equilibrium, the contact A and B (solid - liquid, solid - gas, liquid - gas, liquid - liquid, solid - solid, gas - gas);

$$\sigma_{i\,AB} = \sigma_A - \sigma_B \quad (6)$$

At critical vaporization temperature of the liquid $\sigma_i = 0$, because the separation surface has disappeared and so $\sigma_\ell = \sigma_v$ .

In the case of two liquids in contact, the interfacial liquid - liquid tension will not be immediately determined, because the equilibrium between the two liquids will be set only after the two saturated solution will be formed. In the case liquid - gas system, the interfacial surface tension will be stabilized only when the gas dissolvation in liquid cease. The same phenomenon happens in the limit of separation between the crystals that is formed in the fusion.

The interfacial surface tension decreases with temperature, becoming zero at the critical temperature, when the separation surface disappears, like the relation of Eötvös shows:

$$\sigma_M = K_E\left(T'_{cr} - T\right) \tag{7}$$

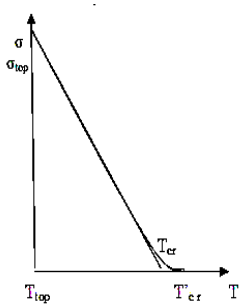



Figure 2. Variation of σ with temperature T for pure metals

The equation is thus derived from the graphical representation of the variation of pure metals surface tension with temperature, figure 2, starting from the melting temperature ($T_{top}$) which corresponds the surface tension ($\sigma_{Top}$), we can write the equation of the right from the figure.

$$\sigma = \sigma_{top} - \alpha\left(T - T_{top}\right) \tag{8}$$

$$\text{for } T = T'_{cr},\ \sigma = 0,\ \text{so } \sigma_{top} - \alpha\left(T - T_{top}\right) = 0 \tag{9}$$

and substituting the $\sigma_{top}$ the relation (9) in relation (10) we obtain:

$$\sigma = \alpha\left(T'_{cr} - T\right) \tag{10}$$

where $\alpha$ is the angle of right: $\alpha = -\frac{d\sigma}{dT}$; $T$ - absolute temperature of the liquid; $T'_{cr}$ - the critical absolute fluid temperature. Because $T'_{cr}$ is constant for a pure metal, ($\sigma$) decreases with increasing temperature ($T$).

If we multiply the equation (10) with so-called "molar area" which is conventionally taken equal to $V^{2/3}$ (V being the molar volume of liquid) we obtain the free surface molar energy:

$$\sigma_M = \sigma \cdot V^{2/3} = \alpha\left(T'_{cr} - T\right) \cdot V^{2/3}\ \sigma_M \tag{11}$$

and noting $k_E = \alpha \cdot V^{2/3}$ is obtained the relation (7). The constant ($k_E$) is the change of entropy for increasing the molar area ($V^{2/3}$).

Beginning from temperatures from 4 ... 7 degrees below the absolute critical temperature ($T_{cr}$) the surface tension varies no longer linearly with temperature. Besides temperature, the surface tension is influenced by other factors, including: the degree of dispersion, the nature of the phases, pressure, density decreasing and curvature radius of the surface.

The surface tension varies with the degree of dispersion and the specific surface of dispersed phase. Under specific surface we understand the relation between the surface phase and its volume. When the dispersion exceeds a certain limit, the surface tension starts to decrease, and when you reach the molecular dispersion of surface, the tension tends to zero. We find a large specific surface by porous bodies which have a great importance in the phenomena of filtration of liquids. The surface tension depends on the nature of the phases in contact, by their molar volume, polarity of molecules, the nature of links between the liquid particles, the phase's density. The surface solutions tension differs from that of pure metal in that the superficial layer has a different composition from the inner layers of the solution. The influence of pressure and radius curvature can be explained as follows: it is considered two fluids at mechanical balance, separated by an interface. The separation area between two fluids may take any form, from flat surface to the spherical. The condition of mechanical equilibrium at every point of the surface is given by Laplace equation.

$$\Delta P = P_2 - P_1 = \pm \sigma \cdot \left(\frac{1}{R_1} + \frac{1}{R_2}\right) \tag{12}$$

Where: $P_2$ is the pressure from outside on the liquid; $P_1$- pressure inside the liquid, $R_1$ and $R_2$ are the radius of curvature in normal section, taken through the separation area. For spherical surface $R_1 = R_2 = R$ and

$$\Delta P = \pm \frac{\sigma}{R} \tag{13}$$

For flat surface $R_1 - R_2 = \infty$ and $\Delta P = 0$.

If the two phases in equilibrium are separated by an interface curvature $C = \frac{1}{R_1} + \frac{1}{R_2}$, $\Delta P$ can be considered as the difference of pressure which push over interface from phase A ($P_A$) and from phase B ($P_B$)). Laplace's relation can be written as follows:

$$P_A - P_B = \pm \sigma_i \cdot \left( \frac{1}{R_1} + \frac{1}{R_2} \right) \quad (14)$$

where: $\sigma_i$ is the interfacial surface tension. For spherical surfaces the relation (14) becomes:

$$P_A - P_B = \pm \frac{2\sigma_i}{R} \quad (15)$$

Besides the pressure difference (ΔP) determined by the surface curvature on each point of the surface separation of two phases, acts also the hydrostatic pressure. If in a particular point from the separation area is the pressure difference $\Delta P_O$, at another point at height h, the pressure difference will be:

$$\Delta P_h = \Delta P_O + \gamma \cdot h = \Delta P_O + g \cdot h \, (\rho_A - \rho_B) \quad (16)$$

where: γ is the specific weight of the phase at a point; $\rho_A$ and $\rho_B$ - density of both phases A and B.

Entering the relation (16) and (14) is obtained:

$$\Delta P_h = P_A - P_B + g \cdot h \, (\rho_A - \rho_B) = \sigma_i \left( \frac{1}{R_1} + \frac{1}{R_2} \right) \quad (17)$$

For linear system the surface tension can be expressed by the relation:

$$\sigma = \sigma_o - D(p - p_o) + (p - p_o)^2 \quad (18)$$

where: $\sigma_o$ is the surface tension at pressure $p_o$;D - positive constant.

According to equation (18) at pressures not too high, the surface tension decreases linearly with increasing pressure.

If we consider three crossing areas and which separate three phases, in a point of intersection (M), acts interfacial surface tension, figure 3.

At equilibrium must be satisfied the condition:

$$\sigma_1 + \sigma_2 + \sigma_3 = 0 \quad (19)$$

An important practice presents special phenomena of moistening the surface of solid melt. If we put a drop of metal melt on a solid surface, this may take the form shown in figure 4 a, b, c.

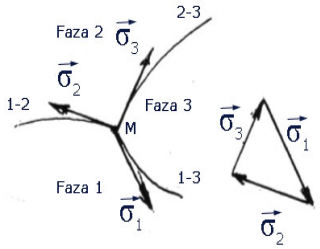



Figure 3. Way of action of inter-phasic tensions and of them composition

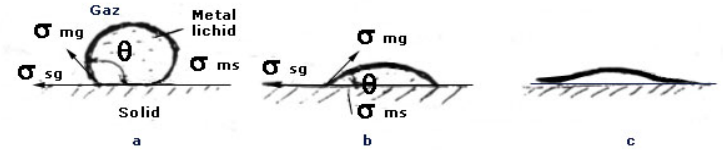



Figure 4. Shapes which could take the drop of metal liquid on the solid surface

In the meeting of the three-phase surface tension acting $\sigma_{sg}$, , $\sigma_{mg}$ , $\sigma_{ms}$ who must satisfied at equilibrium the Neumann's law relation (19).

The angle between $\sigma_{mg}$ and $\sigma_{ms}$ bears the name of moistening angle θ. At mechanical equilibrium must have therefore:

$$\sigma_{sg} - \sigma_{ms} - \sigma_{mg} \cdot \cos\theta = 0 \quad (20)$$

## 4. CONCLUSIONS

Moistening angle θ does not depend on the size fluid drop, but on the nature of the surface separation. As much the superficial tension of flow is lower, better the oxide film moistening and thus better protects the melt from the oven atmosphere, and the ability moistening flow from melt which need to be minimum at discharge the alloy from furnace to ensure the best possible separation of the melt flow during casting. Getting a solid particles moistening from fusion by flow is possible if the inter-phasic tension at separation limit between flow and nonmetallic inclusions is reduced. A good moistening of solid inclusions particles allow their easy removal of fusion. We have complete moistening when θ = 0 and a "good" moistening when θ <90 °; non moistening will occur when: $\sigma_{sg} > \sigma_{ms}$, cosθ < 0 şi θ > 90°; total moistening will be incomplete when θ = 180 ° and cosθ = -1.

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# STATISTICAL EXPERIMENTAL DESIGN OF THE REMOVAL OF DIFFERENT COMPOUNDS FROM SYNTHETIC WASTEWATER BY MICELLAR-ENHANCED ULTRAFILTRATION

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**Abstract**

In this study, the removal of zinc ions ($Zn^{2+}$) and n-butanol (n-BuOH), including salt (NaCl) from model synthetic wastewater was investigated by micellar-enhanced ultrafiltration (MEUF) using sodium dodecyl sulfate (SDS). Statistical experimental design was used in order to analyze the effect of initial concentration of $Zn^{2+}$, n-BuOH, SDS, NaCl on the process performance. Further, the effect of Transmembrane Pressure (TMP) and membrane nominal molecular weight limit (NMWL) were also studied. It was found that n-butanol could not be removed by using MEUF. On the contrary, $Zn^{2+}$ was successfully removed obtaining rejection coefficients up to 99% in the most favorable conditions.

**Keywords**

MEUF, SDS, Zinc, MODDE, Factorial Design

## 1. INTRODUCTION

Heavy metal ions such as zinc are detected in the waste streams of mining operations, tanneries, electronics, electroplating and petrochemical industries, as well as in textile mill products [1]. Heavy metals toxicity in air, soil and water is a global problem and a threat to the environment and human health. Therefore, removal of heavy metals is a technological challenge with respect to industrial and environmental applications. Furthermore, volatile organic compounds (VOCs) such as n-butanol are also commonly present in industrial wastewaters. VOCs have been proven to be carcinogens and mutagens [2]. MEUF is a viable membrane-based separation technology for the simultaneous removal of heavy metals and organic compounds [3]. The principle of the process is that the surfactant monomers are aggregated to form micelles at concentrations higher than its critical micelle concentration (CMC) [4]. The solutes can be retained after being trapped by the micelles, whereas the untrapped species readily pass through the UF membranes [5]. Organic compounds are solubilised in the micelle interior and the metal ions get trapped on the surface of the oppositely charged micelles by electrostatic interaction [6]. The advantages of MEUF are low energy consumption as compared to Reverse Osmosis or Nanofiltration, relatively high fluxes and high removal efficiency. There is very few published information on the application of factorial designs by MODDE in the study of MEUF [7]. Factorial design is an efficient technique that can be applied to determine the main effects and interactions of these factors on process performance. Results of factorial design can subsequently be used to optimize and decreases the number of experiments needed. Furthermore, the use of raw material, time and natural resources will be decreased improving the efficiency of the process. This paper reports the removal of zinc ions from aqueous solutions containing n-butanol and sodium chloride by MEUF. The micelles were formed by adding the anionic surfactant sodium dodecyl sulfate (SDS) to the solutions. The main purpose was to separate zinc ions from the aqueous solutions. Additionally, the removal of n-butanol was also expected. Another goal of the present study was to screen the effect of pressure, membrane nominal molecular weight limit, the feed concentration of zinc, n-butanol, sodium chloride and SDS on the process performance.

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## 2. MATERIAL AND METHODS

### 2.1. Chemicals and equipments

All chemicals involved in the experiments were of analytical reagent grade. Zinc chloride ($ZnCl_2$ extra pure 99.99%) and sodium dodecyl sulfate (SDS, purity > 99%) from Fisher Scientific, UK were used without further purification. SDS has a molecular weight of MW = 288.38 g/mol and it's CMC equal to 8.2mM (2.36 g $l^{-1}$) [8].

N-butanol (obtained from Kemfine Oy, Finland) was supplied by Aldrich. The distilled water used in this study was purified by a Milli-Q plus water purification system (Millipore, USA) and had an initial resistivity of 18.2 MΩ-cm. N-butanol was determined by gas chromatography with a flame ionized detector (Agilent, 6890N). Sodium chloride (Merk, pro-analysi) was quantified.

The concentration of zinc was determined by Atomic Absorption Spectroscopy (Perkin Elmer 4100 with 3047 and 3044 flame atomization methods). The SDS content was analyzed by Total organic carbon portable analyzer (Sievers 900 Portable).

### 2.2. Experimental design

A set of experiments was designed by Modde 8.0 (Umetrics) using a fractional factorial design (Table 1). The factors and their respective range to be studied were pressure (P, 20 and 70 psi), SDS feed concentration ($C_{SDS}$, 3.5 and 20 mM), Zinc feed concentration ($C_{Zn^{2+}}$, 0.5 and 3mM), Sodium Chloride feed concentration ($C_{NaCl}$ 0 and 1w%), butanol feed concentration ($C_{BuOH}$ 1 and 13 mM) and membrane nominal molecular weight limit (NMWL 3 and 10 kDa). Three centre points were included to analyze the reproducibility of the experiments.

Table 1. Experiments conducted using fractional factorial design and their respective results.

| Screening Part | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Experimental Number | Factors | | | | | | Responses | |
| | $C_{SDS}$ [mM] | $C_{BuOH}$ [mM] | $C_{Zn2+}$ [mM] | $C_{NaCl}$ [mM] | Pres. [psi] | NMWL [kDa] | J [$Lm^{-2}h^{-1}$] | $R_{Zn2+}$ [%] |
| 1 | 3.5 | 1 | 0.5 | 0 | 20 | 3 | 3.26 | 73.38 |
| 2 | 20 | 1 | 0.5 | 0 | 70 | 3 | 17.51 | 99.22 |
| 3 | 3.5 | 13 | 0.5 | 0 | 70 | 10 | 69.51 | 53.70 |
| 4 | 20 | 13 | 0.5 | 0 | 20 | 10 | 13.15 | 95.98 |
| 5 | 3.5 | 1 | 3 | 0 | 70 | 10 | 60.81 | 37.83 |
| 6 | 20 | 1 | 3 | 0 | 20 | 10 | 11.36 | 96.86 |
| 7 | 3.5 | 13 | 3 | 0 | 20 | 3 | 3.46 | 36.98 |
| 8 | 20 | 13 | 3 | 0 | 70 | 3 | 20.15 | 90.02 |
| 9 | 3.5 | 1 | 0.5 | 1 | 20 | 10 | 10.34 | 17.52 |
| 10 | 20 | 1 | 0.5 | 1 | 70 | 10 | 63.31 | 57.70 |
| 11 | 3.5 | 13 | 0.5 | 1 | 70 | 3 | 18.60 | 23.19 |
| 12 | 20 | 13 | 0.5 | 1 | 20 | 3 | 2.64 | 56.75 |
| 13 | 3.5 | 1 | 3 | 1 | 70 | 3 | 34.10 | 9.91 |
| 14 | 20 | 1 | 3 | 1 | 20 | 3 | 4.17 | 42.29 |
| 15 | 3.5 | 13 | 3 | 1 | 20 | 10 | 12.88 | 13.42 |
| 16 | 20 | 13 | 3 | 1 | 70 | 10 | 54.30 | 54.87 |
| 17 | 11.75 | 7 | 1.75 | 0.5 | 45 | 5 | 12.21 | 65.36 |
| 18 | 11.75 | 7 | 1.75 | 0.5 | 45 | 5 | 12.88 | 65.68 |
| 19 | 11.75 | 7 | 1.75 | 0.5 | 45 | 5 | 12.76 | 65.05 |

The measured responses were the rejection coefficients for zinc ($R_{Zn}$) and butanol ($R_{BuOH}$) and the absolute permeate flux ($J_V$), which were calculated with the following equations:

$$R = 1 - \frac{C_p}{C_r}, \tag{1}$$

where $C_p$ and $C_r$ are the zinc or n-butanol concentration in the permeate and retentate, respectively.

$$J_V = \frac{V}{t \times A}, \tag{2}$$

where $J_v$ is the absolute permeate flux, V is the volume of the permeate sample collected, t is the time needed for collecting the permeate sample and A is the membrane effective area. The validity of the empirical models fitted with multiple linear regression (MLR) was tested with analysis of variance (ANOVA). The confidence level used was 95 %.

### 2.3. Dead-end micellar-enhanced UF experiments

All UF experiments were carried out in batch solvent resistant stirred cell (Millipore, Model 8400) with a capacity of 400 $cm^3$. In all MEUF tests the TMP was controlled and adjusted with pressurized $N_2$ gas by means of a transducer. The operating temperature was 25 ± 1°C controlled by an air conditioner. The solution in the reservoir was agitated using a magnetic stirrer to provide efficient mixing at 500 rpm. This stirring speed was selected because it could lead a sufficient agitation to result

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a homogenic solution without excessive vortex formation. The permeate flux was determined by measuring the first 100 $cm^3$ (five times 20 $cm^3$) of the feed solutions. In each experiment the first, second and the fifth permeate sample was analyzed and then integrally averaged because the compositions of the permeate varied during the experiments.

In the dead-end ultrafiltration (UF) experiments, UF flat sheet membranes of Amicon regenerated cellulose (PL series, Millipore) of different nominal molecular weight limits were used. Each membrane has a membrane effective area of 0.004$m^2$. Only the membranes with a deviation of the pure water flux, measured before and after MEUF tests, smaller than 5 % were repeatedly used. Ultra distilled water was used after each experiment test for membrane cleanings.

### 2.4. Experimental procedures

The initial feed volume was 200 $cm^3$. The average permeate flux was calculated by measuring the time needed for collecting permeate samples of 20 $cm^3$. The ultrafiltration experiments were carried out until 100 $cm^3$ of the total sample was filtered (VCF = 2). The VCF is defined in Eq. (3):

$$VCF = V_b / V_e \quad (3)$$

where $V_b$ and $V_e$ are the volumes of solutions in the MEUF device at the beginning and at the end of the test, respectively. The membrane was submerged before the concentration tests for 1 h to reach equilibrium with the solution.

## 3. RESULTS AND DISCUSSIONS

The main purpose was the simultaneous removal of $Zn^{2+}$ and n-BuOH by MEUF. From table 1 can be observed that butanol was not removed using micellar-enhanced ultrafiltration. The reason why the $R_{BuOH}$ is not included in Table 1 is that, in all cases, the rejection coefficients of BuOH were very low (average 5 ± 2 %). Therefore, the research was continued in order to see the effect of the mixture of butanol and salt in the removal of zinc by micellar-enhanced ultrafiltration. In this way, the responses included in the experimental design were $R_{Zn}$ and $J_v$.

### 3.1. Effects of factors on the absolute permeate flux

The effect of single factors on the permeate is illustrated in Fig. 1, displaying the change in the response when a factor varies from its low level to its high level while all other factors are kept at their averages. Negligible effects are those where the confidence interval includes zero.

As it can be observed from Fig. 1, pressure has a positive effect on the absolute permeate flux as expected. This means that increasing the pressure, higher permeate flux will be achieved. When pressure is increased the driving force is also increased obtaining a higher flux. NMWL has also a positive effect. Consequently, using a higher pore size membrane higher flux will be observed. Further, concentrations of SDS, BuOH, $Zn^{2+}$ and NaCl show a negligible effect on the absolute permeate flux.

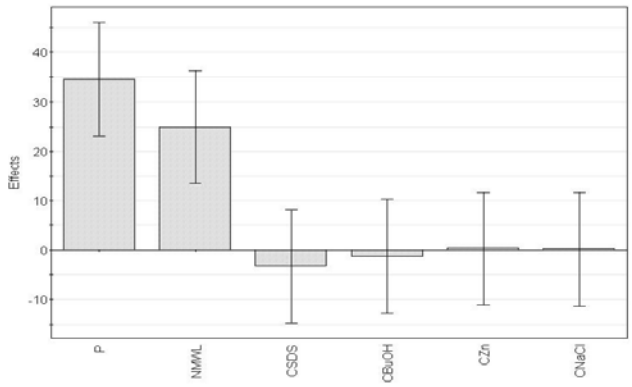



Figure 1. Effect of main factors on the absolute permeate flux

When evaluating the validity of the fitted model with ANOVA, the regression model is statistically significant with a 95% confidence level in the range studied. The response variation percentage explained by the model, $R^2$, for the permeate flux is 0.85. The response variation percentage predicted by the model, $Q^2$, is 0.60. The reproducibility of the experiments is good.

### 3.2. Effect of factors on the rejection coefficient

The effect of single factors on the permeate is illustrated in Fig. 2, displaying the change in the response when a factor varies from its low level to its high level while all other factors are kept at their averages. Negligible effects are those where the confidence interval includes zero.

As it can be observed from Fig. 2, the concentration of SDS, NaCl and the $Zn^{2+}$ have the major effect on the rejection coefficient. Concentration of SDS has a most significant positive effect, thus, when increasing the SDS feed concentration, the rejection coefficient is also increased. This is because at higher SDS concentration, more SDS is present in micellar form. NaCl concentration of the feed has a negative effect on the rejection coefficient, therefore, increasing it will decrease rejection. This result complies with earlier study [9] reported in the literature. Since $Na^+$ is a monovalent ion, it can readily bind with the negative charge head of the micelle competing with the heavy metal cations. Therefore, rejection coefficient decreases with an increase in the salt concentration. Further, zinc feed concentration also shows a negative effect on the rejection coefficient. Consequently, when increasing the zinc feed concentration rejection coefficient decreases. This shows that MEUF is more efficient for

diluted heavy metal streams. Further, concentrations of NMWL, BuOH and pressure show a negligible effect on the rejection coefficient.

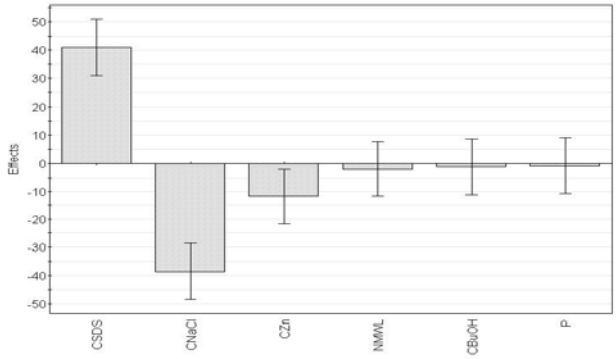



Figure 2. Effect of factors on the rejection coefficient of zinc

When evaluating the validity of the fitted model with ANOVA the regression model is statistically significant with a 95% confidence level in the range studied. The response variation percentage explained by the model, $R^2$, for the permeate flux is 0.93. The response variation percentage predicted by the model, $Q^2$, is 0.82. The reproducibility of the experiments is good.

## 4. CONCLUSIONS

In this study, the removal of zinc ions ($Zn^{2+}$) and n-butanol (n-BuOH), including salt (NaCl) from model synthetic wastewater was investigated by micellar-enhanced ultrafiltration (MEUF) using an anionic surfactant agent, sodium dodecyl sulfate (SDS).

It was found that n-butanol could not be removed by using MEUF. On the contrary, $Zn^{2+}$ was successfully removed obtaining rejection coefficients up to 99% in the most favorable experimental conditions.

A statistical experimental design (including Screening Part, SP) was used in order to analyze the effect of initial concentration of $Zn^{2+}$, n-BuOH, SDS, NaCl on the process performance. Further, the effect of Transmembrane Pressure (TMP) and membrane nominal molecular weight limit (NMWL) were also studied.

Pressure and NMWL have the most significant positive effects on the absolute permeate flux. Concentration of SDS has the most important positive effect, while NaCl has the most important negative effect on the rejection coefficient. Further, $Zn^{2+}$ feed concentration has the major negative effect on the rejection coefficient.

By using fractional factorial design, the effects of 6 different factors on the MEUF process performance were evaluated in only 19 experiments. This shows the high effectiveness of experimental design for screening experiments. Further, experimental designs can now be developed as the factors with statistically no significant effect are identified.

**ACKNOWLEDGMENTS**

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# FATIGUE TESTS AT HYBRYD ALUMINUM ALLOY JOINTS

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**Abstract:**
This paper presents a study on fatigue performance of adhesive/rivets joints in an aluminum structures. Hybrid joints were shown to have greater strength, stiffness and fatigue life in comparison to adhesive joints. The results from fatigue tests confirm the static tests made on the same type of test samples.

**Keywords:**
Aluminum, Adenit, Si-Plane, joints

## 1. INTRODUCTION

Aluminum alloy joints are used in aircraft construction, some cars, railway vehicles etc. The joints can be assembling by welding, gluing, rivets etc.

In this paper it will be presented joints assembled hybrid (gluing and rivets).

The tests were performed in the CEEX program named "Adhesives, Rivets and Hybrid Aluminum Alloy and Composite Materials Joints".

## 2. MEASUREMENT DEVICES AND JOINT TYPES

The tensile fatigue tests were performed at Romanian Railway Authority – AFER on universal testing machine SI-PLANE 942-1 type (fig. 1). The testing machine was designed and manufactured by British Company Si-Plan Electronics Research Limited in the year 2005.

The machine is hydraulically manipulated from a computer and can perform tests with tensile or compressive forces (static and dynamic) and it has the next characteristics:

- Maximum force for static tests: ±350kN;
- Maximum force for dynamic tests: ±250kN;
- Maximum high for the vertical tests: 400mm;
- Frequency for dynamic tests: ≤ 40Hz.

All the preparing operations and the test are performed by the hydraulic installation of the machine. He steps for performing the tests were:

1. Each type of joint was named **N"tip"n** , where „**tip**" means the joint type of the aluminum alloy (nit – rivet joint, hib – hybrid joint or adz – adhesive joint), ***N*** is given by the thickness of the material or the joint geometry and ***n*** is the identification number for the same type of joint.
2. For each of joint a reference tensile force was calculated based on static tests which were performed on other stage of the project.
3. Based on reference tensile force, the maximum and minimum dynamic tensile forces were calculated for five value domains as following: 80%, 70%, 60%, 50% and 40% from the reference tensile force and the minimum values were 10% from the maximum values (the 1/10 value was used for each fatigue cycle).
4. A 5Hz frequency was used for all fatigue tests. During the test it was cases when the joints break it after hundreds of cycles before to reach the stability of the dynamic regime at 5Hz frequency (the test was repeated if it was possible on another same type joint) or the joint doesn't break it not even after 500.000 cycles.

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5. For each joint it was recorded the number of cycles when the joint was break it and the type of joint break (adhesive, cohesive or adhesive-cohesive).
6. Photos were made on each joint before, during and after the tests. Also a print screen on Si-Plane machine computer for each joint was made. In this print screen it is shown the minim and maximum of force cycle, frequency and number of cycles.
7. Based on values recorded at step number 6, the normalized curve $S-N$ (Wöhler curve) was draw by quasi-linearity interpolation which crosses the horizontal axis in the point which has the coordinates (0; 1).

$$\frac{F_M}{F_R} = 1 - k \cdot \lg(N) \quad (1)$$

which mean that the ratio between maximum force of the cycle and the reference force depending on decimal logarithm of breaking number of cycles.

8. The tests were performed at 21 degree Celsius temperature and 55% relative humidity.



Figure 1 The Universal Testing Machine SI-PLAN 942-1 type

Many types of joints were tested. The aluminum pieces were jointed in different shapes: end to end, one above other, angle joint etc. as follows:

- Adhesive joints;
- Hybrid joints (adhesive+rivet).

In fig. 2÷3 are shown the types of joints were the value of ratio 1/K had the highest value.

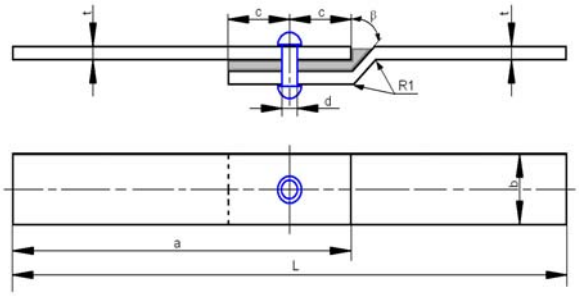



Figure 2 4hib joint type

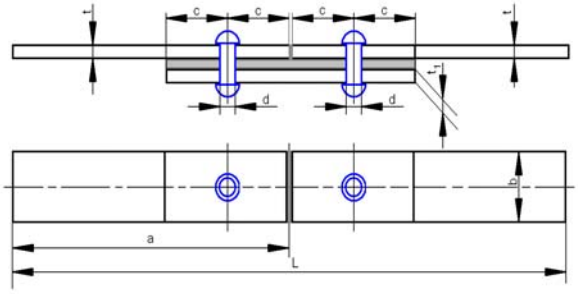



Figure 3 5hib joint type

## 3. RESULTS

### 3.1. 4hib joint type

In table number 1 are presented the results for 4hib joint type.

Regarding to this table the following explanation are necessary:

- $F_{max}$ and $F_{min}$ measured in daN units are maximum and minimum value for a pulsate cycle at 5Hz frequency;
- The value $F_{max}$=170daN, is represent 60% from tensile reference force;

Table 1. Results for 4hib joint type.

| Proof sample | $F_{max}$ | $F_{min}$ | N | Lg(N) |
|---|---|---|---|---|
| 4hib_3 | 170 | 17 | 59844 | 4,78 |
| 4hib_4 | 200 | 20 | 184432 | 5,27 |
| 4hib_5 | 200 | 20 | 2579 | 3,40 |
| 4hib_6 | 230 | 23 | 68413 | 4,84 |
| 4hib_7 | 230 | 23 | 2583 | 3,41 |

- The value $F_{max}$=200daN, is represent 70% from tensile reference force;
- The value $F_{max}$=230daN, is represent 80% from tensile reference force;
- N is the number of cycles when the joint break it.

In fig. 4 is shown the normalized Wöhler curve draw by quasi-linearity interpolation.

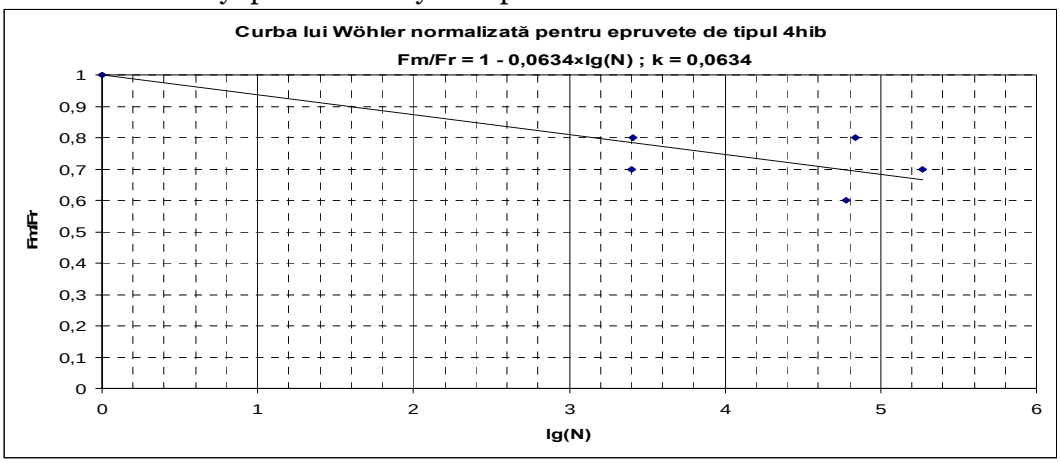



Figure 4 Wöhler curve for 4hib joint type




Figure 5. Adhesive break




Figure 6. Metal break

The proof sample 4hib_3, 4hib_4 and 4hib_6 were break it in the metal and the proof sample 4hib_5 and 4hib_7 were break it in the adhesive.
In fig. 5 it is presented an adhesive break and in fig. 6 it is presented a metal break.

### 3.2. 5hib joint type

In table number 2 are presented the results for 5hib joint type.

Regarding to this table the following explanation are necessary:

- $F_{max}$ and $F_{min}$ measured in daN units are maximum and minimum value for a pulsate cycle at 5Hz frequency;
- The value $F_{max}$=190daN, is represent 60% from tensile reference force;
- The value $F_{max}$=220daN, is represent 70% from tensile reference force;
- The value $F_{max}$=260daN, is represent 80% from tensile reference force;
- N is the number of cycles when the joint break it.

Table 1. Results for 5hib joint type.

| Proof sample | $F_{max}$ | $F_{min}$ | N | Lg(N) |
|---|---|---|---|---|
| 5hib_6 | 190 | 19 | 240037 | 5,38 |
| 5hib_4 | 220 | 22 | 103031 | 5,01 |
| 5hib_7 | 220 | 22 | 120806 | 5,08 |
| 5hib_8 | 220 | 22 | 40100 | 4,60 |
| 5hib_5 | 260 | 26 | 605 | 2,78 |
| 5hib_9 | 260 | 26 | 1939 | 3,29 |
| 5hib_10 | 260 | 26 | 5537 | 3,74 |

In fig. 4 is shown the normalized Wöhler curve draw by quasi-linearity interpolation.

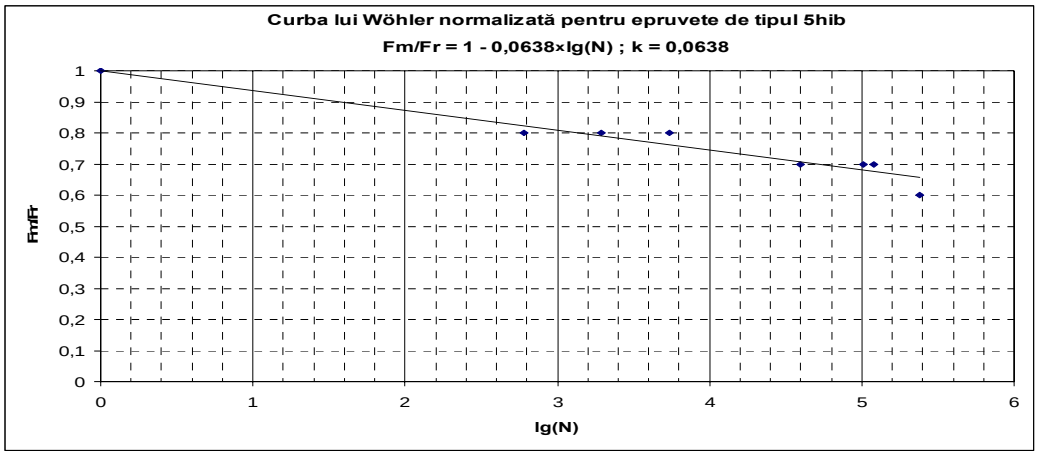



Figure 7 Wöhler curve for 5hib joint type



Figure 8 5hib_6 proof sample



Figure 9 5hib_9 proof sample

The proof sample 5hib_6 has an adhesive break but not a rivet break. The proof sample 5hib_4 has an adhesive-cohesive break and the other proof sample had an adhesive break.

In fig. 8 it is presented an adhesive break and in figure 9 it is presented an metal break.

## 4. CONCLUSION

In fig. 10 the different types of joints had been arranged from the point of view of 1/K ratio (the inverted of normalized Wöhler curve) which significance is the fatigue lastingness of the proof sample.

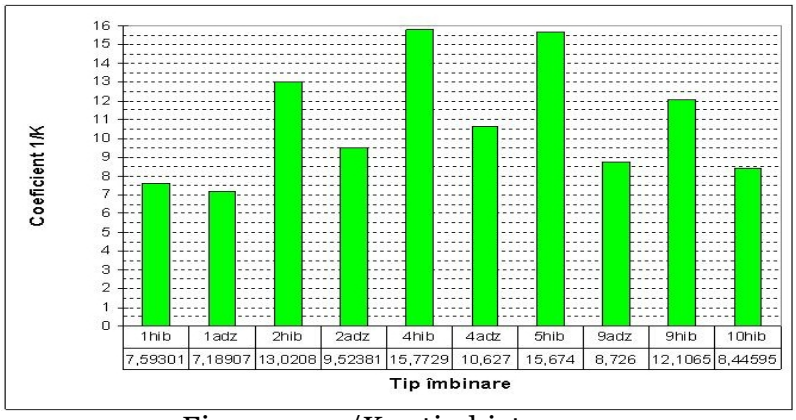



Figure 10. 1/K ratio histogram

From fig. 10, it can be seen that the hybrid proof sample number had a higher lastingness but we must remember that the tensile reference forces are different from one type of joint to other (the tensile reference forces are higher at adhesive joints).

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# ROTORS CASTING FOR AVIATION TURBOCOMPRESSORS

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**ABSTRACT**

Choosing the best casting technology is made considering the quality indices (I.C.) of the casted part, in the status of FINICHED PART. Each phase of the technological process has several possibilities with advantages and disadvantages of techno-technological nature, efficiency, production or the domain in which the part is used.

The projection of the casting technology is realized taking into consideration several imposed parameters – which much be applied and included in the technology which is used and various operations, phases, materials, SDV and technologic equipments, which support optimization processes in order to assure total quality to the casted part.

The current paper intends to present the methodology for choosing the optimum casting technology for a turbo compressor rotor used in the aviation, part which must be assimilated in the national industry.

**Key words:**

casted turbo compressor rotors used in the aviation industry; precise casting thru special procedures, non-conventional

## 1. INTRODUCTION

In a flying aircraft is activating four forces which have to be in equilibrium; these forces are weight, traction, resistance and portanta (fig. 1).




Fig 1 Force systems which operate on an airplane

The traction is assured by the propulsion system; considering the propulsion system the airplanes can be classified in:

- Propeller solutions – equipped with classic engines with pistons (AN-2, Cessna 172, ZLIN Z-142);
- Reaction airplanes – equipped with turbo reaction engines (Boeing 747, A340, MIG-21, F-16, AN-124, Concorde);
- Constructions with propeller and reaction – equipped with turbo propulsion engines (ATR-42, C-130 Hercules).

An engine with reaction produces traction in a similar way as the engine-propeller combination, but while the propeller gives a small acceleration to a high quantity of air, the engine with reaction gives a high acceleration to a small quantity of air.

Currently, there is a large diversification for the aviation engines; if we refere strictly to engines with reaction as aero-reactors, these are developed as:

- Turbo-reactor engine
- Sato-reactor engine: with subsonic burn – ramjet type; with supersonic – scramjet type;
- Pulsoreactor engine;
- Motoreactor engine.

SIMPLE ENGINE REACTOR - MTR is currently equipping the aircrafts flying at high altitudes and speeds over Mach 0.6. Its operating principle is as follows: air entering through the inlet is compressed by the compressor, enters in the combustion chamber where together with fuel injected mixture of combustion gases takes place the actual combustion. The burned gases then pass through the turbine, where the partial retaining thru their rotation, and then pass through the nozzle side and leaving the system with a kinetic energy much higher than the input, thus is providing the traction of the plane. Eventually, at supersonic airplanes we can meet the post-combustion; it is incorporated into

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the exhaust system and has the role to inject a fuel mixture dose in the combusted gas from the combustion chamber.

We have to remember that the double flow turboreactor engines - called generically turboventilator - are actually turboreactor modified. They are characterized by the existence of two streams flowing parallel: one secondary, trained by a fan mounted on the compressor shaft with a low-pressure turbine, which takes the flow of primary air (inside) made from waste gases. The traction of the dual-stream engine is the thrust of the two resulting streams. Do not forget that the fan has the role of propulsion, operating as a propeller. The double flux turboreactor engine - MTR + DF are the most widespread types of aviation engines, which is equipping most of the civilian aircraft and a good part of military aircraft (see tab. 1).

Tabel 1. Types of reaction engines and airplanes equipaded with such systems

| LICENCE – PRODUCTION | AIRPLANE MODELS |
|---|---|
| CIVIL AIRPLANES | |
| SNECMA-GE CFM-56 | Boeing 737, Airbus A318, A319, A320, A321 |
| General Electric GE90 | Boeing 777 |
| CF6 | A300, A310, A330, Boeing 747 |
| Pratt & Whitney JT9D | B747, Boeing 767, A300, A310 |
| W4000 | B777, A330 |
| PW6000 | A 380 |
| Rolls-Royce Trent 500-900 | For almost all types of Boeing and Airbus |
| MILITARY AIRPLANES | |
| General Electric F110 | F14, F15, F16 |
| F103/CF6 | Air Force One, B767 AWACS |
| F404 | F/A-18, F117, A-4 Skyhawk |
| Rolls-Royce EJ200 | Eurofighter Typhoon |
| Pegasus | Boeing-BAe Harrier |
| Snecma M53 | Mirage 2000 |
| M88 | Rafale |

A turbine which functions on gas is a thermo one, which uses the fall of the enthalpy of a gas or a mixture of gases to produce through the spinning blades a quantity of mechanical energy available for the turbine; the gas turbine is also known as GAS TURBINE INSTALLATION – ITG.

For the thermodynamics point of view a gas turbine works rather like a car engine. Atmospheric air is admitted in a blades compressor, where is compressed, follows the introduction of a fuel's ignition and its ignition in a combustion chamber. The combustion gases are then discharged into the atmosphere. The process is continuous, and the parts execute only rotation movements, which for a period of time might lead to smaller total mass; as a result, gas turbines were developed especially as reaction engines: turboreactor, turbo propeller, turboventilator and turbines to engage the helicopter propellers (see tab. 2).

The most prevalent type of jet aviation is the turbojet, the main constructive elements: the speaker, compressor, combustion chamber, gas turbine and effuse component.

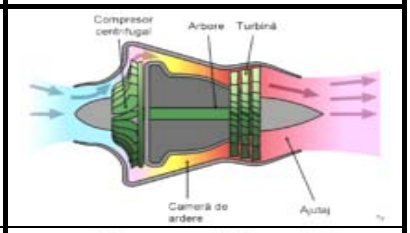
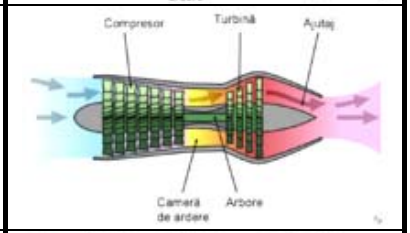
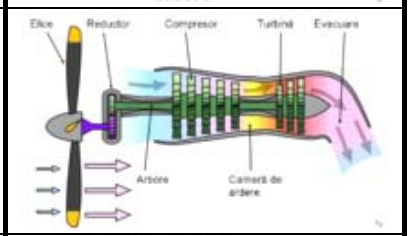
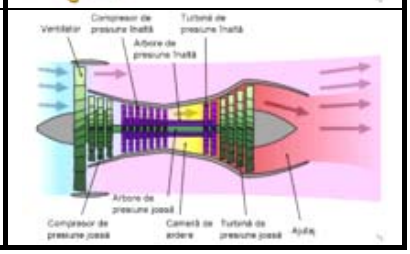
THE COMPONENTS OF A COMPRESSOR - Compressors are labor consuming machine through which gas pressure is raised. After operation principle, compressors can be classified into two main groups namely:

- Volumetric compressor (pressure at which gas lifting is done by closing it within a certain volume, decrease the volume until the lifting of the gas discharge pressure and gas evacuation). In this group can be piston compressors, which have a cylinder moves linearly and rotary compressors, which also have a cylinder in which we can find a piston with rotary motion. These compressors are used for high and very high pressures (1000 bar), with relatively small gas flows (450 cm3/min);
- Dynamic compressor (to increase pressure is done by transferring kinetic energy to the gas, through a large propeller rotor, followed by its conversion into potential pressure energy, the process taking place continuously; in this group we can include the centrifugal compressors and the axial compressors) .

At centrifugal compressors the energy transformation is done through centrifugal force on gas molecules, brought in a circle movement with a propeller rotor. Depending on the ratio of the pressure pr and suction pressure pa, we can identify: - turbo-compressor if pr / pa> 2.5; turbo-ventilator if 1.1 <pr / pa> 2.5; ventilator if pr / pa <1.1.

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Tabel 2. Typical construction, principle, for turbine with aviatic gaz and typical solutions for jet engines

| Constructive types of turbines | Reactive engines |
|---|---|
| Turboreactor with centrifugal compressor |  |
| Turboreactor with axial compressor |  |
| Turbopropulsor |  |
| Turboventilator |  |

In axial compressors the transformation of energy is through done through a gas dynamic forces acting on gas molecules, caused by a large rotor. Are used for pressures of 5 - 6 bar and flow rates that can exceed 10,000 m3/min.

## 2. THE STUDY

High flow centrifugal compressors have a simple rotor or a double sided one, and occasionally is used the two-tier version, simple as building the Rolls-Royce Lance (Dart) engine. Rotor is supported in a housing which also contains a ring of the speaker. If using a rotor with double-entry, the air flow towards the rear is reversed in the opposite direction and requires an intermediary room.

Rotor is whirled at high speed by the turbine and the air is controlled permanently by the rotor. Centrifugal force makes the air flow to propagate to the outside, over to cavil (wall profile) so that accelerating mass will cause an increase in air pressure. Inlet pipe of the engine can be imperfect, which can cause an initial turbulence of the air at its entrance into the compressor.

To maximize air flow and increased pressure by the compressor is necessary that the rotor is rotated at high speeds; thus rotors are designed to work on the peripheral speeds of about 500 m / s.

Aviation turbo compressor rotors are made with different construction solutions, with advantages and disadvantages - aerodynamic efficiency, endurance and reliability, economic efficiency and maintenance:

1. Disk blades, mono-block (similar rotor Platan from dense liquid pumps), active on one part or both sides (see fig. 2);
2. Blocks, embedded in pallets (combined with a type of swallow tail), which on the outside may or may not be additional reinforced with a circular fitting (as classic steam turbines);
3. Sandwich, with two lateral discs, which are disposed profiled palettes (like the suction fan).



Fig. 2 Specific constructions of rotors of centrifugal compressors in aviation

The designer and the company which obtains the manufacturing license is the owner of technical solutions found, they provide and require a number of features and performance of these rotors, which must be accomplished by the casted part, realized by the technologist: shape, configuration and stability during operation; nominal dimensions and admissible tolerances; speed, peripheral speed, temperature and duration of continuous operation to achieve necessary thermodynamic efficiency; flatness of the surfaces, cost limits for part assimilation and production etc.

## 3. ANALISES, DISCUSIONS, APPROACHES, INTERPRETATIONS

The design technical work linked with computer applications is defined as COMPUTER AIDED DESIGN - CAD.

CAD applications, with systems for designing assistance are the most known and consist of the following:

1. a field of communication organizes data entry and exit to and from the design department;
2. a range of methods includes modules for modeling work, information and calculations;

3. a field of administration and management of data and a system of integrated data bank organizes all storage and transfer of data between algorithms and methods of communication on the one hand, and networks of data banks or specialized individual files or standardized on the other; database of design contains all the geometric data and stored non -geometric that both methods are needed to design and communication between the operator and the CAD designer.

A fundamental feature of CAD systems is constituted by the concept RID = internal representation of geometric objects. This system is based on the real object; abstraction is achieved by a virtual mental model, in which the formalization and multiple filtering in specific languages leads to the INFORMATION MODEL. Through a series of transformations and transpositions based on the binary code, it is formed an internal model in the computer memory - RIM type configuration.

Chaining programs with systems engineering data processing, in the engineering sciences field, is abbreviated CAE = COMPUTER AIDEDE ENGINEERING.

The integration of a firm in a complex and comprehensive system of monitoring, processing and managing data is known as COMPUTER INTEGRATED MANUFACTURING - CIM.

In the specific area of design technology of casting systems are used systems as COMPUTER ASSISTED CONCEPTION AND MANUFACTURING - CFAO, and sub-programs: COMPUTER ASSISTED DESIGN - DAO, COMPUTER ASSISTED MANUFACTURING - FAO, COMPUTER ASSISTED CONCEPTION - CAO.

Using computer graphics reduce the period of conception and design; starting from the establishment, development and multiplication of simple design drawing by 3D techniques there have been realized programs that allow complex projections for simple parts or complex parts, rapid completion of drawings by the importation of printed standardized elements (screws, axles, rolling bearings, gears, etc..), the production of prototypes to test the functionality of products for approval and launch phases in the series of casting technologies assimilated.

It has the following special procedures for casting accuracy:

- Static casting in metal shape - shell;
- Casting under high pressure (ICTY) - in the mold;
- Casting at low pressure (TJP) - in the form of mixture or matrix;
- Casting static forms with binder strip thermo-reactive (bakelite; Croning process or Shell);
- Static casting oven by tilting forms multi-layer type crust or rind ceramic form casting, packaged or not: MUF model type, the request - made by injecting mold; MGP model type made by injection or expand in the mold -- REPLICAST process, models of resin made by SLA (see Fig. 3 and 4);
- Casting forms ceramic monolith, Shaw type: metallic, processed on modeling (tool-room) the model consumable - MUF, MGP = injection / expand; of resin, paper.

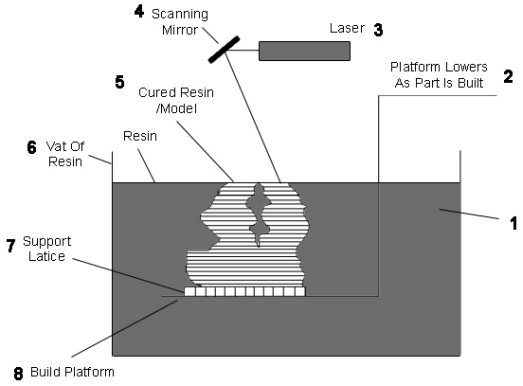



Fig. 3 Stereo lithography SLA: 1- liquid resin; 2 - model support; 3 - laser scanning system; 4 - mirror; 5 – solid model realized by polymerizing the resin; 6- compartment with liquid resin; 7– support for this model; 8 – system with vertical movement.

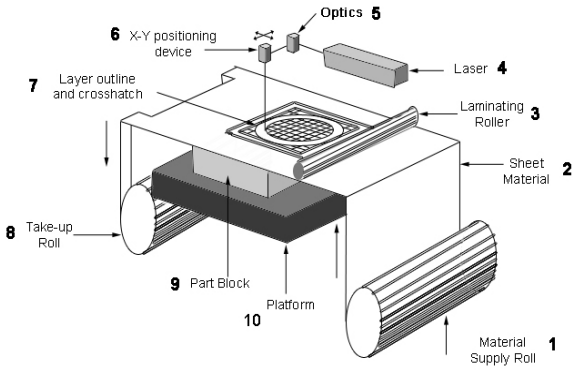



Fig. 4 Scheme to achieve prototypes through LOM technology : 1- material supply role; 2 – sheet material; 3 – laminating roller; 4 –laser scanning system; 5 - optics; 6 – positioning device; 7 – layer outline and crosshatch; 8 – take-up roll; 9 – part block; 10 – platform and system with vertical movement.

The stereo-lithography technique (variants RAPID PROTOTYPING, SLA, LOM) permits to fabricate photo-sensible resin prototypes (MODELS) by selective and controlled strengthening with laser beams and computer assisted control panel; is a current CAD application.

In Table 2 are listed the main indices of quality of casted parts by special casting processes, technologies by which are casted the rotors for turbo-compressors for aviation.

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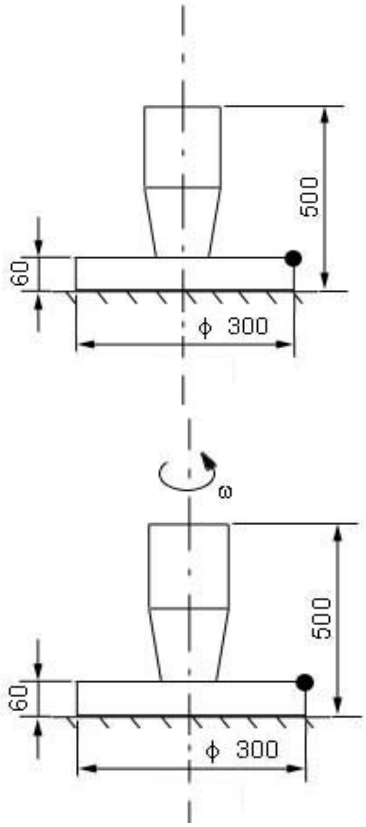
Tabel 2. The main quality indices of casted parts, casted by special procedures

| QUALITY INDICES | SPECIAL CASTING PROCEDURES | | | | | | |
|---|---|---|---|---|---|---|---|
| | CRONING or SHELL | Shaw | MUF ceramic shell | MGP ceramic shell Replicast | Static metallic forms | Casting at high pressure | Casting in liquid form |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Material often cast | cast iron, steel, ferrous super alloy | steel, cast iron, super alloy, nonferrous | special steel, iron, super alloy | special steel, iron, super alloy | non-ferrous, steel, iron, super alloy | non-ferrous (Al, Mg, Zn, Sn, Sb, Pb-Alloy, brasses, bronzes) | special steel, non-ferrous (silumins, brasses, bronzes) |
| Complexity of cast part | large, with cores, straight separation | large, with cores, without separation | Large, with cores, without separation | large, with cores, without separation | big, metallic and un-metallic cores, straight separation | large, with metallic cores, straight separation | small and medium, without cores |
| Parts size min., kg/pc.<br>Min. sizes, mm | 0.02<br>3.0 | 0.03<br>1.5 | 0.01<br>0.3 | 0.01<br>3.0 | 0.03<br>1.5 | 0.01<br>0.2 | 0.04<br>5.0 |
| Parts size max./usual, kg<br>Max. sizes, mm | 150 / 5.0<br>800 | 250 / 25<br>1200 | 40 / 0.8<br>600 | 80 / 15,0<br>700 | 130 / 10<br>800 | 50 / 5.0<br>700 | 60 / 10<br>300 |
| Dimensional precision, %<br>Dimensional tolerances, ± mm / la 100 mm | 10.5<br>± 1.5 | 3.5<br>± 0.4 | 2.0<br>± 0.3 | 3.0<br>± 0.4 | 11.5<br>± 0.8 | 1.5<br>± 0.2 | 12.0<br>± 2.0 |
| Usual rugosities, µm | 12.5 - 25 | 1.6; 3.2; 6.3; 12.5 | 1.6; 3.2; 6.3; 12.5 | 3.2; 6.3; 12.5; 25 | 3.2; 6.3; 12.5; 25 | 1.6; 3.2; 6.3; 12.5 | 25 - 50 steel; 3.2 – 6.3 nonferrous |
| Special properties registered for casted parts | for permanent magnets, refractory and anticorrosive steels, big productivity for iron | for steel-mold for forge and rubber and plastic industry | finless parts, threads from M5 casting parts without pulp, high productivity | Steel parts, big dimmensions like by MUF | armed with inserts parts, parts of cast iron with hard crust, nonferrous with fine structure | finless parts, threads from M2 casting, with micro-porosity, volumetric solidification, armed pieces | structure-oriented material, fibrous, very compacted, special steel and nonferrous |
| SDV durability, max. no. pc. casting parts | 100000 | 25000 | 100000 | 1000000 | 10000 | 50000 | 5000 |
| Efficient lots/ production series, min. pc. | 10000 / 1000000 | 1000 / 15000 | 1000 / 100000 | 1000 / 100000 | 500 / 10000 | 20000 / 1000000 | 1000 / 10000 |

## 4. CONCLUSIONS

As it is known, the mixture forms – ceramics, used exclusively preheating, ensure moderate rates of cooling; on the one hand it fosters a directed and successive solidification, but the gross cast part has a rough appearance, with impurities, which complicates the thermo treatment.

Possibly to increase the wall capacity and its fluidity, either will be used the tipping of the oven when crust shape or form will spin Shaw (see fig. 5, where a rotor with Ø 300 mm and H 60 mm - the horizontal position, with the blade down and blocking the top; for calculation is considered the highest point at the top of the blade).




$$P = \gamma \cdot H$$
$$H = 440\,mm$$
$$\gamma = 7.8\,daN/dm^3$$
$$\Rightarrow P = 7.8\,daN/dm^3 \cdot 4.4\,dm =$$
$$P = 34.32\,daN/dm^2$$

$$P = \rho \cdot \left( \frac{\omega^2 \cdot r^2}{2} - g \cdot z \right) + C \Leftrightarrow$$
$$P = \gamma \cdot \left( \frac{\omega^2 \cdot r^2}{2g} + z_o - z \right)$$
$$H = 440\,mm$$
$$\gamma = 7.8\,daN/dm^3$$
$$n = 600\,rot/min$$
$$\omega = \pi \cdot n / 30 = 3.14 \cdot 600 / 30 = 62.80\,rad/s$$
$$\Rightarrow P = 7.8 \cdot \left( \frac{62.8^2 \cdot 15^2}{2 \cdot 980} + 44 \right) =$$
$$= 7.8\,daN/dm^3 (452.74\,cm + 44\,cm) =$$
$$= 7.8 \cdot 496.74 \cdot 10^{-1}\,daN/dm^2 =$$
$$P = 387.45\,daN/dm^2$$

Fig. 5 Calculation scheme for the metal-static pressure: a – for static casting; b – for centrifugal casting, with vertical ax.

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# THE PROMOTING, THE PARTNERSHIP AND REGIONAL COLLABORATION OF FOUNDRIES

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**ABSTRACT**

The Information Society (I.S.) realized the salt from QUALITY stage (TECHNICAL QUALITY CONTROL – T.Q.C.) to the philosophy and the concepts of TOTAL QUALITY (T.Q.) and TOTAL QUALITY MANAGEMENT (T.Q.M.), with all their particularities and technical and economical consequences.

The activities and processes globalization involves new ways to realize and approach the PROMOTION, PARTNERSHIP and COLLABORATION concepts.

On the other hand, the IT&C field (INFORMATION TECHNOLOGY – IT; TELECOMMUNICATIONS - IT&T; COMPUTERS - IT&C) with its software and hardware elements, as fundamental support of the information society has become omnipresent and the INTERNET – a global way to communicate and an infinite data-base.

The current paper plans only to initiate some discussions in this vast area, which is continuing developing as fund and sophisticated in form.

## 1. INTRODUCTION

In short, is an online strategy to promote websites. More exactly, it is a plan to promote one's website through exclusively online tools, mainly aiming to attract as many new customers, following the strategy: minimum cost - maximum sales profits.

Essential stage of any marketing plan on the Internet is optimization of websites for their identification by search engines, and the insertion of domain and subdomains in web directories.

A modern business, no matter how big or small, is without a marketing plan on the Internet either only a local businessy or a simple business implemented without much perspective in time and space.

From my own experience, I concluded that any person, activity, achievement, etc., as valuable as it would be in theory, if it is not posted and promoted over the internet, is equivalent wth the absence of it. Everything is evaluated and compared with "something", which now the internet makes it accessible to us [2].

For a website to be accessed and seen by as many visitors, it must be designed and implemented a promotion campaign. Neither the best designed wesite doesn't worth anything, if it isn't brought to the attention of field specialists, the public opinion, which is becoming increasingly informed.

To watch how it is achieved this step can create a database that includes all actions to promote. For instance, for the promotion with the aid of search engines you can create a table includes the following information: name of search engine / directory, date of registration, the time required for registration; keywords used. After you complete the online form registration one must wait several days or several weeks (depending on the chosen search engine) until it is registered.

## 2. THE STUDY

An organization can absorb information from other organizations that are considered market leaders in this field based on the results achieved, aiming at continuously improve them [3.7].

To achieve this goal can be used benchmarking as a source of acceleration of organization's progress.

The essence of benchmarking is to choose what is best in a business, to adapt what is best from a company and to continuously improve your operations, by appropriate and specific strategies to ensure success.

Benchmarking is a tool used in management quality, appeared in early 1980 and first time was used by the US company Xerox, following the sudden decline of its market share.

As underlined in a report, the Committee on Industrial Productivity in the Institute of Technology in Massachusetts, benchmarking has been in recent years, an essential factor for success of the biggest known organizations in all areas of the economy.

Currently, the rapid development of the benchmarking lead to including it in the tools to improve the quality standard "ISO 9004-4: Quality management and quality system elements - Part 4. Guidelines for the increase of quality."

Specialists have brought a relatively high number of definitions of the new tool used in quality management and marketing. Among the most significant set of definitions are the following:

- In business, benchmarking is a process in which a company compares its products and methods with those of the most successful companies in its field, in order to try to improve its own performance;
- Benchmarking is the process of comparing the cost, time or quality of what one organization does against what another organization does. The result is often a business case for making changes in order to make improvements;
- Also referred to as "best practice benchmarking" or "process benchmarking", it is a process used in management and particularly strategic management, in which organizations evaluate various aspects of their processes in relation to best practice, usually within their own sector. This then allows organizations to develop plans on how to make improvements or adopt best practice, usually with the aim of increasing some aspect of performance. Benchmarking may be a one-off event, but is often treated as a continuous process in which organizations continually seek to challenge their practices;
- Benchmarking is the process of identifying, understanding and adopting the methods and processes of any outstanding world organization, in order to increase the organization's performance (the American Center for Quality and Productivity);
- Benchmarking represents the research of the best processes, procedures or results relevant to achieve the business targets. Therefore, the goal is to learn to improve ones performance (D.T. Kearns – Xerox GM);

In 2008, a comprehensive survey on benchmarking was commissioned by the Global Benchmarking Network (a network of benchmarking centers representing 22 countries - and for which the founder of benchmarking, Dr Robert Camp, is the honorary president). Over 450 organizations responded from over 40 countries. The results showed that:

1. Mission and Vision Statements and Customer (Client) Surveys are the most used (by 77 % of organizations) of 20 improvement tools, followed by Strengths, Weaknesses, Opportunities, and Threats SWOT (72 %), and Informal Benchmarking (68 %). Performance Benchmarking was used by (49 %) and Best Practice Benchmarking by (39 %);
2. The tools that are likely to increase in popularity the most over the next three years are Performance Benchmarking, Informal Benchmarking, SWOT, and Best Practice Benchmarking. Over 60 % of organizations that are not currently using these tools indicated they are likely to use them in the next three years;
3. When Best Practice Benchmarking is done well significant benefits are obtained with 20 % of projects resulting in benefits worth US$ 250,000.

## 4. ANALISES, DISCUSIONS, APPROACHES, INTERPRETATIONS

- Process benchmarking - the initiating firm focuses its observation and investigation of business processes with a goal of identifying and observing the best practices from one or more benchmark firms. Activity analysis will be required where the objective is to benchmark cost and efficiency; increasingly applied to back-office processes where outsourcing may be a consideration.
- Financial benchmarking - performing a financial analysis and comparing the results in an effort to assess your overall competitiveness.
- Performance benchmarking - allows the initiator firm to assess their competitive position by comparing products and services with those of target firms.
- Product benchmarking - the process of designing new products or upgrades to current ones. This process can sometimes involve reverse engineering which is taking apart competitors products to find strengths and weaknesses.
- Strategic benchmarking - involves observing how others compete. This type is usually not industry specific meaning it is best to look at other industries.
- Functional benchmarking - a company will focus its benchmarking on a single function in order to improve the operation of that particular function. Complex functions such as Human Resources, Finance and Accounting and Information and Communication Technology are unlikely to be directly comparable in cost and efficiency terms and may need to be disaggregated into processes to make valid comparison.

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For a department, industry, foundry in Romania or for an European regional cooperation can use concepts such as:

- "Horizontal benchmarking" - aimed at identifying best practices in the function of processes in referential organizations that are recognized as market leaders, but are not direct competitors of the organization conducting the benchmarking;
- "External benchmarking" - is similar to the horizontal one, but aimed directly competing organizations (in the same activity area);
- "Functional benchmarking" - aimed at comparing the functions of the organization conducting the benchmarking with a similar function in a given referential profitable organization;
- "Internal benchmarking" - aimed to analysis comparatively the processes of two departments of the same organization (one of them being considered as reference) [4.5].

There is no single benchmarking process that has been universally adopted. The wide appeal and acceptance of benchmarking has led to various benchmarking methodologies emerging. The most prominent methodology is the 12 stage methodology by Robert Camp (who wrote the first book on benchmarking in 1989): 1. Select subject ahead; 2. Define the process; 3. Identify potential partners; 4. Identify data sources; 5. Collect data and select partners; 6. Determine the gap; 7. Establish process differences; 8. Target future performance; 9. Communicate; 10. Adjust goal; 11. Implement; 12. Review / recalibrate. There are organizations which use other benchmarks models tailored to their needs (see fig. 1) [7]:

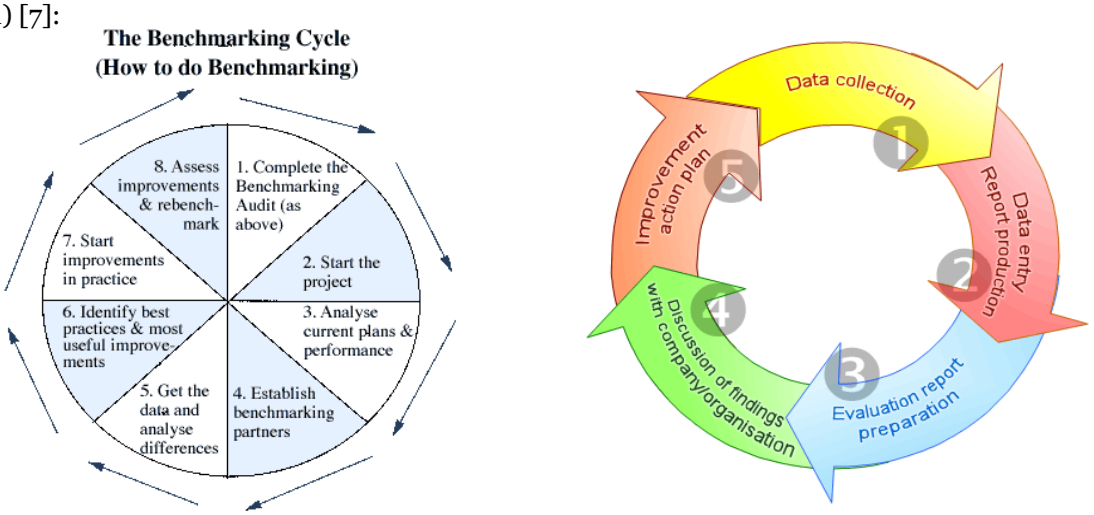



Fig. 1 Different benchmarking models

The following is an example of a typical shorter version of the methodology:

1. Identify your problem areas - Because benchmarking can be applied to any business process or function, a range of research techniques may be required. They include: informal conversations with customers, employees, or suppliers; exploratory research techniques such as focus groups; or in-depth marketing research, quantitative research, surveys, questionnaires, re-engineering analysis, process mapping, quality control variance reports, or financial ratio analysis. Before embarking on comparison with other organizations it is essential that you know your own organization's function, processes; base lining performance provides a point against which improvement effort can be measured.
2. Identify other industries that have similar processes - For instance if one were interested in improving hand offs in addiction treatment he/she would try to identify other fields that also have hand off challenges. These could include air traffic control, cell phone switching between towers, transfer of patients from surgery to recovery rooms.
3. Identify organizations that are leaders in these areas - Look for the very best in any industry and in any country. Consult customers, suppliers, financial analysts, trade associations, and magazines to determine which companies are worthy of study.
4. Survey companies for measures and practices - Companies target specific business processes using detailed surveys of measures and practices used to identify business process alternatives and leading companies. Surveys are typically masked to protect confidential data by neutral associations and consultants.
5. Visit the „best practice" companies to identify leading edge practices - Companies typically agree to mutually exchange information beneficial to all parties in a benchmarking group and share the results within the group.

6. Implement new and improved business practices - Take the leading edge practices and develop implementation plans which include identification of specific opportunities, funding the project and selling the ideas to the organization for the purpose of gaining demonstrated value from the process.

The technique initially used to compare existing corporate strategies with a view to achieving the best possible performance in new situations (see above), has recently been extended to the comparison of technical products. This process is usually referred to as „Technical Benchmarking" or „Product Benchmarking". Its use is particularly well developed within the automotive industry („Automotive Benchmarking"), where it is vital to design products that match precise user expectations, at minimum possible cost, by applying the best technologies available worldwide.

Many data are obtained by fully disassembling existing cars and their systems. Such analyses were initially carried out in-house by car makers and their suppliers. However, as they are expensive, they are increasingly outsourced to companies specialized in this area. Indeed, outsourcing has enabled a drastic decrease in costs for each company (by cost sharing) and the development of very efficient tools (standards, software).

Since the new tend in benchmarking practice establishes a partnership between organizations, before any activity, they are obliged to sign a statement by which each party undertakes to comply with the Code of Conduct for the benchmarking practice.

In the U.S., members of the American Center for Quality and Productivity (APOQ) must, if they practice benchmarking in partnership, apply 8 principles of the Code created by this institution (see tab. 1) [7.8 ].

Another approach to making comparisons involves using more aggregative cost or production information to identify strong and weak performing units. The two most common forms of quantitative analysis used in metric benchmarking are data envelope analysis (DEA) and regression analysis (RA).

DEA estimates the cost level an efficient firm should be able to achieve in a particular market. In infrastructure regulation, DEA can be used to reward companies/operators whose costs are near the efficient frontier with additional profits.

Table 1 Principles of A.P.O.Q. code in the benchmark partnership

| PRINCIPLE | RECOMANDATIONS |
|---|---|
| 1. Legality principle | • There is no discussion about costs<br>• One mustn't offer data and studies to other companies |
| 2. Mutual exchange principle | • The same kind of information is exchanged between partners<br>• All communication channels between partners are active |
| 3. Confidentiality principle | • It is forbidden to trade information with others without the partner's consent |
| 4. Using principle | • The obtained information can be used only in the initial purpose established between partners |
| 5. Contacting principle | • Must be respected the partner's company structure<br>• There will be contacted only the persons indicated by the partner<br>• Must be established communication procedures and responsibilities<br>• The names of the contact persons will be used, no matter the situation, only with their approval |
| 6. Activity preparation principle | • Must be set priorities in the initial contact with the partner<br>• Must be prepared carefully the information exchange between partners<br>• Mutual establishing of the activities and visits calendar |
| 7. The continuous improvement of the activity principle | • Following-up the manner in which is respected the activities calendar previously established<br>• Continuous recording of feed-back |
| 8. The principle of establishing mutual relations with the partner | • Delivery of information in the form and manner requested by the partner |

RA estimates what the average firm should be able to achieve. With regression analysis firms that performed better than average can be rewarded while firms that performed worse than average can be penalized. Such benchmarking studies are used to create yardstick comparisons, allowing outsiders to evaluate the performance of operators in an industry. A variety of advanced statistical techniques, including stochastic frontier analysis, have been utilized to identify high performers and weak performers in a number of industries

The London Benchmarking Group (LBG) is a group of over 100 companies working together to measure Corporate Community Investment (CCI).

It is a member-driven organization where companies have been working collectively since 1994 to:

- Continue development of a global measurement standard - the LBG model;
- Benchmark and share best practice;
- Develop and refine measurement tools;
- Improve management and implementation of CCI projects;
- Better communicate CCI results to stakeholders with LBG centers;

The model is used by hundreds of leading businesses around the world and LBG has centers in a number of key world markets including Australia, Canada, the Czech Republic, Germany and the US. Members include multinationals such as HSBC, Vodafone and Unilever, as well as major UK companies such as Marks and Spencer and BSkyB.

The LBG model provides a comprehensive and consistent set of measures for CCI professionals to determine their company's contribution to the community, including cash, time and in-kind donations, as well as management costs. The model also captures the outputs and longer-term impacts of CCI projects on society and the business itself.

Starting with September 2008, London Benchmarking Group (LBG) has a local branch. The organization provides to its members the LBG Model, a tool for collecting and analyzing data, related to programs. The Association for *Community* Relations (ARC) is the only organization in Romania authorized to manage the LBG model.

For our country it is mandatory to create a benchmarking network in order to use strategic, performance and process benchmarking to support economic reform, commerce for small and medium Enterprises, as Foundries for instance.

What is evident in the production - optimization of the capacity and reduced production costs - can be done successfully and in services. With the design of the Horvath & Partners program to improve the performance of services, indirect costs may be deducted up to 40 %. In light of the current situation and the location chosen for the deployment of services [8]; to be consulted as well the web page http://www.horvath-partners.com.

How can be optimized accounting services, human resources, IT, procurement and facility management? In a first of the services of a company does not appear to fall within the scope of optimization. There is no benchmarking of the „market price" and last but not least, domestic suppliers companies have a real monopoly. However: the implementation of a program to improve the performance of services in certain trees, not only for the purpose of lowering indirect costs - which make it possible depreciation costs of implementation in a very short time, but for better control of costs and greater transparency. Initiative is such a culture of service, bureaucratic structures are replaced with partnerships based on value creation and ensure a standardization processes and systems in the company.

A positive aid for promoting national and foundries business partnership and collaboration was produced by the appearance of the Technical Association of Romanian Foundries (ATTR) and by the profile publication Casting Magazine (RT).

For example in April, May, July and October 2007 were sent questionnaires towards 192 companies from national castings industry for the purpose of drawing up the analysis of production of castings in 2006, unfortunately to this project replied only 121 firms (see tab. 2) [1].

## 4. CONCLUSIONS

We suggest creating a portal about foundries – the casting of foundered products and a discussion topic for the forum on the opportunity and ways of:

- initiating benchmarking program for each company / foundry; - forming a national network of benchmarks in this area; - the training of specialists in initiating, conducting, developing and implementing benchmarking projects;
- identifying the areas of interest and developing a database; - affiliation with European and international benchmarking networks; - organizing international symposiums with international participation; - supporting publishing books, magazines, articles with this theme.

Table 2 Summary of the national production of castings in 2006

| PARAMETER | COMPANY | RANKING |
|---|---|---|
| 1 – Total Production, t | - position 1 / SATURN S.A. Alba Iulia = 15,170.00 | |
| | - position 121 / FORJA Cugir SRL = 6.20 | |
| 2 – Cast iron products, t | - position 1 / SATURN S.A. Alba Iulia = 15,170.00 | |
| | - position 72 / FORJA Cugir SRL = 1.50 | |
| 3 – Steel products, t | - position 1 / DOOSAN – IMGB S.A. Bucuresti = 4,750.00 | |
| | - position 54 / MECANEX S.A. Botosani = 3.50 | |
| 4 – Non-ferrous alloys products, t | - position 1 / PIERREPI PRESSOFUSSIONI Bucuresti = 7,686.00 | |
| | - position 84 / ARIS S.A. Arad = 0.51 | |

The expected results and the estimated effects are: - promoting the concept, techniques and tools of benchmarking in Romania and creating a portal on the Internet in the mentioned field; - forming benchmarking organizations and benchmarking network; - offering a new benchmarking service to SMEs, such as and other governmental or nongovernmental organizations; - creating the premises of continuously improving the performance by identifying and implementing the best technologies and processes for casting, along with the consolidation of a market-specific sales and marketing activities of castings.

These data, and each site / web page of a company represents a database with known valences and opportunities.

The mutual beneficial exchange of technical information and documents of the type of technologies and processes for casting, sales opportunities and sales (raw materials, metal and nonmetallic materials ancillary foundry, SDV technologies, equipment technology, casting), can be achieved by the methodology "SHARED", specify the exchange of multimedia on the Internet (and audio products, video), process the day to day, take a scale difficult to impossible to forecast and counting.

"SHARED" is the past and / or past part. Of the "share" noun with the meaning of: part, quota, exchange (give and receive something else similar).

Intransitive verb has the meaning of: "a share, to take part, to participate". In English, in this sense, are usually present the expressions: "to share in, to share out, a share in doing something, Founder's share, share in profits, to pay one's share, to share something with somebody."

Currently, the Internet with such specialized web-pages regarding local or worldwide foundries, keeps a constant discussion in shared regime. Thru these web-pages and by a good benchmark policy lead to effective promoting, partnerships and collaboration activities between national foundries and the ones from neighbor countries: West – Hungary, Serbia, South – Bulgaria, Turkey, and East – Republica Moldova, Ukraine and Russia.

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# ANALYSIS OF THE TECHNOLOGY OF STEEL ELABORATION *T 35 Mn 14* INTENDED FOR CASTING THE PIECES

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**Abstract:**

In this work it is made a critical analysis of the technology of elaboration of the alloy intended for the obtainment of *Driving spindle wheel*, respectively slightly allied steel *T35Mn14*. There are presented the two types of charges used for the elaboration of steel, respectively the chemical compositions of the charges elaborated. With the help of these data there are made a series of correlations in order to emphasize the variation of the contents of the elements for the 14 bathes elaborated and studied.

**Keywords:**

slightly allied steel, casting pieces, metallic charge, chemical composition

## 1. INTRODUCTION

Steel *T 35 Mn 14* is part of the category of slightly allied steels. The slightly allied steel contain the main alloy element below 2% and the sum of all the alloy elements does not exceed 5%. The slightly allied steel s are part of the perilitic class [1,3].

The chemical composition of steel *T 35 Mn 14*, as per STAS 1773-76 is presented in table 1.

Table 1. The chemical composition of steel T 35 Mn 14 [STAS 1773-76].

| Steel mark | Chemical composition, % | | | | | |
|---|---|---|---|---|---|---|
| | C | Mn | Si | P max. | S max. | Cr |
| T 35 Mn 14 | 0,33...0,38 | 1,30...1,50 | 0,30...0,50 | 0,035 | 0,035 | 0,50...0,70 |

The mechanical characteristics of steel T 35 Mn 14 are presented in table 2.

Table 2. The mechanical characteristics of steel T 35 Mn 14 [STAS 1773-76].

| Steel mark | Mechanical caracteristics | | | | |
|---|---|---|---|---|---|
| | Flow limit, $R_{p\,0,2}$ N/mm² | Traction resistance, $R_m$ N/mm² | Extension at breakage, A % | Swage at breakage Z, % | Hardness, HB |
| T 35 Mn 14 | 295 | 540...780 | 12 | 25 | 160 |

## 2. ANALYSIS OF THE CHARGES ELABORATED IN VIEW OF CASTING THE PIECE ANALYSED

The elaboration of the slightly allied steel *T 35 Mn 14*, out of which it is made the *Driving spindle wheel* is made in electric furnace of the type DSN-3, with basic casing, with a nominal capacity of 3000 kg.

For the elaboration of the batches intended for casting these pieces there have been used charges of the type [3]:

**A). Type I:**

- Scrap iron

- Proper waste, respectively lost heads, casting networks etc. charged from the steel cast pieces T 35 Mn 14
- Scrap cast iron

**B). Type II:**

- Scrap iron
- Proper waste, respectively lost heads, casting networks etc. charged from the steel cast pieces T 35 Mn 14

For the alloy there are used:

- FeSi 66...50
- FeMn 75 or 79
- Gross electrodes
- $CaF_2$

In table 3 there are presented the chemical compositions and the casting temperatures for 14 charges elaborated made of steel *T 35 Mn 14*, out of which there have been cast the pieces studies, respectively *driving spindle wheel.*

Table 3. The chemical compositions for charges elaborated

| No. | No. charge | Chemical composition, în % | | | | | | Evacuation temperature, °C |
|---|---|---|---|---|---|---|---|---|
| | | C | Mn | Si | P | S | Cr | |
| 1 | 6423 | 0,35 | 1,33 | 0,59 | 0,069 | 0,028 | 0,68 | 1580 |
| 2 | 6424 | 0,31 | 1,5 | 0,32 | 0,055 | 0,033 | 0,51 | 1610 |
| 3 | 6425 | 0,36 | 1,3 | 0,3 | 0,059 | 0,035 | 0,52 | 1585 |
| 4 | 6427 | 0,36 | 1,5 | 0,59 | 0,061 | 0,034 | 0,74 | 1580 |
| 5 | 6428 | 0,33 | 1,32 | 0,38 | 0,045 | 0,035 | 0,5 | 1610 |
| 6 | 6430 | 0,36 | 1,44 | 0,23 | 0,045 | 0,029 | 0,63 | 1615 |
| 7 | 6435 | 0,3 | 1,6 | 0,27 | 0,068 | 0,035 | 0,7 | 1610 |
| 8 | 6438 | 0,34 | 1,3 | 0,49 | 0,054 | 0,036 | 0,69 | 1610 |
| 9 | 6439 | 0,35 | 1,46 | 0,4 | 0,045 | 0,034 | 0,7 | 1585 |
| 10 | 6441 | 0,32 | 1,29 | 0,42 | 0,059 | 0,035 | 0,62 | 1610 |
| 11 | 6442 | 0,35 | 1,37 | 0,28 | 0,056 | 0,03 | 0,63 | 1590 |
| 12 | 6455 | 0,34 | 1,17 | 0,53 | 0,03 | 0,037 | 0,37 | 1600 |
| 13 | 6456 | 0,34 | 1,5 | 0,38 | 0,033 | 0,035 | 0,55 | 1590 |
| 14 | 6459 | 0,33 | 1,25 | 0,41 | 0,04 | 0,033 | 0,52 | 1600 |

## 3. CONCLSIONS

With the help of the data presented in table 3, there have been made a series of correlations in order to emphasize the variation of the contents of the elements for the 14 bathes elaborated and studied.

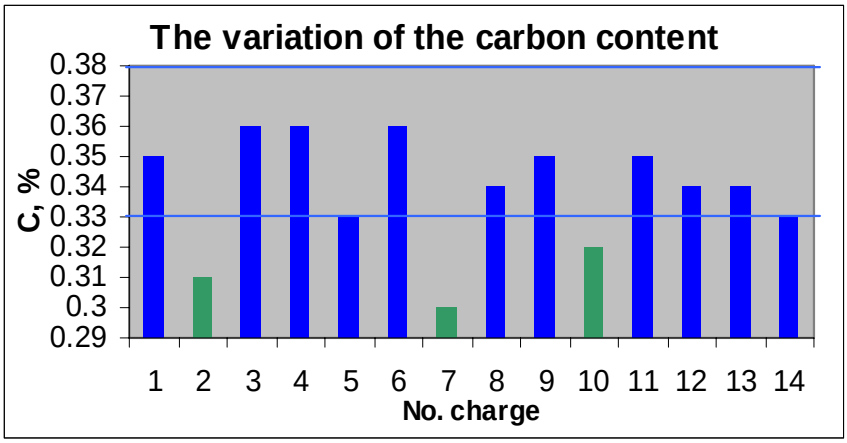



Figure 1. The histogram of the variation of the carbon content of the charges elaborated

Thus, in figure 1 it is presented the variation of the carbon content for the charges elaborated. From the analysis of this histogram there can be noticed that only three charges (6424, 6435, 6441) have a carbon content below the limit provided in the STAS, the other three charges having a carbon content lower than 0,33%.

Similarly, there are executed, with the help of the program EXCEL, the histograms for the contents of manganese and chrome. They are presented in fig. 2, 3.

It results the following:

- the manganese content, for the charge nr.6430, exceeds the value provided in STAS, and charges 6455 and 6459 have a manganese content below the limit allowed;
- the chrome content is lower for charge 6456 only.

In figure 4 there is presented the histogram of the casting temperatures registered. There can be noticed that the casting temperatures are contained in the interval 1585-1615 °C. Most of the values are registered in the interval 1605-1615°C.

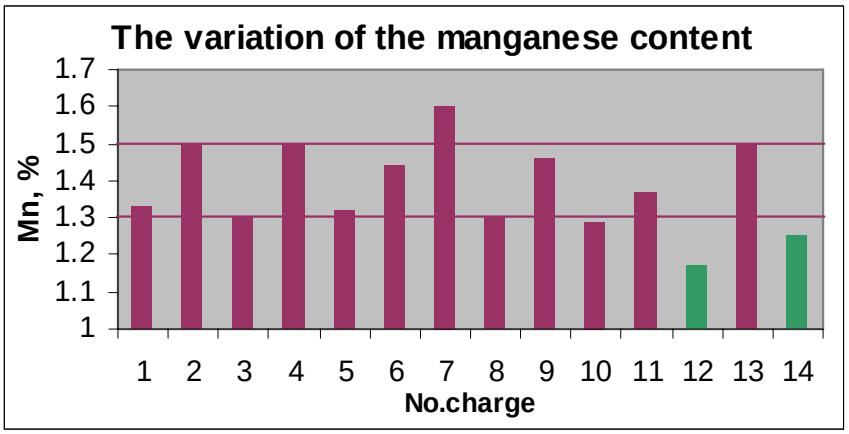



Figure 2. The histogram of the variation of the manganese content of the charges elaborated.

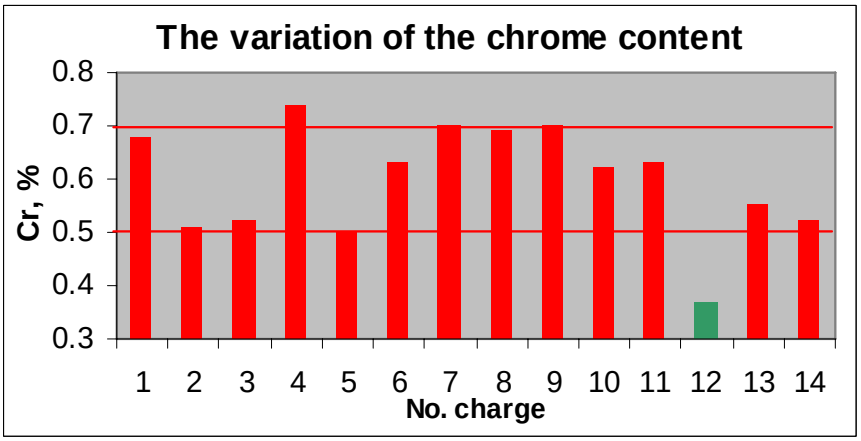



Figure 3. The histogram of the variation of the chrome content of the charges elaborated

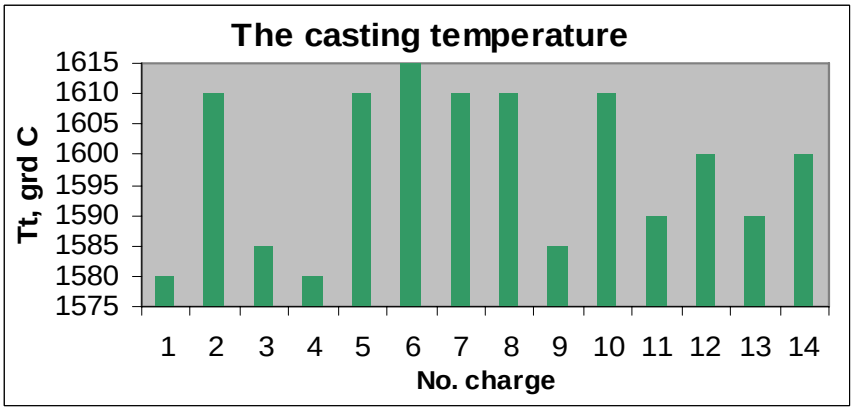



Figure 4. The histogram of the variation of the casting temperatures of the charges elaborated

In general, the elaboration of steel *T35Mn14*, intended for casting the studied piece within a metallurgical enterprise does not raise particular problems, but there must be made a critical control of the process of elaboration of the alloy in view of obtaining quality castings.

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# MATHEMATICAL MODELLING OF THERMAL STRATIFICATION PHENOMENA IN STEEL LADLES

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**Abstract**

This paper presents a three-dimensional numerical model simulating fluid flow and heat transfer in 105 t steel ladles before and during the casting process. The model was developed by combined implementation of a numerical simulation package, TEMPSIM, and a computational fluid dynamics (CFD), simulation package, ADINA (Automatic Dynamic Incremental Nonlinear Analisys). In this study, TEMPSIM was used to calculate the heat transfer in ladle linings and predict the heat losses from the steel melt to the linings. These data were used as input into ADINA for 3-D CFD modeling of fluid flow and heat transfer.

**Key Words**:

Model, numerical simulation, CFD, steel ladle, fluid flow, heat transfer, stratification.

## 1. INTRODUCTION

The melt stratification phenomenon, which results from the natural convection in ladles holding molten steel, is of fundamental importance for the temperature control in continuous casting process. The progressively increasing stress on the quality of continuously cast products necessitates much tighter tundish temperature control, which in turn will require a more precise definition of the extent of melt temperature stratification in ladle.

According to the data to be found in the reference literature, the hydrodynamics of the fluid alloy in the casting ladle during the casting process has been studied by means of 2-D, symmetric - axial simulations of a ladle with the central tapping [3] and by means of 3-D symmetric - axial simulations of an eccentric tapping ladle [4]. The results of such simulations have been compared to those obtained by means of physical models using water [7], or by temperature measurements [1, 2, 3, 5].

The objective of the present study is to establish, under more precisely defined conditions, a 3-D CFD model for simulating stratification and fluid flow in steel ladles during both the holding period and the casting period. The transient and ladle configuration dependent heat losses from steel ladle linings were more accurately predicted by using a numerical simulation package, TEMPSIM. These data were used as boundary conditions for further simulation on the fluid flow and heat transfer, by using a commercial CFD simulation package, ADINA.

## 2. SIMULATIONS CONDITIONS

Considering these aspects, we simulated the hydrodynamics of the fluid alloy in the 105-t ladle used by S.C. Mittal Steel S.A. Hunedoara, before and during the casting process by means of CFD-3D model. This is also due to the fact that the ladle, whose configuration and geometrical dimensions are given in figure 1, has an eccentric tapping.

At first, a geometrical sketch of the ladle was made (fig.2), starting from the configuration and geometrical dimensions of the industrial casting ladle (fig.1). As it can be noticed, in order to simplify the modeling, we neglected the fact that the ladle has a conical shape, it being considered cylindrical.

In order to achieve a closest simulation of the hydrodynamics and temperature of the fluid alloy in the ladle during taping, we considered it necessary to take into consideration the fact that the metal bath in the ladle is thermally stratified at the moment of tapping. The consideration given above is mandatory, as in the secondary refining station (LF), the metal bath is homogeneous from the thermal point of view, but during the ladle transportation from the LF station to the tundish a thermal stratification of the metal bath takes place because of natural convection.

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Considering this, the simulation will be done in two stages: the first will simulate the 10 minute-station of the ladle, when the metal bath will be thermally stratified, and the second will simulate the ladle emptying during the casting process.

The emptying stage also involves two periods:

- the first period, which lasts about 3 minutes, represents the filling of the 15-t tundish;
- the second period, which lasts about 40 minutes, corresponds to the normal casting rate.

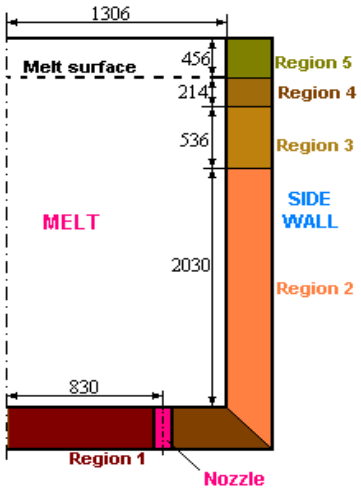



Fig.2. The geometry of the ladle used in the CFD-3D simulation

According to the reference information and also considering the practice of continuous casting (TC) at S.C. Mittal Steel S.A. Hunedoara, in the simulations we considered constant casting flow rates of 77,8 kg/s for the first period of emptying, respectively 36,1 kg/s for the second period.

Using two custom softwares, we simulated the hydrodynamics and the temperature of the fluid alloy in the ladle during the period of its emptying.

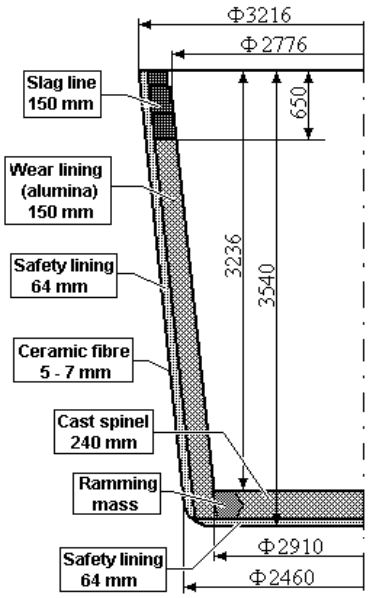



Fig.1. Geometric dimensions and configuration of the refractory masonry of the ladle under study

## 3. RESULTS OF NUMERICAL SIMULATIONS

After having simulated the thermal stratification of the metal bath, for a 10-minute period of stationing, we obtained the rate field (fig.3) and the distribution of temperature (fig.4). These data shall be further used as initial conditions in the stage of ladle emptying. In order to better emphasize the temperature differences arising in the thermally stratified metal bath, because of the phenomenon of thermal convection, we gave the distribution of temperature field for different planes of the field of analysis (fig.5). Further on, we gave the results of the simulations after 10, 25, and 39 minutes from the opening of the tap.

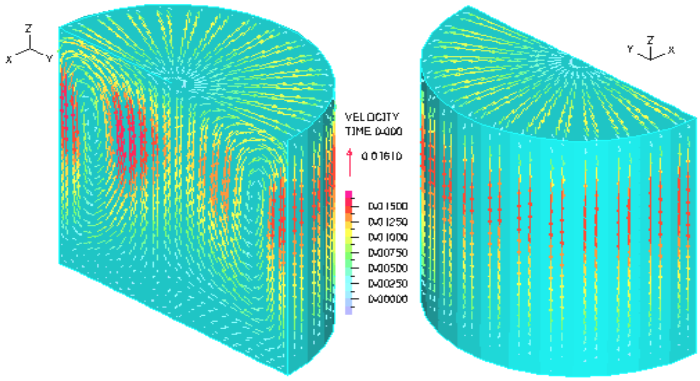



Fig.3. The rate field after 10 minutes of thermal stratification simulation

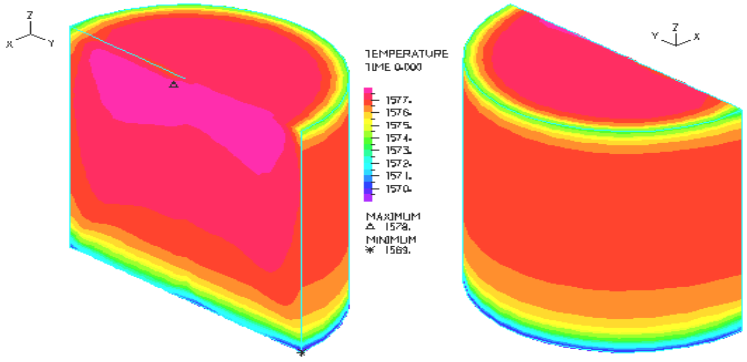



Fig.4. The rate field after 10 minutes of thermal stratification simulation

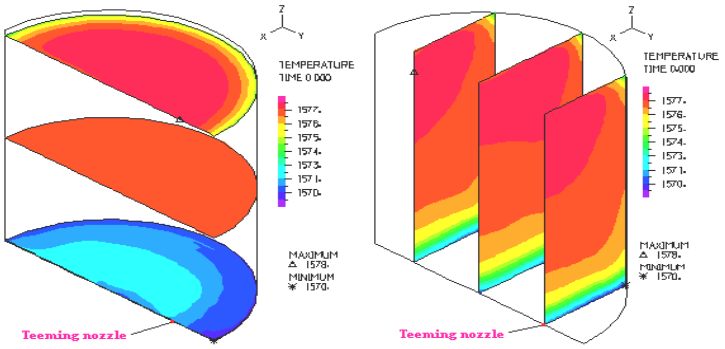



Fig.5. The temperature of the metal bath in different horizontal and vertical planes, after 10 minutes of thermal stratification

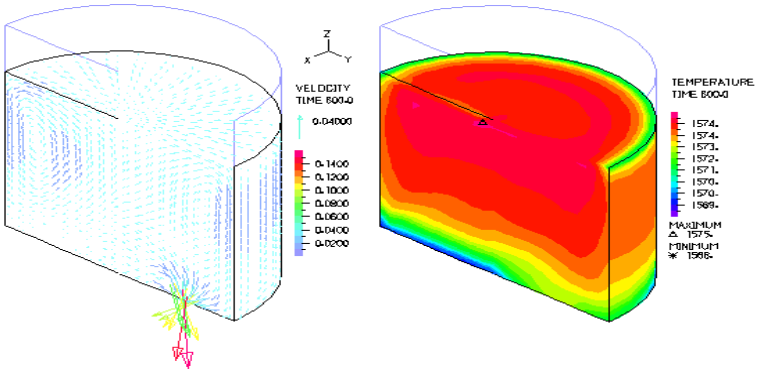



Fig.6. The field of rates and temperatures of the metal bath after 10 minutes from the opening of the tap.

## 4. ANALYSIS OF THE SIMULATION RESULTS

Figure 6 gives the field of rates and the distribution of temperature in the metal bath after 10 minutes from the opening of the tap. One can notice that the movement of the alloy in the ladle is further due to the phenomenon of natural convection, the rate field having the same profile as in the initial stage (fig.3).

Continuing the analysis of the rate field evolution, one can notice that it starts being influenced increasingly by the fact that a movement of the alloy arises from its flowing out through the tap. After about 25 minutes from the opening of the tap (fig.7), this movement starts to prevail over the one due to natural convection.

This tendency is also revealed by the evolution of the temperature field inside the metal bath. Thus, at the beginning of tapping, the phenomenon of thermal stratification is still present because the metal bath keeps losing heat to the environment and natural convection is still present. In the latter half of the tapping period (after about 25 minutes from the opening of the tap), because of the low level of the metal bath in the ladle, the heat lost to the exterior is diminished and the phenomenon of thermal stratification comes to an end. At the same time, the movement of the fluid alloy through the tap determines the mixing of the metal bath, which leads to diminishing the thermal stratification already existent.

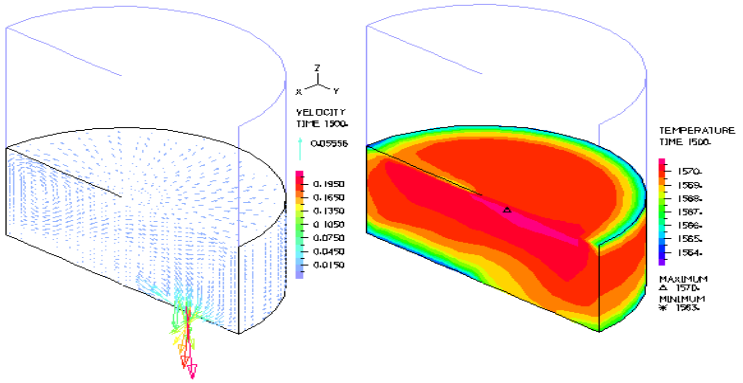



Fig.7. The field of rates and temperatures of the metal bath after 25 minutes from the opening of the tap

One very important result to be noticed when simulating the hydrodynamics and temperature of the fluid alloy from the ladle during its emptying is the fact that we know the temperature of the fluid alloy at the knots of the domain of analysis, corresponding to the entrance of the ladle tap. Taking into consideration the fact that, on leaving the tap, the alloy flows through a protection ceramic tube, up to the tundish of the continuous casting machine, and the loss of heat to the walls of this ceramic tube is very low (corresponding to a decrease of under 0,1 °C of the temperature of the fluid alloy [6]), we can consider that this is the temperature at which the fluid alloy enters the tundish and we shall further call it *the temperature of the alloy flow*.

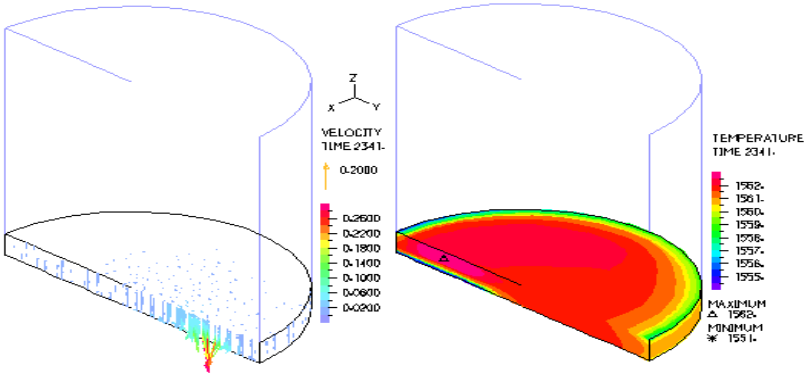



Fig.8. The field of rates and temperatures of the metal bath after 39 minutes from the opening of the tap.

## 5. CONCLUSIONS

The results obtained by modeling and simulating the hydrodynamics and temperature of the fluid alloy in the ladle during its emptying stage can lead to the following conclusions:

- the three-dimensional model developed in order to simulate the phenomena occurring in the ladle before and during its emptying stage is valid if one considers the results obtained. This model has been developed starting from the one-dimensional model of thermal conduction (1-D), which simulates the non-stationary heat transfer through the refractory masonry of the ladle, and also using the CFD-3D model, which simulates both the thermal stratification of the fluid alloy in the ladle during its stationary period and the hydrodynamics and heat transfer occurring in the fluid alloy during the emptying of the ladle.
- at the beginning of the emptying period, the phenomenon of thermal stratification is still present, as the metal bath keeps losing heat to the environment by natural convection. In the second period of emptying (after about 25 minutes from the opening of the tap), because of the fact the level of the metal bath in the ladle is low, the amount of heat lost to the environment diminishes, and the phenomenon of thermal stratification halts. At the same time, the movement of the fluid alloy due to its flowing out through the tap triggers a mixing process of the metal bath, which leads to the diminishing of the existent stratification.
- once we know the variation of the alloy flow temperature into the ladle, we can take technological steps in the sense of increasing, respectively decreasing the temperature inside the tundish in order to range it within the limits required by the continuous casting technology.

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# DETERMINATION OF TEMPERATURE VARIATION IN THE METALLIC WALL FORMS AT THE STATIC CASTING OF BIMETALLIC MILLING ROLLS

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**Abstract:**
In the paper it's proposes, in main, to obtain of a model of numerical simulation, valid general and applicable the whole peculiars cases of bimetal casting, model with which help can be studied through the computer, the optimization possibility of flowing working condition of liquid alloy of the distribution of temperatures field, of the liquid phase and contraction during the solidification, with the minimum price (necessary reimbursement of the software and calculus equipment) in very short time etc.

**Key words**:
bimetal casting, milling rolls, temperature

## 1. INTRODUCTION

Bimetals cylinders rolling destination are make, in Romania, by casting of a two alloys types into a shape from making (for inferiors axels and maselote) combined with metallic one (for pane), this casting could be made static (S.C. "Cilindrul" S.A. Călan) or dynamic (S:C: Fortus" S.A. Iaşi).

Static casting presume the casting of an alloy named "primary", alloy whit who it is wanted to obtain of an hard crust, and an alloy named "secondary", who is whicker alloyed and leads to the obtain of a middle and a inferiors axels with mechanical characteristics of an lower resistance, but tenacious. This variant of casting presume more stage: primary alloy casting trough the casting net, until the filling of a certain part of casting shape (over the chill mould level); after this operation, it is stay a time part to realization the hard crust solidification, from the chill mould thru the shape center, next moment a refer to beginning of gradually washing of the middle with secondary alloy, and then the finale stage – continuous washing, until the axels and middle obtaining.

In this paper has as purpose the technology optimization of bimetal casting, in static variant, as a result of economic technical analysis of the current technology from S.C. Cilindrul S.A. Călan, on a 78 cylinders $\phi$ 750x1740 mm and $\phi$ 928x3300 mm lot, and also, by originals contributions bringed casting ensemble, by numerical modeled and simulation of the shape filling processes and alloys solidification. In sequel, under surname "*communication vessels system*", it is will be present the purposed bimetal casting technology.

## 2. STUDIES AND RESEARCHS

The establish of the bimetal casting technology (of a communication vessels), in porous metal consumption reduction and taking out index increasing. The presented proceeding in figure 1 remove the classical method short comings, anterior remembered, by using of un exact quantity of an secondary and primary alloys, realization an hard crust and passing stratum dimension well checked, removing of cracks appearance to warm or/and to could and the cylinder relating, on base internal tension decreasing.

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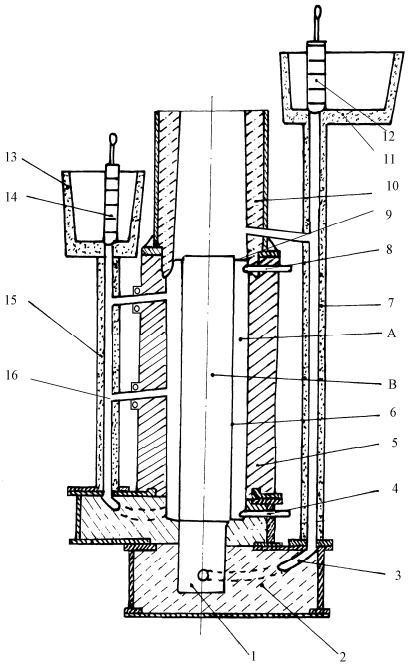



Fig.1. Proceeding and plant for casting of bimetals rolling cylinders, with the possibility of primary alloy casting on ranged net: 1 – inferior axle shape; 2 – inferior frame; 3 – alimentary channel; 4 and 8 – level signaling device; 5 – metallic shape (chill mould); 6 - dissolvable membrane; 7 and 15 the foot of casting net; 9 – membrane supports; 10 – superior frame (for making of superior axle); 11 and 13 – casting reservoir; 12 and 14 - stopper; 16 – the alimentary of ranged net.

The installation for the proceeding realization it is composes from an inferior frame *2*, provided with an alimentary channel *3* which is in relation with an alimentary net *7* (in cascade, with two alimentary). This from behind distribute secondary liquid alloy from casting reservoir *11*, assured with an stopper *12*, which role is to begin and interrupt the shape supply and, also, retain the slag in reservoir *11*.

Over inferior axle shape 2 it is set the metallic shape *5*, having vertical separation surface to allowed the making out and extract casted raw cylinder. In her interior is dispose cooling membrane dissolvable of cylinder shape *6*, which symmetrical axe correspond to with the child mould one, her role being the one of a separate this space in two compartments: exterior compartment **A** destinated primary alloy casting, for making hard crust of the pane, and interior compartment **B** is destinated secondary alloy casting, which will make the cylinder middle. Separating membrane is centered at superior part of the chill mould by three supports *9* (manufactured from the same material as the membrane) fixed in shape wall, which have also the role to stop membrane raising during shape alimentation with the two alloy. Separating membrane and fixing supports it is realized from alloys with thermo-physical characteristics of well-determinated material, will alled the dissolved during the solidification of two types of pig iron (with which comes in contact), having measured thickness from the condition of thermic balance.

To the inferior part of the chill mould it is dispose a second casting net (in cascade, with three supply, vertically set) mint to the primary alloy casting, adequate dimensioned, from the shape filling condition, in compartments **A** and **B** of the chill mould *5*, with the same speed:

$$s_{alloyI} \cong s_{alloyII},$$

in which $s_{alloyI}$ and $s_{alloyII}$ are increasing speeds in the shape of the two alloys, primary and secondary. Casting reservoir *13*, with who are connected the net *15*, is assured with stopper *14*, having the same role as the one in the position *12*.

Presented proceeding allowed concomitant casting of the liquid alloys, by different ways, for the liquid alloy, which will make the axles and the cylinder middle, to rise in shape at the same level, with the alloy which will make hard crust or active part of the cylinder.

After the both casting reservoirs are supplied with adequate alloys, at the optimum temperatures of casting, it is rise de stopper *12*, beginning filling sequence of the supply net *7* with secondary alloy, fallowed by the inferior shape filling *1*. When liquid alloy touched the inferior level of the cylinder pane, begin also the casting sequence of the primary alloy, by the second net of casting *15*. This sequence it is initiated by rising de stopper *14*, in the moment of touching realization between the secondary liquid alloy and level signaling device *4*.

Departing membrane it is dimensiong in such way the not dissolve her self, on her height, before the chill mould filling with the both liquid alloys. Because of the alloys themperature, still in liquid phase, with which comes in contact, the membrane it is dissolve, taking place a miscibilitate a tho two alloys, realizing the passing zone between the hard crust and the tenacious middle of the cylinder, on a thickness not bigger then 20 ... 40 mm, because of the solidification, in species by meeting of the two crystallization fronts (from the chill mould *5* to the cylinder axe and from the cylinder axe to the cavity periphery **A**).

Next sequence of the proceeding it is refer to the stopping of the primary alloy casting, when this level is in the right of the second signaling device *8*, identical from building point of

view with the signaling device *4*, established in the superior frame, at the superior quote of the cylinder pane. The casting stopping it is realizes by obturating supplies net *15*, by descending of the stopper *14*. In this time, the secondary alloy casting continues, until the filling of the superior shape, when it is descending also the stopper *12*, and the supply net *7* are so obdurate.

If the alimentation net with primary alloy would have the alimentary disposed ranged, differenced, no in the same vertical plane, the rotation move imparted to the liquid alloy will be accelerated, then eventual impurity attracted in the time of casting processes will be decanted in the exterior stratum of the pane and in the superior part of the cylinder maselot, parts which, any way, are removed by mechanical processing (of the ulterior unthichen).

## 3. BIDIMENSIONAL NUMERICAL MODEL (WITH FINISHED DIFFERENCES) OF TEMPERATURE VARIATION IN THE METALLIC WALL FORMS OF BIMETAL MILLING ROLLS

It is purpose a model of numerical simulation using the method of finished differences, of the solidification phenomenon of the bimetal cylinders rolling. In this purpose, the analysis field, represented by a continuous medium is transformed in a discontinuous medium (discreet), formed by a points net (discretionary net), of which density is given by the chooses steps for each coordinates axe (fig. 2). The temperature in each knot represents the medium temperature of the knot adjacent surface. In those knots it is written the differential equations of the transforming heat transition in equations with finished differences.

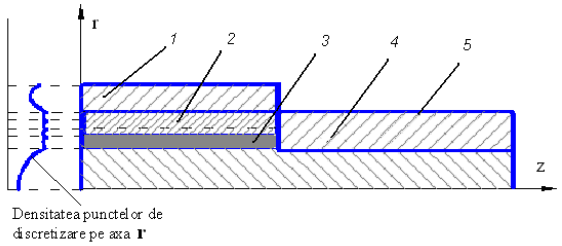



Fig. 2. Quality schem of thermic system used in simulation: 1 – chill mould; 2 – hard crust; 3- cooling membrane; 4 – middle and cylinder axle; 5 – axle shape

Differential equation of the heat transmition after the three axes has the form:

$$\frac{\partial t}{\partial \tau} = a \cdot \nabla^2 t \,,$$

where: $t$ - themperatura, [°C];
$\tau$ - time, [s];
$a$ - thermic difuzivity, [m²/s];
$\nabla^2$ - Laplace operator (laplacian).

The realization of numerical model imposes the establishment of the simplifications ipotesis:

1. It is considering that the system has perfect axial symmetry (after **z** axe). As a result would not be transmitted heat only radial and vertical.
2. Because the cylinder has a complex shape, this will be simplified, removing the conics and connection rays.
3. It is neglecting the density variation, so of volume of the materials which form the system.
4. The heat transmition to the chill mould surface and the frames to the ambient medium take place by convection and radium.
5. It is neglecting the heat release by the superior surface of the maselot and the inferior one of the inferior axle frame of the cylinder.
6. The hit transmitions by removing surfaces (middle – membrane – hard crust – chill mould) take place by conduction.
7. The latent heat release of melting. It is make during liquidus – solidus, proportional with the themperature.

## 4. THE DESCRIPTION AND PROGRAM FUNCTION FOR THERMIC FIELD SIMULATION. THE RESULTS PRESENTATION

The simulation was realized for the casting ansamble (the casting shape and casting raw cylinder), which geometrical dimensions are ϕ1440x8200 mm. As the number of discretisation knots are bigger (for the casting shapes, as for the bimetal cylinder), respective enthalpy variation maximum in a smaller iteration, so as the real time of simulation is bigger.

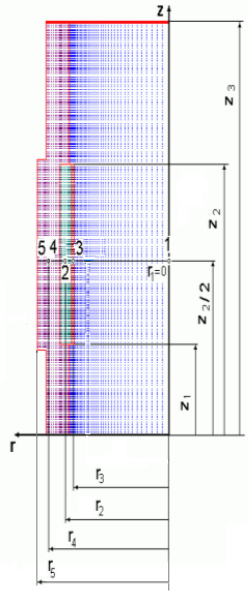
In the case of presented data, de simulation time was of 20 minutes for a real time of flowing process, solidification and cooling of 500 minutes.

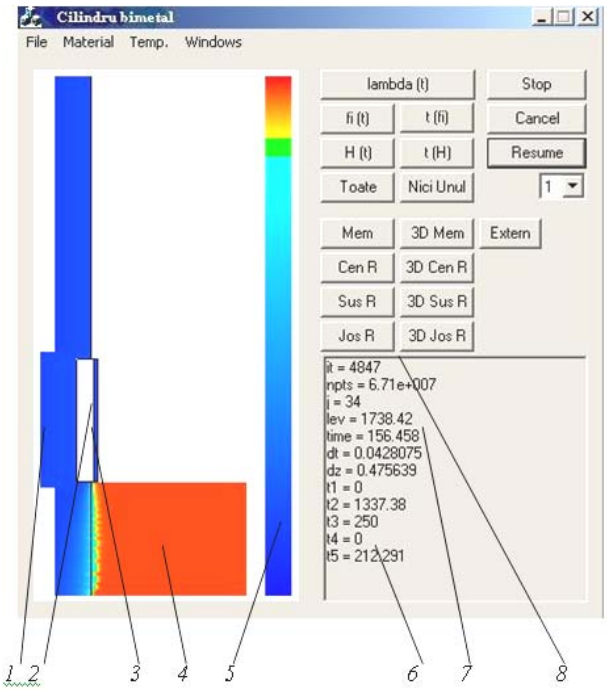
The realized program allowds the quality seeing of the thermic field, for differentious time moments, in planes section of the cylinders ϕ928x3300 mm, perpendiculars on z axe of the choosen reference system (in cylindrical coordinates). z axe is identical with symmetry axe of the bimetal cylinder, and the section are situated at the differentious heights face to the base plan, with whom those are parallels (for example z = 0, the plan is situated at the inferior axle base of the rolling cylinder).

In 1 table are presented the planes quotes of the discretionary net section from numerical model field with finished diferentious, those having correspondent with de planes from real field.

Table 1. The coordinates of sections planes and points in discretionary net

| Quote on **z** axe | Mesuring points from cylinder inside | Mesuring plan from discretonary net inside of cylinder |
|---|---|---|
| $z_1$=1750 | 1 ($r_1$ =0; $z_2$/2 =2675), placed in cylinder axe | |
| $z_2$=5350 | 2 ($r_2$ =455; $z_2$/2=2675), placed in cylinder crust | |
| $z_3$=8000 | 3 ($r_3$ = 415; $z_2$/2=2675), placed in membrane | |
| | 4 ($r_4$ = 500; $z_2$/2=2675), placed to the interface of chill mould - crust | |
| | 5 ($r_5$ = 700; $z_2$/2=2675), placed to the interface ambient field – chill mould | |




In the very next moment, the obtained image allowd the seeing of the discretionary net (fig. 3), of the simulation time and of the themperatures from diferentious zones of bimetal cylinder, as also the level to which are arrived the alloys in shape. The themperatures are showed trough color gradient, with the values: red for casting themperature, blue for ambient thermic themperature and green for their mediate. Any intermediate themperature is a combination of those.

Fig.3. Seeing the simulation steps of the solidification and filling processes of bimetal cylinder: 1 – chill mould; 2- hard crust; 3 – disolvable cooling membrane; 4 – inferior axle; 6 – touche temperatures in differentious zones of the casting ansamble; 7 – simulated time; 8 – iteration (simulation step).

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In 3 figure, the 5 color gradient allowds an quality analysis of the solidification in time. So, the coloured zones in red are liquidus, tore in blue are solids, and the zone in greed shades show the distribution of biphasic zones (liquid and solid), with other words liquidus – solidus interval.

From 3 figure it is could be observe that at the 4848 iteration (mining 156,458 seconds simulated time) secondary alloy, arrived to the table level. Next step, to 158,08 seconds from the simulation beginning, mentions the beginning of 2 crust alimentation with primary alloy, to the themperatur of $t_4$ = 1370°C (in figure 3, indication $t_4$ = 0 show that still it is not begin the primary alloy casting).

The membrane themperature is introduced in simulation with initial value $t_3$ = 250°C, so as the one of the chill mould $t_5$ = 250°C. The themperature $t_1$ is measured to the superior part of the cylinder superior axle, and the indication $t_1$ = 0, from 3 figure, is refers to the fact that, at this moment of simulation, the liguid alloy have not arrived to the respective level.

From the tridimensional representations of the thermic field it is could be made the conexions between the level (z quote) to which had increase the alloys in shape, the themperatures and the simulated time (fig. 4). This imagines tipes are obtained by activating the dialog window Metal3DGraph, or of the butons from main window (3D Cem R etc).

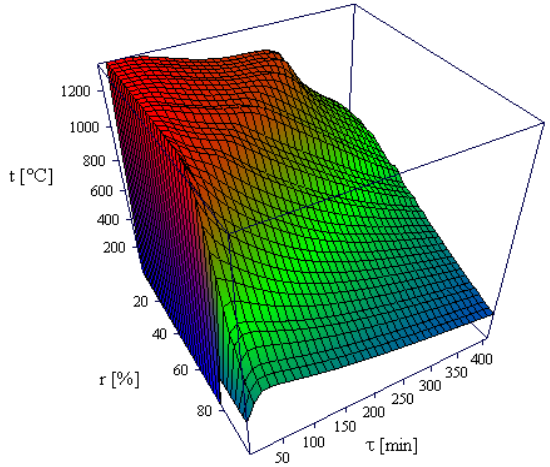



Fig.4. The temperature variation in time, determinated at the quotation $z_2/2$ = 2675, after 400 minutes from the simulation beginning

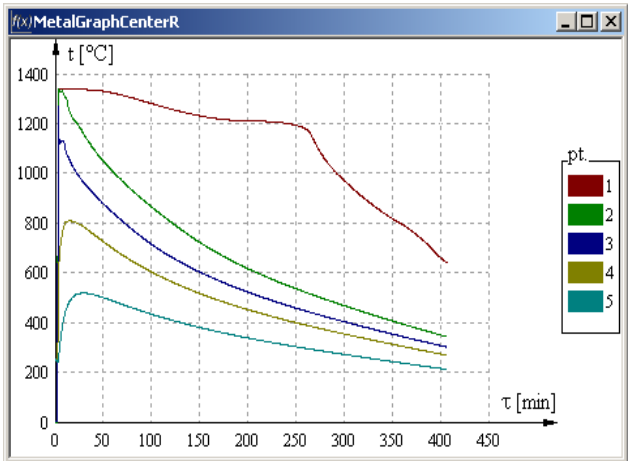



Fig.5. The graphic presentation of temperature evolution at the chill mould middle ($z_2/2$ = 2675), after 400 minutes from the simulation beginning

*Observation:* The variation graphics of the time, temperature, at the differentious planes of the section in long axes **r** and **z**, use the procentual expression of the coordinates.

The evolution in time of the 1, 2, 3, 4 and 5 points themperature (table 1) may be fallowed by activating the window **MetalGraph**, or directly, pushing the main window buttons (Cen R, Sus R etc), presented in figure 5.

The obtained data can be exported in purpose of their comparation with the obtained values by casuals experimental measures, realized with the helps of immersion thermocouples (plased in points of real field corresponding to the points of definite measure in discretionary net, simulated with the helps of finished differentious method.

## 5. CONCLUSION

As a result of critical analysis of actual technology of bimetal casting, in static regime, of the big diameters cylinders, destinated pane rolling, it were proposed three variants (author own conception) of technology improving, final, establishing as optimum the vessels communication, which use a dissolvable micro-cooler membrane and of ranged casting nets. Beginning from filling up principle of the two cavity of chill mould (**A** – destinated to the tenacious middle obtaining of the cylinder pane and **B** – destinated the hard crust realization, of equal thickness on pane generatrix) at the same level, on filling up whole way, it was dimensioned casting system, compose from the independent alimentary two nets.

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Taking account of micro-cooler effect played by the dissolvable membrane, introduced in chill mould, was effectuated a moulding study of solidification process of bimetals cylinders (casting from A and B fusions), in this ipothesis.

The numerical and analytic moulding of the flowing processes solidification and cooling constitue a base instrument, useful as in conception phase such as in the analysis one of the metallurgical processes, which, combined with computers use, allowds the establish of the optimums regims of those development.

The results and the obtained conclusions after numerical moulding with the help of finite differences method can be extrapolated with a high veracity at the industrial processes which take place at the solidification conduction of bimetal cylinders of big diameters, in porous of their quality improving in exploitation.

In the presented context, one of the main objectives of this thesis (the quality improving of big diameters bimetal cylinders) was realized by solidification research and the links establishment regarding to technologic parameters various (casting temperature, specific consume of micro-coolers and those dimensions) depending on operational variables specific of solidification processes, to determinate the influence modalities of those in view of obtaining of some pieces (bimetals rolling cylinders) of superior quality, reproducibility conditions and maximum economic – technical efficiency.

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# SOLIDIFICATION AND COOLING PHENOMENON IN THE AREA OF STEEL CONTINUOUS CASTING

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**Abstract**

The mathematical molding of the solidification and cooling phenomenon of continuously cast semi-products, presented the in afterwards, is based on the mathematical description of phenomenon. This solution problem is, practically, the heat solving equation in of non-steady regime. For defined the heat conduction between semi-product and crystallizer is necessary the cognition of initial conditions, the variation law of the heat flux between semi-product – crystallizer and the heat flux between crystallizer – cooling water.

Primordial method for the decrease of the superheat of the steel of the in of the crystallizer, consist in the introduction of consumable micro-coolers, which can be exterior or internal. In this paper is presented simulation solidification model of steel continuous casting, using finite element model. For this is considered a section in mould-continuous casting system. This section is divided with discreet element structure. Using these experiments is made graphical dependents of temperature in some different point from surface crust to center of semi-product, and also solidification speed for S235 (OL37) steel.

**Keywords**

continuous casting, steel quality, semi-product, crystallizer, mathematical molding, solidification and cooling phenomenon

## 1. INTRODUCTION

The main task of the continuous cast is improved of continuous cast steel quality. In order to assured the solidification conditions imposed by the steel chemical composition must be synchronize a numerous technological factors, the most important be the steel chemical composition, the casting temperature and speed of drawing.

Primordial method for the decrease of the superheat of the steel of the in of the crystallizer, consist in the introduction of consumable micro-coolers, which can be exterior or internal. The exterior micro-coolers can be prepared out of the system and entered the crystallizer, and the internal micro-coolers are constituted from steels crusts, immediate format in the core of the semi-products, on the water cooled surfaces. The outside micro-coolers can be entered in the liquid steel below different forms: small shots, granules or particles, draw-bars, wire, tube, etc. The addition of micro-coolers in crystallizer drives to the growth of the zone of the echi-axial crystals, diminish the degree of superheat and reduce the axial porosity.

The mathematical molding of the solidification and cooling phenomenon of continuously cast semi-products, presented the in afterwards, is based on the mathematical description of phenomenon. This solution problem is, practically, the heat solving equation in of non-steady regime. For defined the heat conduction between semi-product and crystallizer is necessary the cognition of initial conditions, the variation law of the heat flux between semi-product – crystallizer and the heat flux between crystallizer – cooling water. Some conditions are can easy schematized, other only that drive to systems of which equations can be solved on analytic path.

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## 2. IMPLEMENTATION OF THE ALGORITHM

The computer program is written in C++ and works under Win32 (i.e. Windows 95, 98, Me, NT4, 2000, XP – with Intel processor). For the graphic interface, the program uses MFC (Microsoft Foundation Classes), a class library that encloses the functional character of the standard programming interface Windows API – Application Program Interface. The 3D graphs are realized with the Windows implementation of OpenGL specification (Open Graphics Library).

For implementation of an algorithm of the above described model we need the fallowing initial data: ambient temperature, casting temperature, initial temperature of the crystallizer, number of nodes from half-finished product and from crystallizer with respect to both axes, values of thermal conductibility for steel and cupper function of temperature, values of enthalpy for steel and copper function of temperature. In case of steel this functional dependence need to include fusion latent heat; tapping condition of half-finished product from equipment; stopping condition of the algorithm. This could be: manual stopping, after a given time period, at a specified minimum, average, or maximum temperature of the half-finished product, maximum variation of enthalpy at an iteration.

## 3. THE SIMULATION OF THE CONTINUOUSLY CAST SEMI-PRODUCTS

The simulation is realized for a half-finished product (bloom), having the cross-section 240x270 mm, made of steel OL37-2K, according to the SR EN 10025 standard. The data are: the ambient temperature 20°C, the casting temperature 1550°C, the convection constant K = 15. The simulation of the continuously cast semi-products is effectuated in the case of 5% consumable micro-coolers introduced in crystallizer. The simulation is effectuated just for the primary and secondary cooling and not for the entire line of cast installation. Thus is explained the great values of the temperature of steel in the interior of the semi-products (the middle layers) but which we diminish the feather below the value of the temperature solidus up to the moment which in the semi-product is uttered.

With the number of knots of digitization is major (both the crystallizer and the semi-product) and the maximum the variation of in an enthalpy in single iteration is less, the real time of simulation is major. In this case, the real time is 9h 8 min 44 s corresponding to the 13 min 21 s, in simulated time. The run of the program can be interrupted all moments, but with the mention as be start from same moment of time but must run the program from beginning. For illustrate the operation of the program, we accomplished captures of the screen to different moments of times, from which can obtain some information concerning the temperatures in the cast equipment, the real and simulated times.

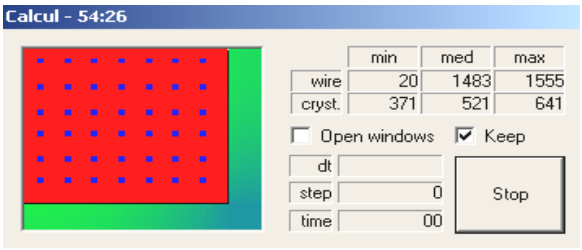



Fig. 3. The dialog window at 54 min 26 s (real time), respectively 0 s (simulated time) (at the moment of the micro-coolers introduces)

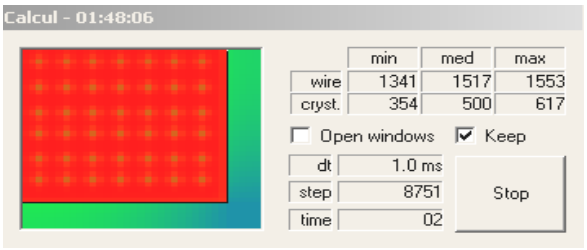



Fig. 4. The dialog window at 1h 48 min 06 s (real time), respectively 2 s (simulated time)

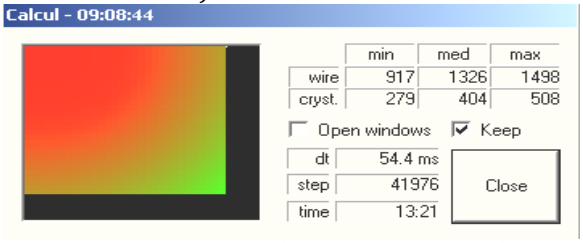



Fig. 5. The dialog window at 9 h 8 min 25 s (real time), respectivelly 13 min 21 s (simulated time) (at the end of program simulation)

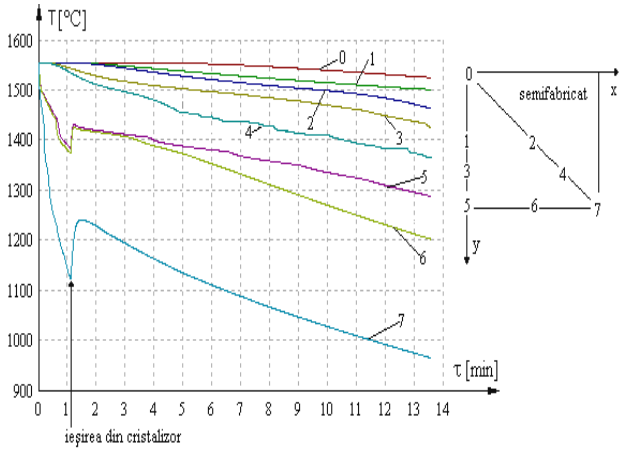



Fig.6. Temperature variation function of time

The temperatures are indicated by the mean of a colored gradient, having the values: red for casting temperature, blue for ambient temperature and green for their average. Any intermediary temperature is a combination of these.

A first obtained dependence is represented by temperature variation of the half-finished product function of time (fig.6.). The distribution of the discredited points is also presented.

At a time moment (in the presented case equal with 1 min 7s), when it took place the driving out of considered surface from crystallizer, it took place an increasing of temperature in the superior layers of the half-finished product (with approximately 100°C in the corner and with 35...50°C in points 5 and 6 of the surface).

This increasing of the temperature is due to the lack of cooling of the wire immediately after the driving out from crystallizer to the firs ring of secondary cooling. After this moment the cooling and the solidification of the wire took place normally, the recorded temperatures corresponding to the measured ones.

It needs to be specified that the simulation was realized just for primary and secondary cooling, not for the entire running of the wire in the equipment. This explains steel's high temperature values in the interior of the half-finished product (middle layers), but they are decreasing under the solidus temperature value until the cutting of the half-finished product.

As regards the temperatures distribution in the crystallizer (which take over the heat transferred by the half-finished product and transfer it to the cooling water), it is presented in fig.7. In this case to it is presented also the position of the discredited points.

In the moment of the cast process beginning, in crystalizer (in discretized points), the temperatures are relative high. At 10s (simulated time) the temperature is between 350-600°C, and it is observed a slowly decreasing of the temperature of points placed near the center of the half-finished product, but also the variation mode of the temperature from layers closer to wire surface (320...550°C at 30s, 275...520°C at 1 min 7s, in final moment of simulation ).

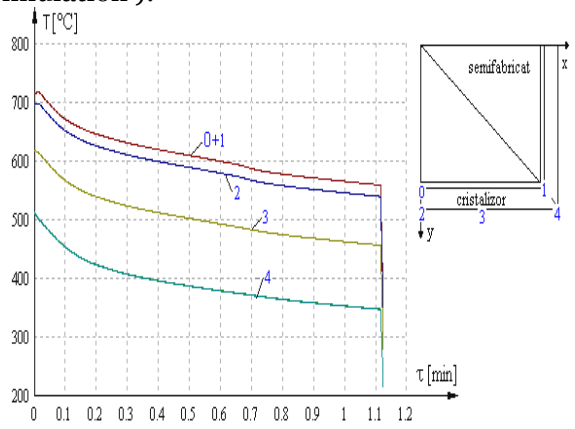



Fig.7. The temperature variation in the crystallizer, function of time

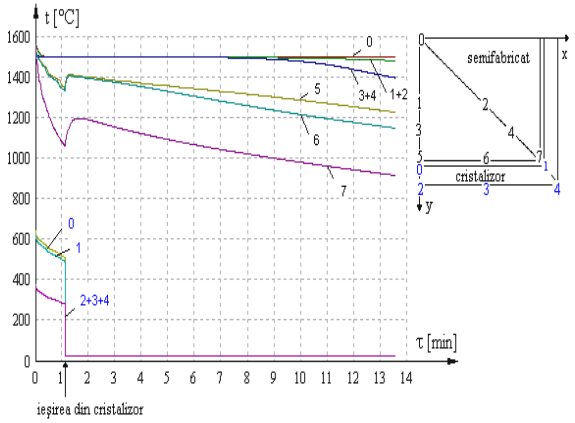



Fig. 8. The temperature variation in crystallizer and the cast line

In fig. 8 the cumulate diagramme of the temperature are presented. It is observed the two cooling zone, respectivelly the primary cooling (when variated both the temperature in crystallizer and the cast line), and the secondary cooling (when only the cast line temperature is present). It was obtained variation type for the solidification speed, function of time. It refers to a solidification speed calculated between two consecutive iterations, fact that partially explain the oscillating aspect of the curves.

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Another type of temperature distribution, when the half-finished product is droved out from secondary cooling zone, it is presented in fig. 9...fig.13, at 3s, 9s, 24s, 30s and 60s, after introduced the micro-coolers.

The fig. 14 presents the thermal field in the semi-product in the moment of the 13 min 21s (simulated time). The obtained regression surfaces corresponded from a quarter from the semi-product section is like similarly of the other parts of the section. From the point of view of the temperature values, the semi-product corner is the first cooled section, and the core is the most slowly cooled part.

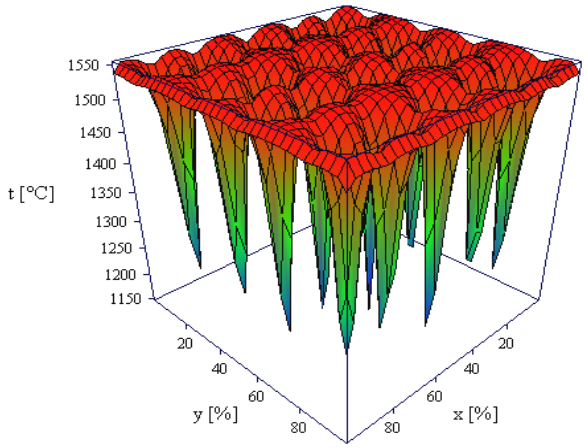



Fig. 9. The thermal field at 3s after the micro-coolers addition

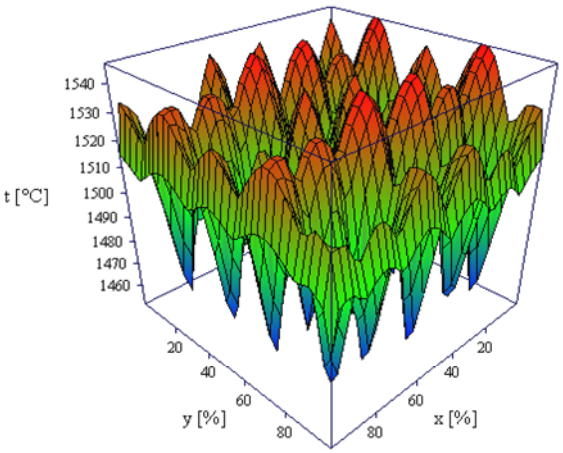



Fig. 10. The thermal field at 9s after the micro-coolers addition

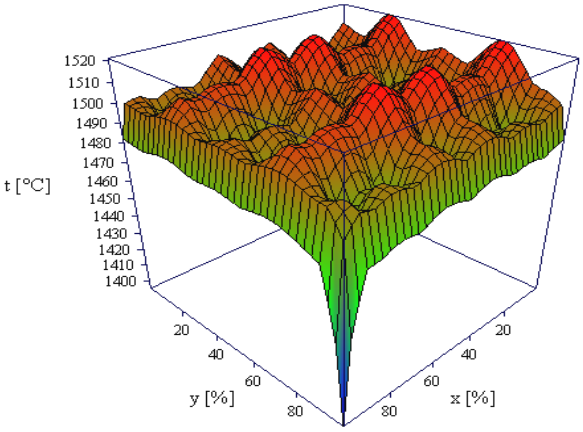



Fig. 11. The thermal field at 24s after the micro-coolers addition

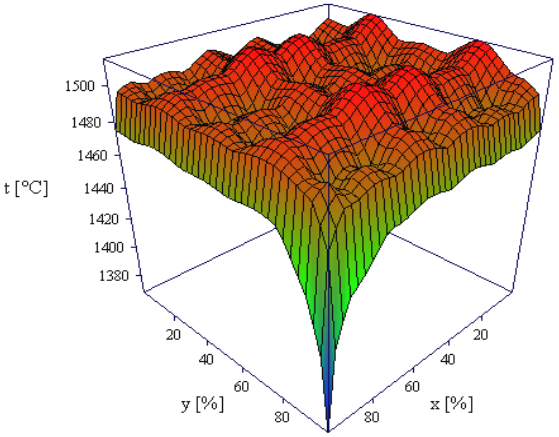



Fig. 12. The thermal field at 30s after the micro-coolers addition

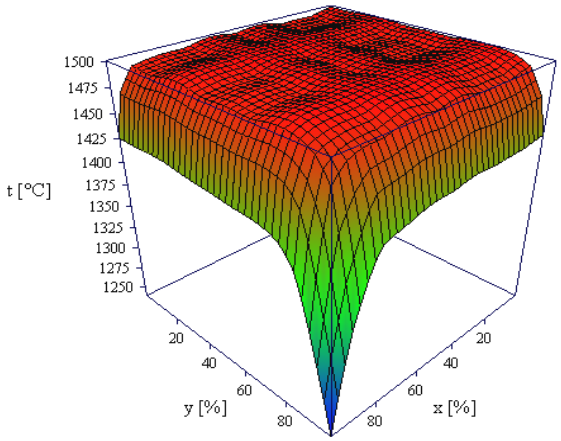



Fig. 13. The thermal field at 60s after the micro coolers addition

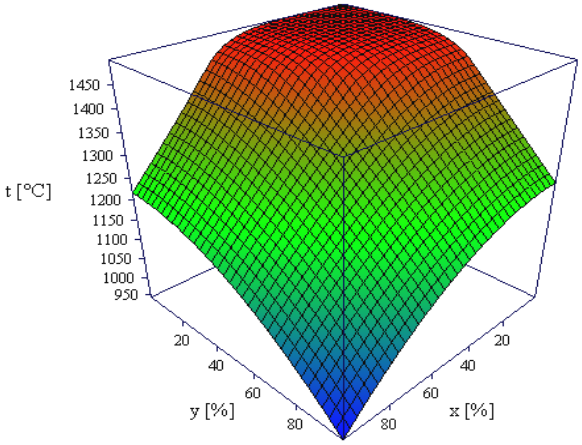



Fig. 14. The thermal field in semi-product (with section 240x270mm) at 13 min 21s (simulated time)

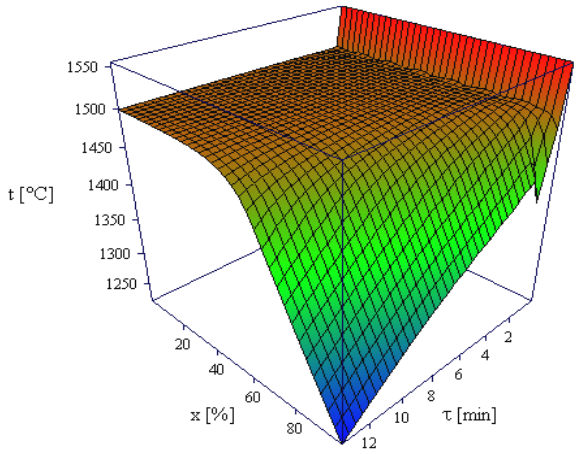



Fig. 17. The thermal field in semi-product (240x270mm) across the axe x for y = 0, depending in time

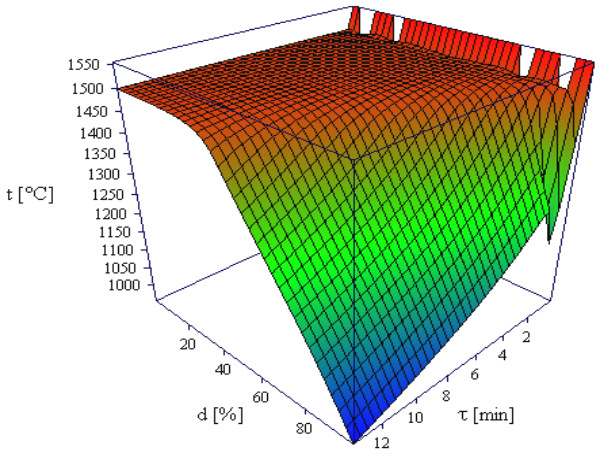



Fig. 18. The thermal field in semi-product (section 240x270mm) across the diagonal, depending in time

In order to realize a bi-dimensional mathematical modeling of a semi-finished product it is considered a section of half-finished product-crystallizer assembly, which is divided using a discretisation network. As results of the considered hypothesis, the half-finished product-crystallizer assembly is symmetric with respect to longitudinal axis of the half-finished product. The origin of the system of coordinates will be in the center of the half-finished product and the calculus will be made just for positive x and y.

The temperature of every node represents the mean temperature of node adjacent surface. In these nodes are written the finite differential equations presented above.

The model is realized based on the fallowing simplifying assumptions:

- the heat transfer on longitudinal axis is neglected, considering that heat transfer take place just in horizontal section of the half-finished product
- the density variation is neglected
- the crystallizer section is consider to be a equivalent rectangular section
- it is consider that the crystallizer loose heat uniformly on each surface
- it is consider that at zero moment the temperature of steel mass is uniform. For the surface nodes it is correct to assume that at the casting moment it took place the formation of a thin solidified steel layer, and the loosed heat by this layer is transmitted instantaneously to the nodes from the interior surface of the crystallizer.
- the evolving of fusion latent heat it is produced in liquidus-solidus interval, direct proportional with the temperature

## 3. CONCLUSIONS

Analyzing the graphical dependences from the performed researches, based on literature review data and from own experimental work it results the fallowing conclusions:

- The results obtained by simulation with presented program being similar with practical data;
- In every diagram there are observed a temperature leap or a solidification speed leap after approximately 1 min 7 s from the beginning of the casting, respectively immediately after the driving out from the crystallizer of the considered section, leap caused by the impossibility of elimination of a heat flux from the half-finished product interior;
- It is observed a numerous crystallizing centers, uniform distributed;
- Also, it is observed an appreciate difference between the liquid steel temperature and the steel temperature from immediate proximity of micro-coolers
- The indurations advances consisted standardized it a temperatures of first in of the minute after the administration of micro-coolers
- Through the addition of micro-coolers is obtained adjustment of the a temperature of the in of the crystallizer depending on the quality and the quantity of micro-coolers

- After precinct a minute from the administration micro-coolers don't else notices significant differences what in looks the variation of the temperature of the in mass of steel
- Modifying a series of parameters (number of discretized points, dissipated heat in crystallizer and in secondary cooling, data of steel grade) it could be obtained more correct values, applicable to other steel grades.

The number of nodes is established starting with the necessity of finding a solution for the following contradiction: the use of a high number of nodes increases the precision of the model (the error introduced by the hypothesis that the adjacent surface of every node has the same temperature as the node is decreases with the decrease of node area); on the other hand a high number of nodes lead to an increasing of processing time due to the increasing of nodes number and due to decreasing of time intervals between iterations imposed by stability conditions of the solutions.

The chosen time interval represent the time in which the unsteady heat transfer process is approximate with a steady process. From this reasons as well as the characteristics of the real process are far from that of a steady one, the iteration period should be smaller.

In order to realize a bi-dimensional mathematical modeling of a semi-finished product it is considered a section of half-finished product-crystallizer assembly, which is divided using a discretisation network. The temperature of every node represents the mean temperature of node adjacent surface.

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# MULTIDISCIPLINARY APPROACHES IN THE FIELD OF THE CAST IRON ROLLING ROLLS MANUFACTURING

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**Abstract**

The irons destined to these cast rolls belong to the class of low-alloyed irons, with reduced content of chrome, nickel and molybdenum. The technological instructions firmly state the elements required raising the quality of rolls, but the limits can be extensive or limited. Depending on the number of the technological parameters, it was chosen the analysis of multiple regressions studying the influence of the chemical composition upon the hardness, through the mathematical modeling.

The technical conditions, which are imposed to the cast iron rolls in the exploitation period, are very different and often contradictory. The obtaining of various physical and mechanical properties in the different points of the rolls meets difficult technological problems in the industrial condition. This supposes us to know many technological factors, which lead to the exploitation of this deformation equipment.

The experimented researches, as well as the optimization of the manufacturing technology, allow the conclusion of direct results for the rolls. The beneficiaries of these results are the unit in which the rolls are manufactured, as well as the unit that exploits them.

**Keywords:**

cast iron rolls, alloying elements, mathematical interpretations

## 1. INTRODUCTION

Poverty of detailed researches, theoretical and experimental, about the thermo-mechanical processes take place during the plastic deformations between the rolling mills rolls, represents a factor that reduces the possibility of rational exploitation of rolling mills. In the context of market economy is necessary a new evolution in the area of scientific researches, in the purpose of modernization of the equipments and metallurgical plants, using the most efficient solutions for obtaining aggregates with performances to the level of world technique. The technological processes of the rolls manufacture, as well as the quality of used materials have a quick extension, materialized in worldwide market competition, through exceptional qualities of rolls.

The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation. Our proposal approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation.

In these sense, our researches propose, on aside, to analyze the technological field of the rolling rolls manufacturing process – analysis materialized from prism of the foundry experiments, including the metallurgical and mechanical aspects (casting process, moulding, iron melting, nodularization of graphite, hardness, durability and so others), and on another side, the optimization of the manufacturing technology of the cast rolls, especially those from cast-iron – using electronic calculus technique as the molding phenomenon and mathematical interpretation of the technological processes.

The research on rolling mills rolls quality experimentally and teoretically defines an important chapter from the metallurgical, mechanical and mathematical aspects of these machines organs in the movement of rotation, in variable temperature mediums. Also, the

mathematical modeling establishes a methodology for the determination of the technological parameters values, for which a mechanical characteristic (the hardness) has the desirable values. Because is disposed of real data, the optimization model is based on industrial data, obtained from cast-iron rolling rolls. Their analysis shall lead to the optimization pattern, through the prism of the multicomponent correlations, enounced by mathematical formulae.

Starting from the principle of molding process, used as necessary basic instrument, both in phase of conception, as well as in the industrial technologies analysis, is determined the optimum regimes of the cast rolls, from the view from chemical composition, as one as the most important parameters of disturbance of the manufacturing process. The enunciation of some mathematically molding results, described through a number of multicomponent equations determined for the spaces with 3 the and 4 dimensions, as well as the generation of some regression surfaces, of some curves of levels, of the volumes of variation, of the lines of outlines of the volumes of variation of surfaces and the areas of variation of these, can be represented and interpreted by technologists and can be considerate diagrams of correlation between the analyzed variables. From this point of view the project is inscribes in context of scientific capitalization of the process and the industrial technologies optimizations, on the way of the analysis and the mathematical experiment.

## 2. THE TECHNOLOGICAL APPROACHES

The nodular graphite cast iron is considered as one of the most versatile roll materials nowadays. This type of material may be used to produce large scale rolls in double pouring process, the barrel of rolls has high hardness while the neck has high toughness, so this type of rolls exhibits the properties of high thermal stability and resistance to wear. As the characteristics of any casting are influenced by the microstructure that is formed during the solidification in the cast form, and under the influence of the cooling speed, the main criteria, which determines the mechanical properties of the rolls is the structure. All structural components can be found in cast iron rolls, each of the components having its own well-determined hardness. One of the parameters, which are determined the structure of the irons destined for rolls casting, is the chemical composition. If we do not respect this composition, which are guarantied by the exploitation properties of the each roll in the stand of rolling mill, this leads to rejection. All FNS type rolls are alloyed especially with chrome, nickel and molybdenum, in different percentages. The irons destined to these cast rolls belong to the class of low-alloyed irons, with reduced content of these elements. The technological instructions firmly state the elements required to raise the quality of rolls.

The recommended hardness's for the working surfaces of the half-hard rolls are presented in Table 1, according with the hardness classes adopted by the Romanian Standard Regulations. Also, the recommended hardness for the rolls necks and the core are presented in same Table 1. The usual chemical composition of the irons destined for casting the half-hard rolls is presented in Table 2.

TABLE 1. The recommended hardness's of the half-hard rolls for the rolls working surfaces (body), the necks and the core

| Rolls Type | Hardness Classes | Hardness | | | |
|---|---|---|---|---|---|
| | | on the rolls working surface | | on the necks and in the core | |
| | | [HS] | [HB] | [HS] | [HB] |
| FNS | 0 | 33...42 | 218...286 | 30...40 | 195...271 |
| FNS | 1 | 43...59 | 294...347 | 30...40 | 195...271 |
| FNS | 2 | 69...75 | 499...550 | 35...45 | 218...309 |

TABLE 2. The usual chemical composition of the irons destined for casting the half-hard rolls

| Rolls Type | Chemical Composition, [%] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C | Si | Mn | P | S | Ni | Cr | Mo | Mg |
| FNS | 3,0..3,5 | 1,2..2,5 | 0,1..0,7 | max. 0,15 | max. 0,02 | 1,5..2,5 | max. 0,8 | 0,3...0,5 | 0,02... 0,04 |

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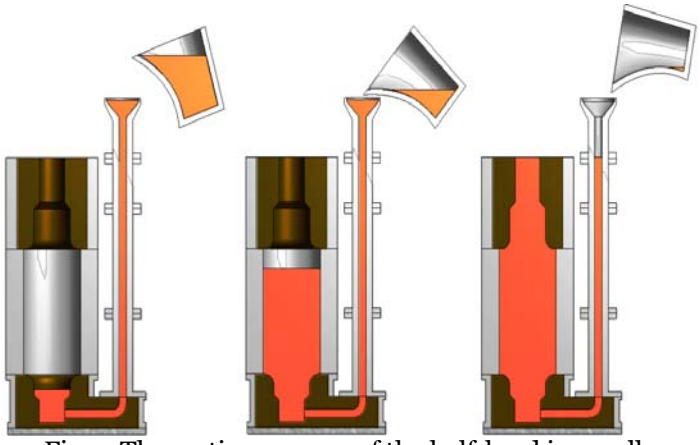


Fig. 1. The casting process of the half-hard iron rolls

The quality of rolls is determined through hardness and through wear resistance, last index having a special importance for all modern rolling mills with a growth production. Of major importance for the rolls exploitation is not merely growth resistance, but also the ability to oppose to different types of wear. Thus, rolling mill rolls considerable influence the specific production and the qualitative level of laminates, reason for which they are given a special attention, in manufacturing, as well as in usage. These requirements can't be completely fulfilled, compelling to the granting of priorities depending on the type of laminates, therefore to compromises. At large, the problem is reduced to the correct material choice, eased by the rich available experience in the current conditions of manufactured and burdened, in the same time, by the large diversity of material used.

Although the manufacture of rolls is in continuously perfecting, the requirements for superior quality rolls are not yet completely satisfied, in many cases, the absence of quality rolls preventing the realization of quality laminates or the realization of productivities of which rolling mills are capable.

To the selection of materials is considered the type of rolling mill, the sizes of rolls (in specially this diameter), the speeds of lamination, the stands from the train of lamination for which is achieved rolls, the working temperature in the lamination process, the module of cooling during work, the size caliber, the pressure on rolls, the rolled material hardness, etc.

The choice of material for rolls is the operation which takes into consideration the own solicitations of the lamination process afferent to the type of laminates (semiproduct or the finite laminate), and the features of different materials considerate optimum in the fabrication of different typo-dimensions of rolls.

Having abrading and dry friction wear resistance, as well as another mechanical characteristic superior to cast irons with lamellar graphite, the cast-irons with nodular graphite are successfully used to the cast of types of rolls. The main structural constituent of the cast-iron is the graphite, of the amount, form, sizes and module of allocation in basic metallic mass depends the physical and mechanical property of the cast-iron, inclusively of the rolls, as well as the wear resistance. For this reason, the amount and the module of distribution of the graphite separation in working surface of rolls it can be considered as main criterion of classification. The presents of graphite in working surface (body of rolls) assures the friction coefficient necessary to obtain quality laminate. From this point of view, the cast irons with nodular graphite is used to manufacture large types of rolls.

Having in view the complex solicitations in exploitation, another important characteristic imposed to the rolling mills rolls is the thermal shock resistance. The main cause of wear is the appearance of fissures on the working surface, due to thermal fatigue. The thermal wear, in principle, can be explained through the different behavior of the constituents that compose the basic metallic mass, in variations of temperature. The thermo-mechanical wear, due the crossing among the rolls of the laminates, warmed in the austenitic area, is direct influenced by the fineness of the basic metallic mass structure, as well as the form and size of graphite disjunctions. In order to obtained a good durability, it is needed a fine homogeneous structure, with a great degree of dispersion of the pearlite.

## 3. THE MATHEMATICAL APPROACH

The statistical methods of the analysis do not solve a whole series of appearances regarding to the decisions model to establish the management of the process. For this reason, in parallel with the statistical methods, was developed the methods of optimization.

As part as the basic experiment, through the regression analysis, it was aimed the determination of the mathematical functions form which connect the dependent variables *u* of the technological process with the free variables (the technological parameters) *x, y, z,...*, meaning $u = f(x, y, z,...)$, on the strength of some experimental determinations, this after it accomplished a dispersion analysis of these correlation data. The determination of what real coefficients enter into the expression $u = f(x, y, z,...)$ is done, in the vast majority of the cases, through the method of the smallest squares.

Depending on the number of free variables (the technological parameters) that we consider, it was chosen the analysis of multiple regressions studying the influence of free variables *x, y, z,...* upon the dependent variable *u*. In this sense, it was aimed to establish calculus methodologies of values for the technological parameters in the manufacturing process of the semihard rolling mill rolls, obtained through the simplex classical cast of the iron with nodular graphite, for which the mechanical features of rolling mill rolls have the required values.

Having "*n*" experimental points, respectively $(x_1, y_1, u_1)_1$, $(x_1, y_1, u_1)_2$, .... $(x_1, y_1, u_1)_n$, we need to determine the real coefficients $c_0$, $c_1$ and $c_2$ in the equation of the plan. This is accomplished through the method of the smallest squares, which leads to finding them through the following system of three equations with three unknown variables $(a_0, a_1, a_2)$:

$$\begin{cases} n \cdot c_0 + \left(\sum_{i=1}^{n} (x)_i\right) \cdot c_1 + \left(\sum_{i=1}^{n} (y)_i\right) \cdot c_2 = \sum_{i=1}^{n} u_i \\ \left(\sum_{i=1}^{n} (x)_i\right) \cdot a_0 + \left(\sum_{i=1}^{n} (x)_i^2\right) \cdot a_1 + \left(\sum_{i=1}^{n} (x)_i \cdot (y)_i\right) \cdot a_2 = \sum_{i=1}^{n} (x)_i \cdot u_i \\ \left(\sum_{i=1}^{n} (y)_i\right) \cdot a_0 + \left(\sum_{i=1}^{n} (x)_i \cdot (y)_i\right) \cdot a_1 + \left(\sum_{i=1}^{n} (y)_i^2\right) \cdot a_2 = \sum_{i=1}^{n} (y)_i^2 \cdot u_i \end{cases} \quad (1)$$

where the real coefficients (the sums from parentheses) are calculated tabularly. The solution of the system is done through the Cramer rule, using the determinants of the system.

Departing from the experimental results, in a first phase the stage are determined the mathematical models of dependencies for optimized parameters (the mechanical features the materials) with the technological parameters in the influences of the process, in the form of equation (2). In mathematical model it is reduced to complex mathematical processing of dependences in the features analyzed depending on two or three chemical elements, grouped depending on the influence upon them. Thus we can analyze dependences type (3).

$$\begin{array}{ll} HB_{(infneck)} = f(\text{basic chemical elements}) & HB_{(infneck)} = f(\text{alloying chemical elements}) \\ HB_{(supneck)} = f(\text{basic chemical elements}) & HB_{(supneck)} = f(\text{alloying chemical elements}) \\ HB_{(body)} = f(\text{basic chemical elements}) & HB_{(body)} = f(\text{alloying chemical elements}) \end{array} \quad (2)$$

$$\begin{array}{lll} HB_{(infneck)} = f(C, Si, Mn); & HB_{(supneck)} = f(C, Si, Mn); & HB_{(body)} = f(C, Si, Mn); \\ HB_{(infneck)} = f(Ni, Cr, Mo); & HB_{(supneck)} = f(Ni, Cr, Mo); & HB_{(body)} = f(Ni, Cr, Mo); \end{array} \quad (3)$$

Following the experiments we determine the mechanical features according to the technological parameters of influences in the process. Because we dispose of real data, afterwards it is required to present the model of optimization on industrial data, sampled from rolling mills rolls. As parameters for optimization we selected:

- the Brinell hardness, measured on the body of rolls, $HB_{(body)}$;
- the Brinell hardness, measured on the necks of rolls, $HB_{(infnecks)}$ and $HB_{(supnecks)}$.

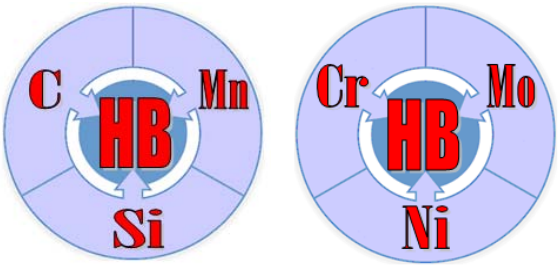



Figure 2. The influence of the basic and the alloyed elements upon the brinell hardness, in mathematical perspective

In order to reduce the experiments number and to simplify the optimization calculi, among the parameters of influence,

we chose the chemical composition of the cast irons with nodular graphite. These hypotheses lead the optimization model through the prism of the multi-component correlations in formula (II).

The industrial data are modeled in the form of equation (4). We consider the variations limits of the variables ($x, y, z$), as well as the variation limits of the analyzed features. Also, in the limits of graphical representation ($lim\ x_{inf}$, $lim\ x_{sup}$, $lim\ y_{inf}$, $lim\ y_{sup}$, $lim\ z_{inf}$, $lim\ z_{sup}$), as well as the average values of the variables and of the analyzed features ($x_{med}$, $y_{med}$, $z_{med}$, $u_{med}$) are stated.

$$u(x, y, z) = C_1 x^2 + C_2 y^2 + C_3 z^2 + C_4 y z + C_5 x z + C_6 y x + C_7 x + C_8 y + C_9 z + C_{10} \quad (4)$$

At that rate, the equations of the regression hyper-surfaces are in equation (3), for which there is a correlation coefficient ($rf$) and a deviation from the regression surface ($sf$).

## 4. THE PRESENTATION OF GRAPHICAL ADDENDA

Figure 3 presents the screen which generates the regression surfaces of the variable ($HB_{(body)}$, $HB_{(infnecks)}$, $HB_{(supnecks)}$) for the cases $x = x_{med}$, $y = y_{med}$ and $z = z_{med}$, waves $x, y, z$ represent combination of chemical elements depending on the mathematical model under study.

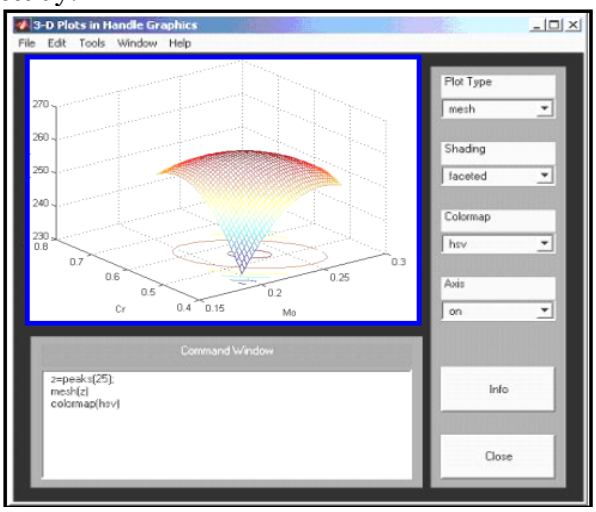



Figure 3. Regression surface of the variabile $u$ ($HB_{(body)}$, $HB_{(infnecks)}$, $HB_{(supnecks)}$) for the cases $x = x_{med}$, $y = y_{med}$ and $z = z_{med}$

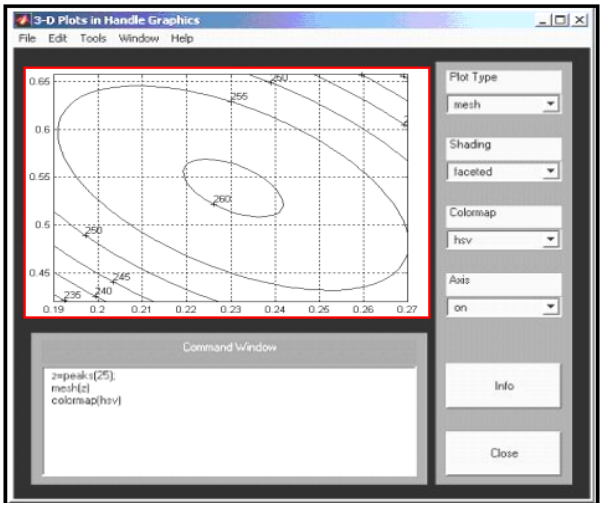



Figure 4. The level curves generation for the dependences $u = f(x, y, z)$, formally $u = f(x_{med}, y, z)$, $u = f(x, y_{med}, z)$ and $u = f(x, y, z_{med})$

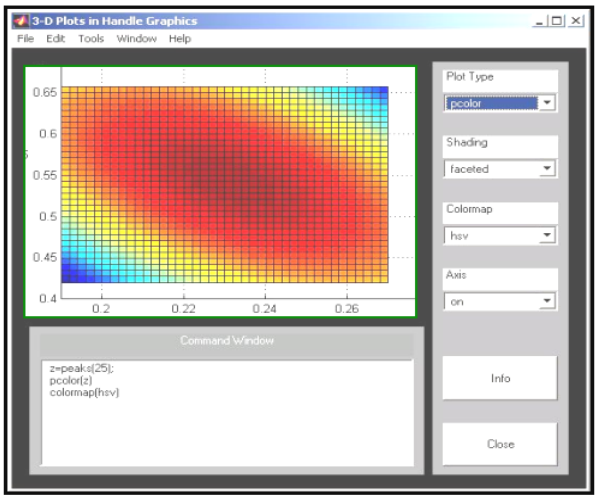



Figure 5. Screen for the variation domain generation of the dependences $u = f(x, y, z)$, formally $u = f(x_{med}, y, z)$, $u = f(x, y_{med}, z)$ and $u = f(x, y, z_{med})$

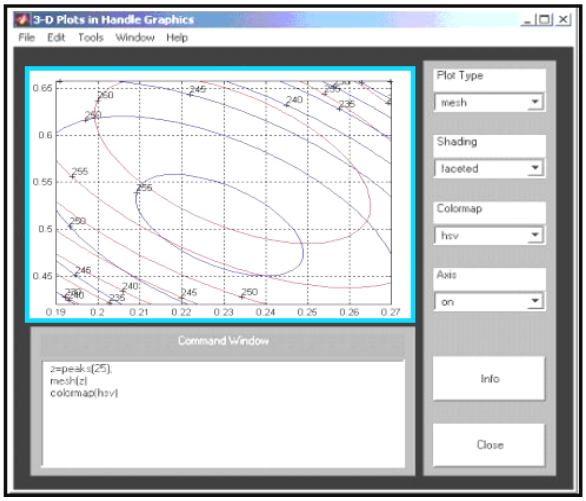



Figure 6. Screen for the adjusting diagrams generation built for the average values ale parameters ($x_{med}$, $y_{med}$, $z_{med}$)

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Figure 4 presents the program screen capture which generates the level curves of the dependence $u = f(x, y, z)$, formally $u = f(x_{med}, y, z)$, $u = f(x, y_{med}, z)$ and $u = f(x, y, z_{med})$ for the cases $x = x_{med}$, $y = y_{med}$ and $z = z_{med}$. This level curves represents the projection in the two-dimensional plan of the regression surfaces presented in the Figure 3. Figure 5 presents the screen which generates the variation domain of the characteristics $u = f(x, y, z)$, formally $u = f(x_{med}, y, z)$, $u = f(x, y_{med}, z)$ and $u = f(x, y, z_{med})$ for the cases $x = x_{med}$, $y = y_{med}$ and $z = z_{med}$. This geometrical areas represents level curves variations in the two-dimensional plan.

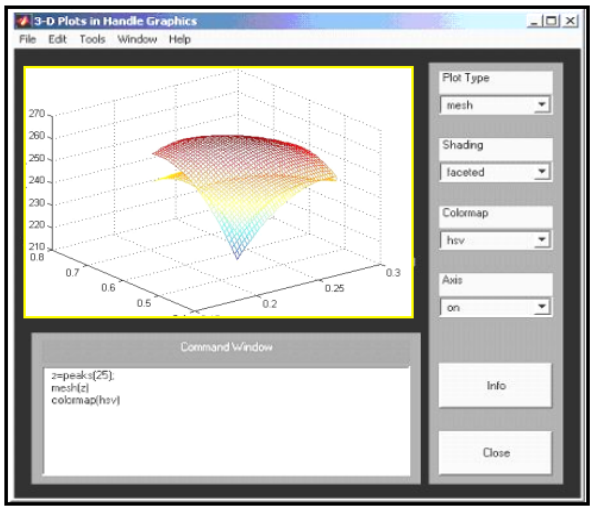



Figure 7. Screen for the regression surface volume variation generation for the average values $x = x_{med}$, $y = y_{med}$ and $z = z_{med}$

These diagrams are built for the average values of the parameters ($x_{med}$, $y_{med}$, $z_{med}$), only that through the representation of the diagrams for parameters values contained in the variations limits we can obtain adjusting diagrams (Figure 6), with which we can completely controlled the process. Figure 7 presents the screen, which generates the correlation surfaces, meaning the projection in the two-dimensional plan of the variation volumes of the regression surfaces. These are obtained through superposing of the $u = f(x_{med}, y_{med}, z_{med})$ and one of surfaces corresponding for the average values $x = x_{med}$, $y = y_{med}$ and $z = z_{med}$, meaning $u = f(x_{med}, y, z)$, $u = f(x, y_{med}, z)$ and $u = f(x, y, z_{med})$.

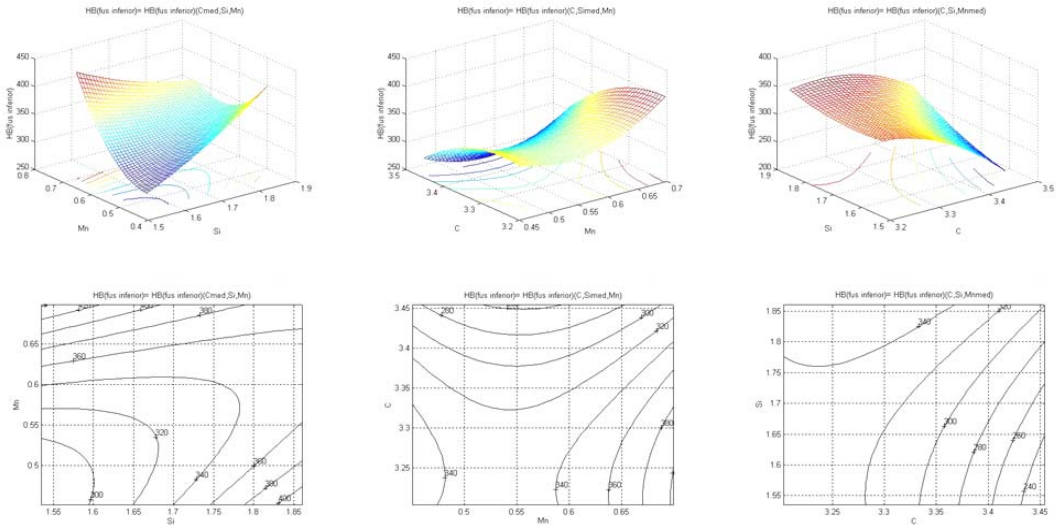


Figure 8. The regression surface and the level curves generated by the program for the dependences between hardness and chemical composition [presented example for the variation of the parameter $HB_{(Fusinf)}$ in the cases $C = C_{med}$, $Si = Si_{med}$ and $Mn = Mn_{med}$, in the $HB_{(Fusinf)} = f(C_{med}, Si, Mn)$, $HB_{(Fusinf)} = f(C, Si_{med}, Mn)$ and $HB_{(Fusinf)} = f(C, Si, Mn_{med})$ dependences]

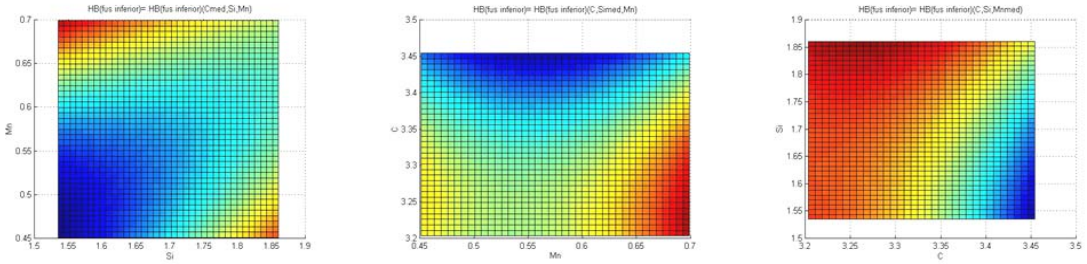


Figure 9. The variation domain in color panel presentation for the dependences between hardness and chemical composition [same case]

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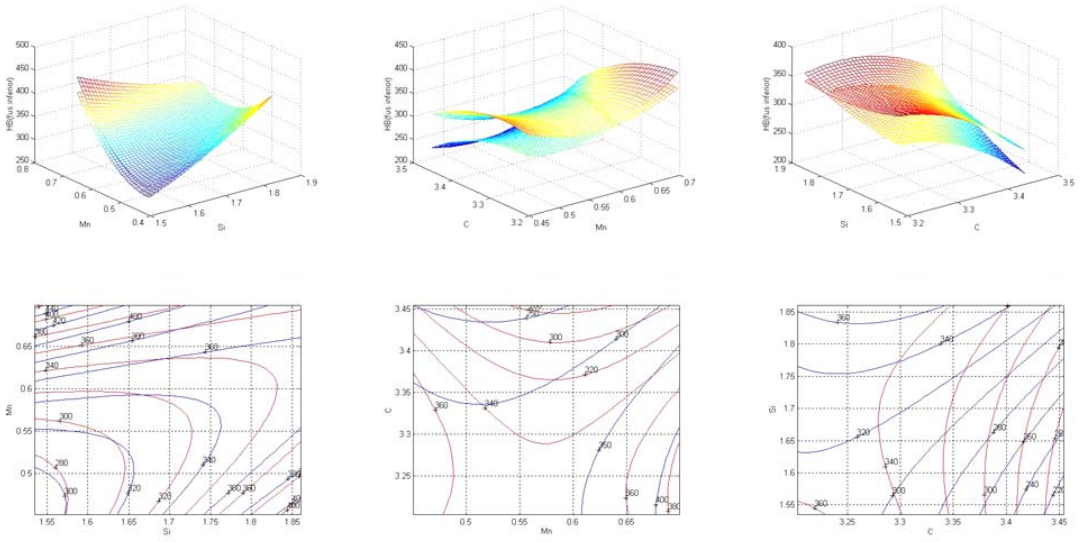


Figure 10. The regression surface volume variation domain and the adjusting diagrams for the dependences between hardness and chemical composition [same case]

## 7. CONCLUSIONS

The performed study had in view to obtain correlations between the hardness of the cast iron rolls (on the necks and on the working surface) and its chemical composition, defined by basic and the representative alloying elements. Analyzing the graphical dependences from the performed researches, based on literature review data and from own experimental work it results the fallowing conclusions:

- the values processed were made using Matlab calculation program. Using this calculation program we determine some mathematical correlation, correlation coefficient and the deviation from the regression surface. This surface in the four-dimensional space (described by the equation) admits a saddle point to which the corresponding value of hardness is an optimal value of alloying elements.
- the existence of a saddle point inside the technological domain has a particular importance as it ensures stability to the process in the vicinity of this point, stability which can be either preferable of avoidable.
- the behavior of this hyper-surface in the vicinity of the stationary point (when this point belongs to the technological domain) or in the vicinity of the point where the three independent variables have their respective average value, or in a point where the dependent function reaches its extreme value in the technological domain (but not being a saddle point) can be rendered only as a table, namely, assigning values to the independent variables on spheres which are concentric to the point under study.
- as this surface cannot be represented in the three-dimensional space, we resorted to replacing successively one independent variable by its mean value. These surfaces (described by the equation), belonging to the three-dimensional space can be reproduced and therefore interpreted by technological engineers.
- knowing these level curves allows the correlation of the values of the two independent variables so that we can obtain a viscosity within the required limits.

The realization of a mathematical model starting from industrial data, gathered at the rolls hardness measurement, and at the national standards reglementations, which recommends the hardness, for different chemical compositions, also determines the degree of originality of the research. The determination of the equations of regression hiperplanes, which describe the mathematical dependency between the chemical composition and the hardness, the determination of the multicomponent relations and the realization of the graphic interfaces for the representations variation areas of the cast-irons chemical composition, completes this area of preoccupations within a processing mathematical of molding and optimization.

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The realization of an optimal chemical composition can constitute a technical efficient mode to assure the exploitation properties, the material from which the rolling mills rolls are manufactured having an important role in this sense. From this point of view is applied the mathematical molding, witch is achieved starting from the differentiation on rolls component parts, taking into consideration the industrial data obtained from the hardness measuration on rolls, as well as the national standards reglementations, which recommends the hardness, for different chemical compositions.

The optimum solution is determined through some mathematical restrictions to the input values that the mathematical molding is started. As a work method is chosen the way of the constraint of average successive values to some of the elements of chemical composition, leaving free the variation of a number of variables submitted to optimization. Is searched to constraint average values, inclusively to dependent variables, desired to achieve through the chemical optimum composition. It will be determined the equations of regression hiperplanes, which describe the mathematical dependency between the chemical composition and the hardness, and is searched a solution which can determine the optimum chemical composition for hardness desirable values.

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# STUDY OF THE MACHINING ERROR DUE TO CONTACT DEFORMATION OF WORKPIECE-FIXTURE SYSTEM

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**Abstract**

In this paper work there are described the error's sources due to workpiece-fixture compliance which appear while the workpieces are clamped, is presented the analytic models of calculus of the errors due to contact deformation between locators and workpiece and an example of using the finite element method in order to determine the contact deformation for a practical example. The differences between the results obtained using the finite element method and the results obtained using analytical relations are very small, which demonstrates that the finite element method can be used for determining the machining error due to contact deformation.

**Keywords:**

Workpiece, fixture, deformation, machining error

## 1. INTRODUCTION

In the machining process the fixtures are used for the orientation and clamping, for the workpiece to be machined through various methods, assembling and controlling. Once the workpiece is orientated and clamped with locators and clamping devices the workpiece can be machined in order to accomplish the imposed accuracy conditions.

The errors due to fixtures are major ones and influence the workpiece's machining accuracy; the errors can amount to 20-60% of the overall machining error. Therefore, performance evaluations of the workpiece-fixture system constitute a significant task for fixture design optimization and control of the machining error before manufacturing and the application in production.

The errors due to the workpiece-fixture system can be classified in two categories: errors due to orientation of the workpiece in the fixture and errors due to deformations of the workpiece-fixture system during clamping and machining.

During clamping and machining the workpiece, for a point P situated on the machined feature, the force assembly which acts on the workpiece-fixture system determines the appearance of three types of errors: errors due to contact deformation, errors due to locator's deformation and errors due to workpiece deformation.

## 2. ANALYTIC CALCULUS OF THE ERRORS DUE TO CONTACT DEFORMATION

In many different situations, in device design practice, the contact geometry between surfaces of workpieces and locators or clamping elements of fixture can be a point (sphere–sphere contact), a line (cylinder - plane contact) and a plane surface (plane – plane contact).

The contact deformation between workpiece and locators and clamping elements of fixtures can be characterized with Hertz's model of contact stress. The hertzian theory of contact is based on the following simplifying assumptions [1]:

- the materials in contact are homogeneous and the yield stress is not exceeded;
- contact stress is caused by the load which is normal to the contact tangent plane which effectively means that there are no tangential forces acting between the solids;
- the contact area is very small compared with the dimensions of the contacting solids;
- the contacting solids are at rest and in equilibrium;
- the effect of surface roughness is negligible.

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*2.1. Contact between a sphere and a plane surface*

The contact area between a sphere and a plane surface, as shown in Figure 1, is circular.

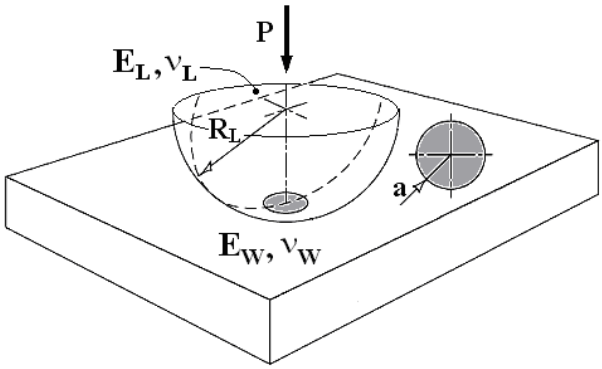



Figure 1. Contact between a sphere and a flat surface

The contact parameters for this configuration can be calculated according to the next formulae:

- contact area dimensions: $a = \left(\frac{3PR'}{E'}\right)^{1/3}$ (1)
- maximum contact pressure: $p_{max} = \frac{3P}{2\pi a^2}$ (2)
- average contact pressure: $p_m = \frac{P}{\pi a^2}$ (3)
- maximum contact deformation: $\delta = 1.0397\left(\frac{P^2}{E'^2 R'}\right)^{1/3}$ (4)
- maximum shear stress: $\tau_{max} = \frac{1}{3}p_{max}$ at a depth of $z = 0.638a$ (5)

where $a$ is the radius of the contact area [m]; $P$ is the normal load [N]; $p$ is the contact pressure (Hertzian stress) [Pa]; $\delta$ is the contact deformation (total deflection at the centre of the contact $\delta = \delta_A + \delta_B$, where $\delta_A$ and $\delta_B$ are the maximum deflections of body A and B respectively) [m]; $\tau_{max}$ is the shear stress [Pa]; $z$ is the depth under the surface where the maximum shear stress acts [m]; $E'$ is the reduced Young's modulus [Pa] and $R'$ is the reduced radius of curvature [m] ($R' = R_L$).

The reduced Young's modulus is defined as:

$$\frac{1}{E'} = \frac{1}{2}\left(\frac{1-\upsilon_L^2}{E_L} + \frac{1-\upsilon_W^2}{E_W}\right) \quad (6)$$

where $\nu_L$ and $\nu_W$ are the Poisson's ratios of the locator and workpiece, respectively and $E_L$ and $E_W$ are the Young's moduli of the locator and workpiece, respectively.

*2.2. Contact between a cylinder and a plane surface*

According to the Hertz theory for the contact of cylindrical locator, when one of the contact bodies roughly takes the form of a rectangular block of thickness $t$, as shown in figure 2, then the deformation of the block through its thickness may be obtained with reasonable approximation, provided that the thickness of the block is large compared with the contact width (t>>a), then the deformation of the block through its thickness is

$$\delta = P\frac{1-\nu_L^2}{\pi E_L}\left[2\ln\left(\frac{2t}{a}\right) - \frac{\nu_L}{1-\nu_L}\right], \quad (7)$$

where $t$ is the thickness of the block; $\nu_L$ is Poisson's ratio of the cylindrical locator; $E_L$ is Young's modulus of the cylindrical locator; $a = \left(\frac{4PR_L}{\pi E'}\right)^{1/2}$ (8) is the contact width.

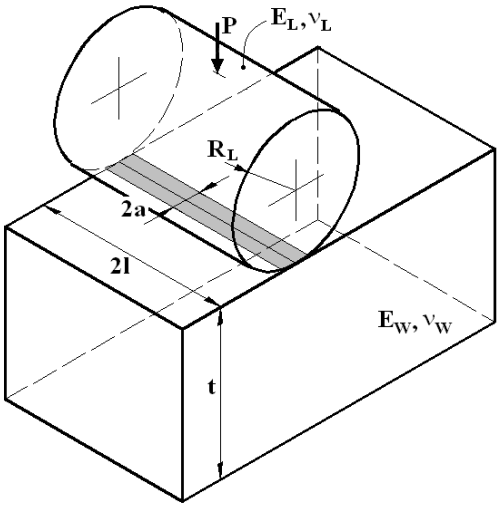



Figure 2. Contact between a cylindrical locator and a rectangular workpiece

## 3. EVALUATION OF THE MACHINING ERROR DUE TO CONTACT DEFORMATION WITH THE FINITE ELEMENT METHOD

A quick and efficient evaluation of the machining errors due to contact deformation which appear during clamping of workpieces can be realized with the finite element method. Forwards it is presented an example of application of this method for contact between a cylindrical locator and a rectangular workpiece.

An elastic cylindrical locator of steel with a radius of R=10 mm pressed against a flat surface of a workpiece of the same material by a pressure P=0,20 MPa. Geometry of the rectangular workpiece: length 25 mm, width 25 mm and height 20 mm. Materials for cylindrical locator and rectangular workpiece: steel having Young's modulus E =205 GPa and Poisson's ratio ν=0.29. The clamp–workpiece contact was modeled using surface to surface contact elements.

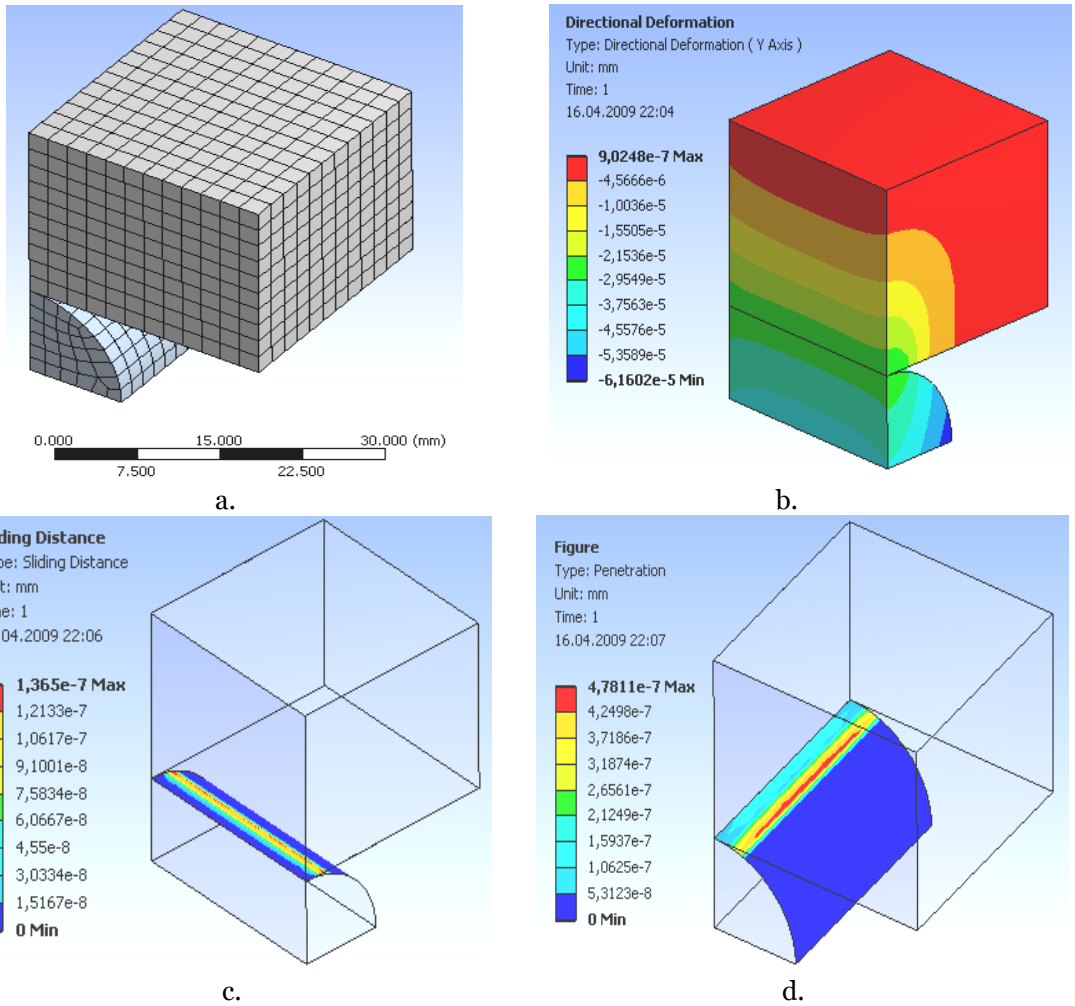



Figure 3. FEA analysis of the workpiece-locator system

The results are presented in figure 3. The contact deformation in contact zone are evaluated in figure 4, b.

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## 3. CONCLUSION

The maximum contact deformation calculated with relation (7) is 0,388 μm. The contact deformation evaluated with the finite element method in middle point of contact line is 0,357 μm. These results demonstrate that the finite elements method permits a quick and efficient evaluation of the contact deformation due to workpiece-fixture system and the machining error due the contact deformation.

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# MULTIDISCIPLINARY RESEARCH AREAS FOR INCREASING THE ROLLING-MILL ROLLS QUALITY

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**Abstract:**

Quality assurance is the activity of providing evidence needed to establish quality in work, and that activities that require good quality are being performed effectively. All those planned or systematic actions necessary to provide enough confidence that a product or service will satisfy the given requirements for quality. Quality assurance covers all activities from design, development, production, installation, servicing and documentation. It includes the regulation of the quality of raw materials, assemblies, products and components, services related to production, and management, production, and inspection processes.

Our approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. The experimented durability research, as well as the optimization of the manufacturing technology, allows the conclusion of direct results for the rolls. The beneficiaries of these results are the unit in which the rolls are manufactured, as well as the unit that exploits them. The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation.

**Keywords:**

quality assurance, cast-iron rolls, manufacturing, laboratory research, mathematical modeling

## 1. INTRODUCTORY NOTES

Roll makers always ask about rolling conditions and the necessity to choose the right grade of roll material and roll users always ask about the mechanical and physical properties of roll material. Sometimes they feed these figures into their rolling model, but sometimes they also need them for unknown reasons. This information is very rarely useful for selecting the right supplier. Roll makers and roll users frequently have to discuss experiences, performance results, special requirements of the mill. Roll failure problems can be solved by good co-operation. In engineering and manufacturing, quality control and quality engineering are involved in developing systems to ensure products or services are designed and produced to meet or exceed customer requirements. These systems are often developed in conjunction with other business and engineering disciplines using a cross-functional approach. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer.

Quality assurance covers all activities from design, development, production, installation, servicing and documentation. It includes the regulation of the quality of raw materials, assemblies, products and components, services related to production and inspection processes. Production logistics is the term used for describing logistic processes within an industry. Also, the purpose of production logistics is to ensure that each equipment and technologies is being fed with the right product in the right quantity and quality at the right point in time.

What materials, products, or information come into the activity? What materials, products, or information flow out of the activity? Quality engineers use the D-M-A-I-C model (define, measure, analyze, improve, and control) to document processes before beginning process improvement. If processes are documented, another series of logical questions apply: Are the processes being followed? Are they within acceptable control and performance parameters? Are they outdated? Can they be improved? Those are the questions which determine the correlations between the logistics process and the quality assurance.

## 2. QUALITY ASSURANCE IN THE ROLL INDUSTRY

The manufacture of rolls (see Figure 1) is in continuously perfecting, the requirements for superior quality rolls are not yet completely satisfied, in many cases, the absence of quality rolls preventing the realization of quality laminates or the realization of productivities of which rolling mills are capable. Basic properties of rolls and properties of the material are two totally different sides of a problem and very often this difference is ignored. However, when we start to discuss about the rolls mechanical properties, we have to analyze the rolls material or the roll-properties.

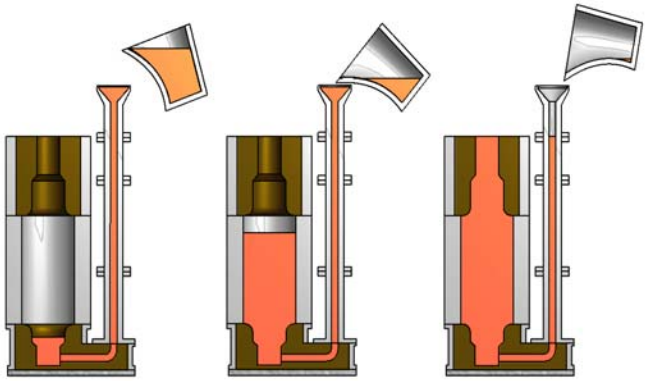


Figure 1. Casting technology of the iron rolls

The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation. Our approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. The quality assurance research fields can be defined through the general research area, throught the different experiments effectuated in the laboratories, and, also, throught the modern calculation programms, optimization technologies and the better capitalization of the manufacturing data (see Figure 2).



Figure 2. Quality assurance research fields




Figure 3. Quality assurance in rolling industry

In the rolling industry, the quality of the rolls is in directly accordance with the quality of technologies (defined by the casting equipments, materials, applied procedures, etc), and also, by the quality of the manufacturing process (charging, melting, innoculation, laddle treatment, casting, cleaning, etc), which are presented in Figure 3.

## 3. QUALITY OF ROLLS ASSURED BY MODELLING OF MANUFACTURING

Industrial engineering is also operations management, systems engineering, production engineering, manufacturing engineering or manufacturing systems engineering. Where as most engineering disciplines apply skills to very specific areas, industrial engineering is applied in every industry. Industrial engineers typically use computer simulation, especially discrete event simulation, for system analysis and evaluation. The computer is used to generate a numerical model of reality for the purposes of describing complex interaction among components of a system.

Starting from the principle of modelling process, used as necessary basic instrument, both in phase of conception, as well as in the industrial technologies analysis, is determined the optimum regimes of the cast rolls, from the view from chemical composition, as one as the most important parameters of disturbance of the manufacturing process. The enunciation of some mathematically modelling results, described through a number of multicomponent equations determined for the spaces with 3 the and 4 dimensions, as well as the generation of some regression surfaces, of some curves of levels, of the volumes of variation, of the lines of outlines of the volumes of variation of surfaces and the areas of variation of these, can be represented and interpreted by technologists and can be considerate diagrams of correlation between the analyzed variables. From this point of view the project is inscribes in context of scientific capitalization of the process and the industrial technologies

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optimizations, on the way of the analysis and the mathematical experiment. The quality assurance through the modeling phenomenon is presented in Figure 4.

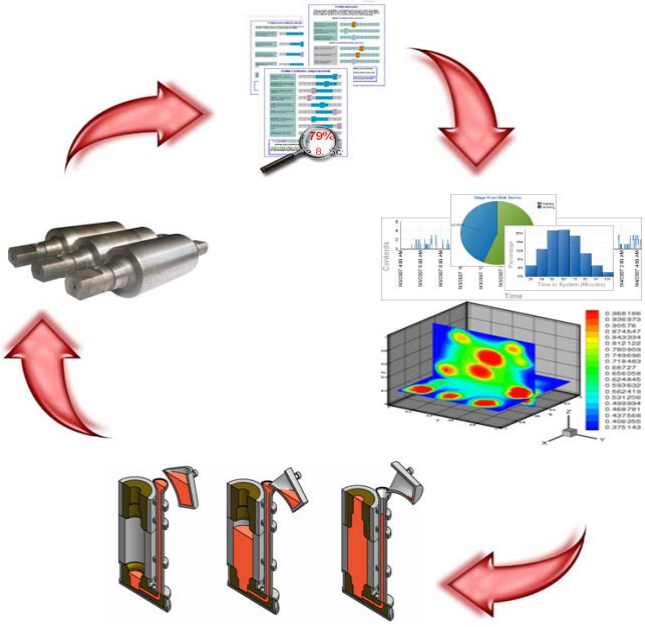


Figure 4. Quality assurance through the modeling phenomenon

The character of the metallurgical processes optimization is influenced by the complex peculiarities of these, which take place into a great number of variables (parameters) that operates independently or cumulate.

For this reason, to analyze the metallurgical processes is used, mainly, the statistical fundamental methods that permit to drawn conclusions, from the observed values, about the repartition of the frequencies of various parameters, about their interaction, about verification validity of certain premises, and about the research of the dependencies among different parameters. However, the statistical methods of the metallurgical process analyses do not solve a series of aspects regarding the mode of establish the decisions for the management of the process. Thereof, parallel with the statistical methods it was developed optimization methods.

The optimization of any technological process has, as a base, a mathematical model. The search for the best solution, for the truth, requests either to find, on the way of a study, definitive truths, or of relative valid truths, valid only in certain conditions, and which, in relation with the definitive truths, include implications and errors.

## 4. QUALITY OF ROLLS ASSURED BY THE LABORATORY EXPERIMENTS

The researches of durability in the exploitation of cast from cast-iron rolls, constitute a scientifically novelty, and experimentally define an important chapter from the thermal fatigue of the organs of machines in the movement of rotation, in variable temperature mediums. Hot rolling mills rolls work the in the variable compound solicitations, due to lamination process and which repeated to regular intervals of time.

All these phenomena, which are more or less emphases depending on the type and typical of rolling mills, are not taking into consideration in the classic calculus of rolls. If the study of the rolls resistance is extended upon their durability, we must consider the whole complex of tensions with mechano-thermic influences. The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that are submitted the rolls or other organs of machines, that works in constant (symmetrical) or variables (asymmetrical) thermal solicitation conditions.

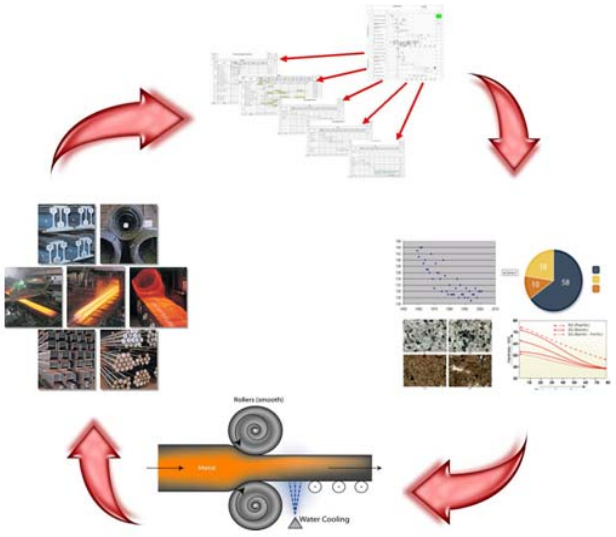


Figure 5. Quality assurance through the laboratory and industrial experiments

The recommendations for the increase of the duration of exploitation and remove of the damages through the accidental rupture of rolls from the stands of lamination, the attenuation of rolls thermal fatigue, the avoiding of thermal shock and their rational exploitation are actuality issues that must be continuously researched.

In this trend is situated the research of the thermal fatigue phenomena, materialized in technical reports, whose

beneficiary is the unit in which the rolls are exploited, as well as through scientific papers, that can develop the framework of scientific research. These researches results lead to direct conclusions about the cast-iron rolls, and permit their comparison with date about steel rolls, area studied thoroughly researched of specialists. The quality assurance through the laboratory and industrial experiments is presented in Figure 5.

The work is of practical immediate utility, inscribing itself in the context of technical capitalization of the manufacturing technologies and of exploitation of cast-iron rolling mill rolls, for which exists an attentive preoccupation both from foundry sectors, as well as from lamination sectors, having as determinate aim the quality assurance and increase the durability in exploitation.

## 5. CONCLUSION

The aim of the propose research is to answer to as many questions possible regarding the quality of rolls. In this sense, durability in exploitation is extremely current, both for immediate practice, and for the scientific research attributed to the cast-iron. Also, the realization of optimum chemical compositions of the cast-iron can constitute a technical efficient way to assure the exploitation properties, the material from which the rolling mills rolls are manufactured having an important role in this sense.

In these sense, our researches propose, on aside, to analyze the durability in industrial exploitation of rolling mills rolls – analysis materialized from prism of the laboratory experiment (Figure 8), and on another side, the optimization of manufacturing technology of the cast rolls, especially those from cast-iron – using electronic calculus technique as the modelling phenomenon (Figure 7) and mathematical interpretation of the technological processes. The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that are submitted the rolls or other organs of machines, that works in constant (symmetrical) or variables (asymmetrical) thermal solicitation conditions. Also, it can be emphasized the thermal shock, phenomenon that constitutes a permanent danger, which leads to rupture, specific to rolling mills rolls. On another hand, the realization of an optimal chemical composition can constitute a technical efficient mode to assure the exploitation properties, the material from which the rolling mills rolls are manufactured having an important role in this sense. From this point of view is applied the mathematical modelling, witch is achieved starting from the differentiation on rolls component parts, taking into consideration the industrial data obtained from the hardness mensuration on rolls, as well as the national standards reglementations, which recommends the hardness, for different chemical compositions.

Through the original aimed elements mentioned above, the suggested researches allows the enunciation of new approaches in the area afferent to the theme. The best way for roll makers to achieve better rolls is to ensure that better materials and improved manufacturing processes are used and that roll users take account of rolling conditions and improved rolling processes. When we start to discuss about the rolls mechanical properties, we have to analyze the rolls material or the roll-properties. In conclusion, the rolls quality problems can be solved by good co-operation between the rolls manufacturers and roll users.

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# EXPERIMENTAL RESEARCH IN PILOT PHASES REGARDING THE SEMISOLID STATE PROCESSING OF STEEL

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**Abstract**

The work presents the results obtained through laboratory stage experiments regarding the semisolid state die forging of steel. The studied steel is submitted to semisolid state die forging in the presence of mechanical vibration with frequencies of 15, 25 and 40 Hz. The use of mechanical vibrations is very important as they play the role of modifying the microstructure and decreasing the quantity of defects. Also through this process the mechanical characteristics of the part are changed.

**Key words:**

semisolid, steel, die forging, mechanical vibration, frequency, microstructure

## 1. INTRODUCTION

The early 1970's represents the appearance period of a new material processing technology, currently known as semisolid metal forming (SSF) [1]. This technology was discovered by a student from MIT (Massachusetts Institute of Technology) which obtained for the first time a semisolid suspension with thixotropic characteristics by mechanical stirring [2]. Due to the observed advantages, the researches continued on low melting point alloys. Currently, in the world are many companies which implemented this new technology and commercialized parts, mainly from aluminum and magnesium alloys [3-5]. Simultaneous with the research of the low melting point alloys were studied and the high melting points alloys like steels, cobalt alloys, etc [6].

Semisolid state processing consists in obtaining of a semisolid suspension formed of spherical solid particles included in a liquid matrix. This suspension has a thixotropic behavior i.e. to behave like a fluid when it's agitated and like a gel when it's at rest. The investigations carried out on Sn-15Pb semisolid suspension with the viscometer, showed that the apparent viscosity of the suspension decreases with increasing shearing rate [7]. Hence are resulted the main advantages of this technology namely: improved flow properties, reduced processing forces, obtaining parts in a finished and complex shape, etc. [8]. In the main there are two options for obtaining parts by semisolid state processing namely: rheocasting and thixoforming. If the liquid metal is intensively agitated in the solidification range the dendrites are broken and thus spherical particles are formed which float in the liquid mass. If this semisolid suspension is used to produce parts directly by casting the process is called rheocasting, and if it's used to obtain semi-finished products which are subsequent heated in the semisolid range and used to produce parts, the process is called thixoforming [9]. The methods used to obtain the precursory alloy with globular structure for thixoforming are: electromagnetic stirring, low superheat casting, SIMA method, etc.

The experimental process presented in this paper use mechanical vibration in order to stir the melt. Experiments were conducted on 200-400 steel in order to obtain glass shape parts. Throughout the die forging process the melt was mechanically agitated with an eccentric vibrating motor powered by a frequency converter. Thus the frequency varied in the range 0Hz - 40Hz.

## 2. EXPERIMENTAL PROCEDURE

### 2.1. Obtaining the pieces by die forging

Experiments were conducted on the laboratory hydraulic press shown in the photo from Figure 1. The material used for experimentation, 200-400 steel (in correspondence with the OT400 steel, STAS 600-82), has the following chemical composition: 0.18% C, 0.40% Mn, 0.25% Si, 0.011% S, 0016% P, 0.12% Ni, 0.03% Mo.



Figure1. Photo of the experimental set-up

The steel was melted in the 100kg induction furnace. The melt reached to the desired temperature has been cast in to the mold through a chute (Figure 2). The die, the punch, the counter-punch and the chute were lubricated with refractory paint to avoid melt sticking. When the melt in the die reached the semisolid temperature range corresponding to a solid fraction between 40-60%, the punch was lowered and the material took the form of the gap between die and punch.



Figure2. Casting of the melt in the die

We have obtained four pieces in glass shape through experiments conducted in different conditions given in Table 1. The first piece (denoted A) was obtained without the use of vibrations at a temperature above the liquidus line. The other three pieces (denoted C, D, E) were obtained in a field of mechanical vibration at different frequencies and amplitudes (see Table 1), in the semisolid temperature range. The vibration frequency was changed by supplying the three-phase vibrating engine with a static frequency converter.

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Table1. Conditions used for die forging of the pieces

| Piece | A | B | C | D |
|---|---|---|---|---|
| Vibration frequency, f [Hz] | 0 | 15 | 25 | 40 |
| Vibration amplitude, a [mm] | 0 | 1 | 0.7 | 0.4 |

The temperature range of the semisolid state processing (40-60% solid fraction, $f_s$) was determined both by the calculations (based on the Fe-C equilibrium diagram) and by the Thermocalc soft [10]. Due to the small differences between temperature results obtained by calculations and by the Thermocalc soft (1-3 degrees), for further experiments we have considered the processing temperature range of 1504-1514 °C, corresponding to 40-60% $f_s$.

The piece A (Figure 3, a) was longitudinal cut into four equal parts noted A1, A2, A3, A4 as seeing in Figure 3, b. These samples were used for different analysis as: metallographic observations, impact tests and Brinell hardness tests. For metallographic observations and Brinell hardness tests, A1 and A2 samples were transversal sectioned in pieces of 10 mm size. Samples A3 and A4 as-obtained were used for impact tests.




a) b)

Figure3. Piece A (a) and the cutting way of the samples notated A1-A4 (b)

The pieces B, C and D were sectioned in the same way as the piece A and submitted to the same analysis.

### 2.2. Sample preparation and analysis details

The sample preparation for microstructure observations was made in accordance with the standard procedure. For preliminary polishing we have used seven different metallographic papers with SiC fine abrasive particles (200, 280, 360, 400, 600, 800 and 1000). The final polishing was made on a felt disk impregnated with alumina suspension ($Al_2O_3$) of 0.3 μm granulation. Then, the samples were etched with 3% Nital reagent and observed by means of a Kruss optical microscope.

The impact test (at room temperature) was performed on U notch samples. From each piece (denoted A-D) were tested two samples of 55x10x8 mm size. The experimental values represent the arithmetic mean of two tests conducted on each piece.

The Brinell hardness test was performed with a Brinell instrument on three transversal cut samples from each piece, having about 20x20x10 mm size. So, the experimental values represent the arithmetic mean of three tests conducted on each piece. The Brinell ball has 10 mm diameter and the static force applied for 10-15s was of 3000 daN.

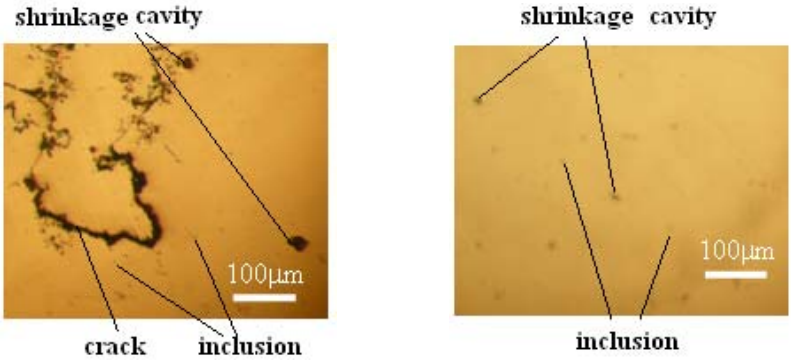
## 3. RESULTS AND DISCUTIONS

### 3.1. Microstructural study

The samples were studied with the microscope before and after the 3% Nital etching. On the un-etched samples obtained without mechanical stirring was reveal defects like: shrinkage cavity, cracks and inclusions. A micrograph of this structure is shown in Figure 4,

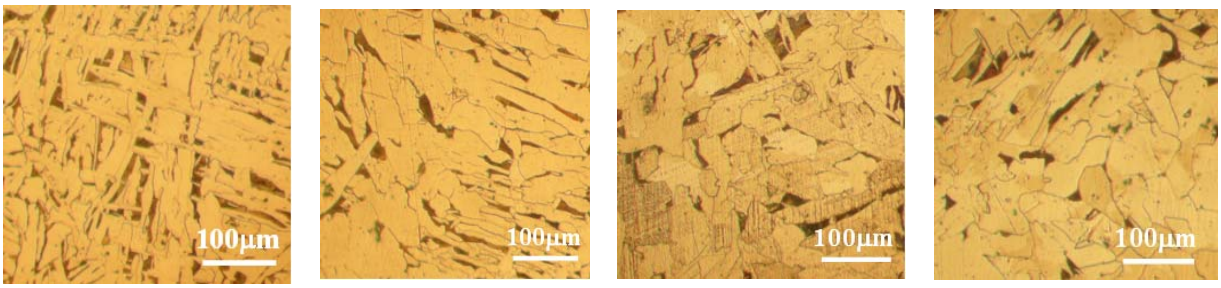
a. The samples obtained by mechanical stirring reveal a reduction of defects quantity, as shown in micrograph from Figure 4, b.

The microstructure of the steel samples consists of ferrite and pearlite, which was revealed after 3% Nital etching (Figure 5). The dark areas represent pearlite and the bright areas represent ferrite. It's also noted that the grain boundary are represented by the thin dark lines. In the micrograph of piece A (see Figure 5) is observed an acicular structure (Widmannstätten), specific to cast steels [11]. This structure is formed due to that, at fast cooling rate it's not possible the complete separation of ferrite at the large austenite grain boundaries. Another feature of this structure is that it has low impact values and percentage elongation, so in generally must be avoided.




a) b)

Figure4. Micrographs of the un-etched samples: a) Piece A and b) Piece D




Piece A (f=0Hz) Piece B (f=15Hz) Piece C (f=25Hz) Piece D (f=40Hz)

Figure5. Micrographs of A, B, C and D pieces, etched with 3% Nital

Low frequency vibrations, applied to the semisolid melt lead to the formation of spherical particles in the semisolid suspension [12]. It is well known that by mechanical stirring the dendrite arms are broken (which usually are formed by classical casting), thus results solid spherical particles dispersed in the melt [13]. These solid particles represents new crystallization nucleus which lead to obtaining of a semisolid suspension with thixotropic features. As can be seen in Figure 5, there is a difference between piece A and B, C and D pieces obtained by semisolid die casting in the mechanical vibration field. This is because with increasing the vibration frequency of the die, the structure becomes more globular, with a direct proportional dependency.

### 3.2. Impact and Brinell hardness tests

The variation of the energy absorbed trough tearing (KU) with the die vibration frequency is shown in Figure 6.

The results show an increase of the energy absorbed trough tearing (KU) with increasing vibration frequency up to 40 Hz. So, due to the application of low frequency mechanical vibration during solidification, the alloy no longer has a typical casting structure, but a globular structure with fewer defects (inclusions, shrinkage cavities). This leads to an increase of the energy absorbed trough tearing. One can see that the highest value of KU corresponds to the highest vibration frequency, i.e. 40 Hz. Hence, the vibration applied during solidification makes the steel to be more tenacious.

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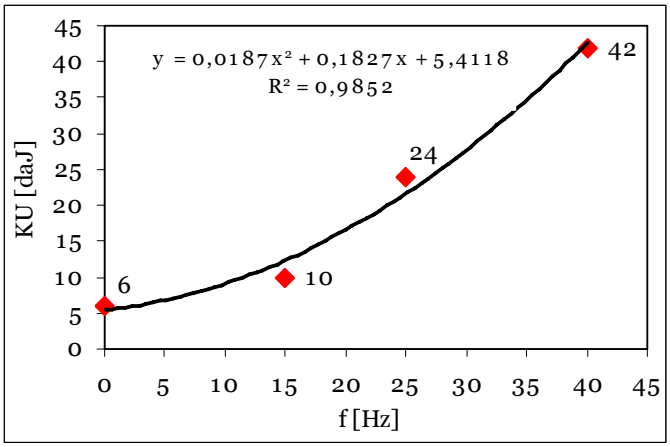



Figure 6. Variation of the energy absorbed trough tearing (KU) with the die vibration frequency (f)

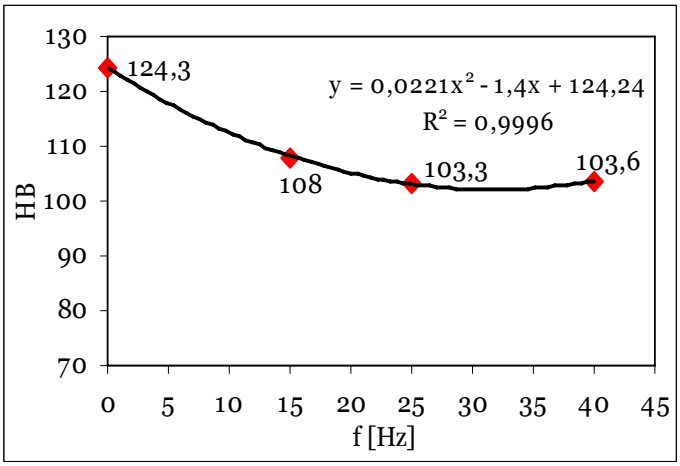



Figure 7. Brinell hardness variation (HB) with the vibration frequency (f) of the die

In Figure 7 is presented the Brinell hardness variation (HB) with the vibration frequency of the die. It is noted a decrease of hardness experimental values with the increase of the vibration frequency. This is because a lamellar structure (obtained in this case by liquid state die forging- Figure 5, piece A) is harder than a globular structure (obtained by semisolid state die forging- Figure 5, piece B, C and D). It may be seen that for vibration frequencies of 25 and 40Hz, the hardness values are approximately the same (about 103 HB). Also, for small vibration frequencies the Brinell hardness have the biggest values.

## 4. CONCLUSION

The interpretation of the obtained results led to the following conclusions:

- Application of the mechanical vibration of low frequency at semisolid die forging reduces defects as: shrinkage cavity, cracks and inclusions. This improves the quality of the obtained pieces.
- It was remarked that the microstructure of the pieces subjected to mechanical stirring by vibration have a spherical grain structure, which favors the thixotropic behavior. This feature is best observed in the C and D pieces structure obtained at 25 and 40 Hz frequencies.
- The energy absorbed trough tearing (KU) increases with increasing the vibration frequency for the semisolid die forged pieces compared to those die forged in liquid state.
- It was observed that the Brinell hardness depends on the microstructure features.

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# VIEWING PERIODICAL SYSTEM WITH THE HELP OF MICROSOFT ACCESS DATA BASE

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**Abstract**:
The aim of this paper is to use a Microsoft Access study program for teaching purposes. This application is intended for high school pupils and for 1st and 2nd year college students as well, thus they will enlarge the perspective upon physical and chemical properties and electronic configuration of elements in periodical system.

**Keywords**:
periodical system, nonperiodic properties, atomic numbers, data base

## 1. THEORETICAL CONSIDERATIONS

As an expression of periodic law, the structure of periodical system created by Mendeleev embodied many forms in time. For the present form of the periodic table, knowing the electronic configuration of each element and of outermost electrons in particular is of great importance.

This explains the periodicity of specific properties in terms of atomic number Z (atomic and ionic radius, ionization energy, electron affinity, melting and boiling points). There are also certain properties, called *nonperiodic properties* that vary constantly (atomic mass, for example). Nonperiodic properties of elements are given by atomic nuclei, as the periodic properties are given by their electron shells.

The periodic table contains 110 elements organized in groups and periods, and recently elements with atomic numbers 111, 112, 114, 116, 118 have been discovered.

The most important properties are presented for each element (discovery, natural state, source, use and biological role), physical properties (atomic number, atomic weight, melting and boiling point, density, electron configuration, electron affinity), information on isotopes (nuclei, atomic mass, range, life duration), ionization energy.

## 2. APPLICATION PRESENTATION

To study the periodic table, a data base called *Periodical System* was created. The data base is designed to align all the elements with all their physical and chemical properties. Autoexec will open the form *Introduction* which is active for 8 seconds and then the main menu opens automatically. This form appears as:



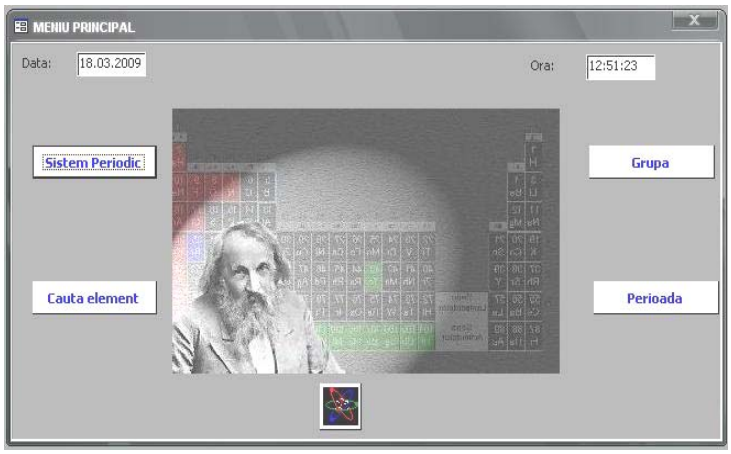

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For the form to work properly, the event Timer was programmed (with an 8000 millisecond interspace)

```
Private Sub Form_Timer()
        DoCmd.Close
        DoCmd.OpenForm "meniu"
End Sub
```

Thus, after 8 seconds this window will close automatically and it will open MAIN MENU; which is for us the main form. The main menu contains two text boxes that inform us on date and time, events programmed with Timer property at a 1000 mseconds interspace. The code is:

```
Private Sub Form_Timer()
        Me!Data_txt.Value = Date
        Me!Ora_txt.Value = Time
End Sub
```




As for the rest, when pressing the buttons, the work forms will open, except for the button "close application". The code for the 4 open buttons is similar, so we will present only one

```
Private Sub sisp_btn_Click()
On Error GoTo Err_sisp_btn_Click
   Dim stDocName As String
   Dim stLinkCriteria As String
   stDocName = "SIS_P"
   DoCmd.OpenForm stDocName, , , stLinkCriteria
Exit_sisp_btn_Click:
   Exit Sub

Err_sisp_btn_Click:
   MsgBox Err.Description
   Resume Exit_sisp_btn_Click
   End Sub
```

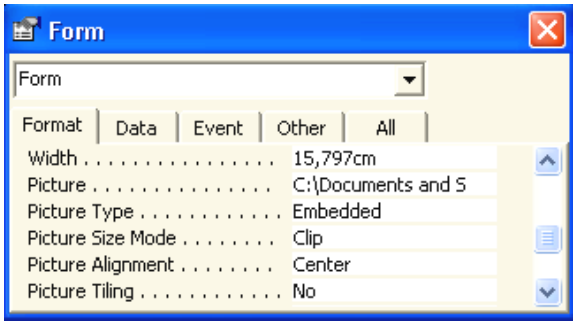
The code for closing application:

```
Private Sub STOP_Click()
On Error GoTo Err_STOP_Click
   DoCmd.Quit

Exit_STOP_Click:
   Exit Sub

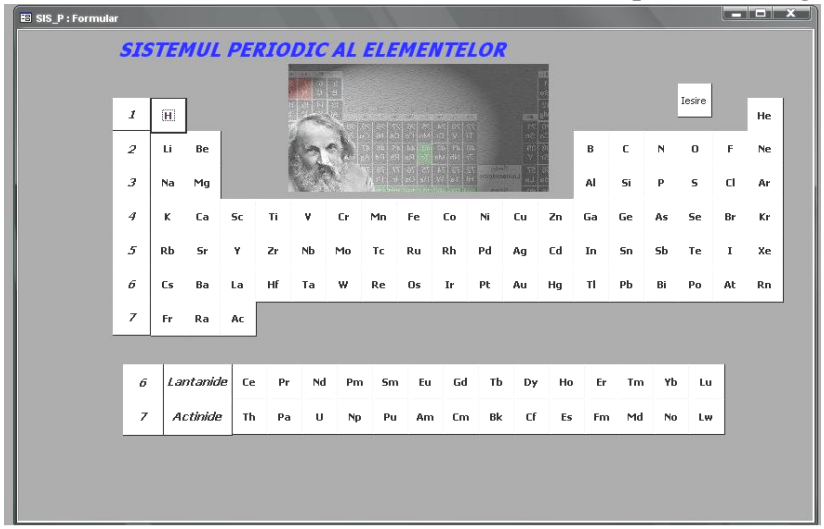
Err_STOP_Click:
   MsgBox Err.Description
   Resume Exit_STOP_Click

End Sub
```




For most of the forms we used background images which can be added by opening the **Properties** window.

Thus, for **Pictures** property we choose the background file, **Embeded** type, in order to differentiate it from the image on the hard disk of the computer, and to embed it in our data base. For the forms that are bigger than the image we choose Strech option instead of Clip for the image to cover the entire form.




When pressing the *Periodical System* button, the form with the same name will open. The form contains numerous buttons with the name of each element in periodic table. By pressing one button a form will open, the same for all buttons, Element form, which will post all elements' properties.

We realized the capture of this form in DESIGN mode to highlight the text box, Texto, which is a hidden box, and in this box the symbol of each element will appear when pressing the drawn buttons. We realized this to open the form Element, for the element which corresponds to each button. The form Element is generated when querying Element, and it will make a selection based on the content in the text box hidden in our form.

```
Private Sub H_Click()
On Error GoTo Err_H_Click

   Me!Text0.Value = "O"

   Dim stDocName As String
   Dim stLinkCriteria As String

   stDocName = "ELEMENT"
   DoCmd.OpenForm stDocName, , , stLinkCriteria

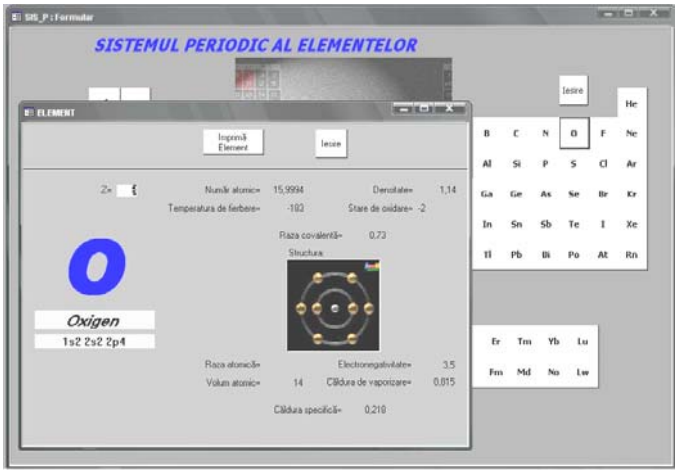
Exit_H_Click:
   Exit Sub

Err_H_Click:
   MsgBox Err.Description
   Resume Exit_H_Click

End Sub
```

The Element form appears as:

We can observe The Structure image, which is an OLE type object in our data base. A second button, Search element in main menu, opens a form where we can search a chemical element using three criteria: name, symbol, atomic number.



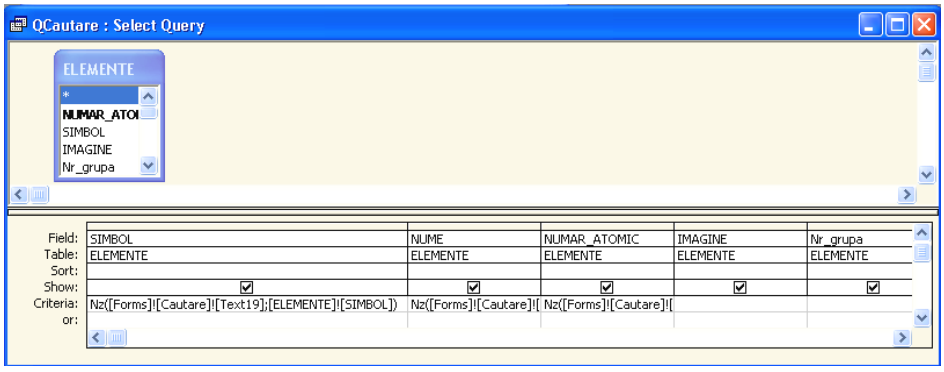








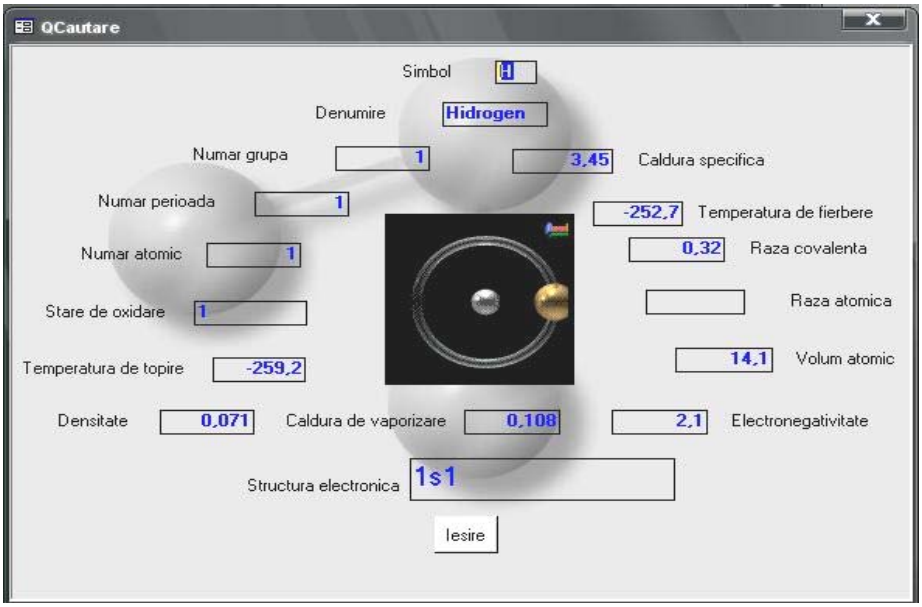

Apart from the filled in text box, when pressing the Search button a new form will open and it will contain the element we searched for with all its properties. Behind this form there is a query which will have as a selection criterion all the 3 text boxes, and only one of them needs to be filled in.



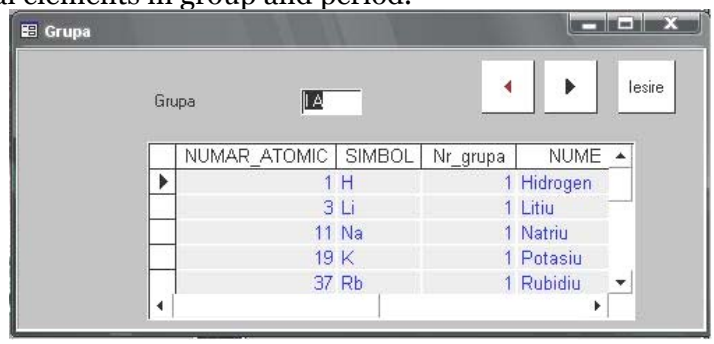
Thus, as a selection criterion, we will use a function:

*Nz([Forms]![Cautare]![Text19];[ELEMENTE]![SIMBOL])*

This will search in the text box corresponding to our Serch form for any text, and if there is a text inside, the value in the text box will be the criterion, and if there is no text, it will select all values in Elements table, then it will pass to the next column to continue the criterion. The generated form will have a structure that differs from Element form shown above.




On the main interface there are two more buttons; when pressing them we can see the position of chemical elements in group and period.







Groups are considered the most common way to classify the items. In some groups, the elements have properties similar or identical property whole group - these groups are given names that are used quite often, eg. alkali metals, alkaline-earth metals, transitional metals, etc.

A period is a horizontal row of the periodic table. Although groups are the most common way to group elements are regions of the periodic system where the similarities are

more significant horizontal than vertical. The number shows the number of layers occupied by electrons.

The problems encountered when using the periodic table for teaching purposes are: the complexity of properties that characterize each and every element and the multitude of elements.

## 3. CONCLUSIONS

The usage of educational soft will increase the students' proficiency and creativity, the level of medium and superior training, the amount of knowledge and it will lead subsequently to a better usage of Informatics in various fields of activity.

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# INFLUENCE OF THERMAL REGIME IN THE CALCULUS OF THE THERMAL STRESSES UPON WARM CYLINDERS

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**Abstract**

The research of the thermal stress that action in the rolling cylinders is impetuously necessary not only to diminish the fissures caused by thermal fatigue, to increase the exploitation duration, but also to avoid thermal shocks, which are very dangerous in the exploitation process and produced by large variations, temperature snapshot that lead to shearing of caliber beads in cylinders.

The present work proposes to determine the influence of thermal regime in the calculus of the thermal tension upon warm cylinders.

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# INFLUENCE OF SOME ELEMENTS FROM ANODE COPPER ON CATHODE COPPER QUALITY

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**ABSTRACT**

In the sites of TIR BOR, electrolytic refining process of the fire refined copper is used for obtaining the cathode copper quality according to the Standard BS6017.
Defined parameter values of electrolytic refining process of anode copper as well as process realization according to the Standard JUS ISO 9001, defined procedures and instructions, present the basic precondition for cathode copper production of suitable quality.
The aim of this work was to determine the influence of some chemical elements that were present in anode copper considerably over permitted limits, predicted by suitable JUS ISO 9001 Standard on chemical quality of cathode copper. The investigations have showed that the increased values of oxygen (up to 1 500 ppm) and nickel (up to 800 ppm) in anode have no important effect on quality of cathode copper, what was confirmed by production of 91.14 % cathode copper of BS6017 quality from total production in the observed period.

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# ELECTROCHEMICAL BEHAVIOR OF COPPER WITH NON-STANDARD IMPURITIES CONTENT

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**Abstract**

This paper presents the results of electrochemical behavior of copper recycling anode with non-standard impurities content in sulphuric acid solution. The anodes were obtained by casting the waste material formed in Cu refining processes and contained the next alloying elements: Ni in concentration up to 10 % and Sn and Pb in concentration of some percentage. The present impurities remain the various problems on electrochemical behavior of anode material.

The obtained results showed that the pasivation of recycling anode during the electrolytic process in sulphuric acid solution is not registered. Copper is dissolved from the anode and deposited on cathode by using the direct current. In the same time, nickel is dissolved from anode and retained in electrolyte. The possibility of nickel separation and production from this solution in a form of salts using chemical method or pure metal form of electrochemical deposition is feasible according to concentration increasing.

For better understanding the electrochemical behavior of recycled anodes, the corrosive behavior of anodes was studied in a three arrangement cell. Sulphuric acid solution was used as electrolyte, and the method of linear potential change was used in defining the phase content.

**Key words**:
recycling anode, Cu, Ni, Sn, Pb, electrochemical process

## 1. INTRODUCTION

Large amounts of waste materials from the copper smelting process are used for recycling. Selection of recycling methods depends on material type for recycling.

The most often used method for Cu, Ni, Sn and Pb production from various types of waste materials is the electrolytic refining process. It is known that Ni presence in anode material, higher than about 3 %, results into anode passivation in the sulphuric acid solution.(1,2). For better understanding the electrochemical behavior of recycled anodes, the various electrochemical measuring were done.

## 2. EXPERIMENTAL PROCEDURE

The copper and nickel bearing waste materials obtained in copper refinement processes are used for the production of materials which could be use in electrolytic process for copper cathode production in the one side and on the other side, for the nickel transferring in solution form aim to further valorization.

According to this request, it was done multiphase experiment in a three electrode arrangement cell, according to the industrial parameters:

- Material which was used as anode material was prepared from pure metals: copper, nickel, tin and lead. Copper was main component, nickel was added in content up to 10 % and tin and lead in content up to 1 %.

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An induction furnace (Balzers) with melting power of 10 - 15 kW is used for casting. The crucible made of graphite; with volume of 1.8 l. Smelting and casting process does not carry out by the use of pressure or vacuum. When temperature of 1300°C is reached, alloying elements are added. Graphite sticks are utilized for oxygen reduction in melt. Oxygen content was measured before casting by the use of Electro- Niter oxygen measuring system. Glass pipettes were used for sampling and determination of oxygen content. Reduction process is stopped when the oxygen content was achievement the value of under the 200 ppm. an melt is cast at approx. 1300°C. After the self-adsorbtion cooling, anodes are preparing for the electrolytic treatment by mechanical removal of 2 mm surface area.

Chemical analyses were performed using an optical emission spectrometry (OES) on apparatus OES ARL 4460.

Electrochemical measurements were conducted in 3 electrode arrangement cell where the working anode was pure Cu, pure Ni or some copper bearing alloys. The saturated Callomel electrode (SCE) was used as reference electrode and Pt with the same area as so as working anode. Polarization curves and measurements by anodic liner sweep voltammetry (ALSV) method are done on potentiostat PAR 273 A, on voltage scan rate of 2 mV/s. Electrolyte of concentration of 172 g/dm$^3$ was prepared by using the 98 % sulphuric acid p.a quality and bidestilated water.

## 3. RESULT AND DISCUSSION

The results of chemical analyses:
1st sample: Cu - purity of 99.95 %
2nd sample: Ni - purity of 99.9 %
3rd sample: Alloy Cu-Ni with 5 % Ni and up to 1 % of Sn and Pb
4th sample: Alloy Cu-Ni with 7.5 % Ni and up to 1 % of Sn and Pb
5th sample: Alloy Cu-Ni with 10 % Ni and up to 1 % of Sn and Pb

The corrosion property of different samples is presented on Figure 1.

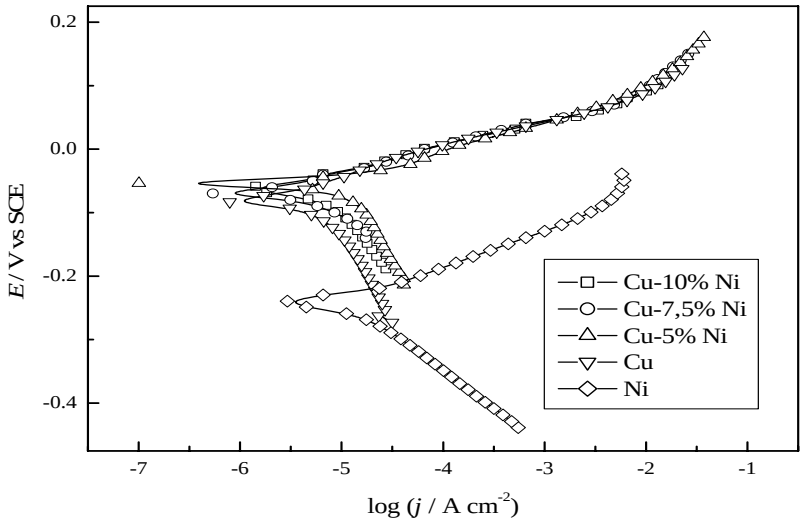



Figure 1. Corrosion behavior of pure Ni, pure copper and Cu-Ni alloys with 5 % Ni, 7.5% Ni and 10% Ni in sulphuric acid solution.

From the diagram on Figure 1, the values of corrosion potential as so as the values of corrosion current for pure Ni, pure Cu and Cu-Ni alloys could be readout. It could be seen that the corrosion current value of pure Ni is lower than corrosion current value of pure Cu. Also, the corrosion current value for pure Ni is lower than values for Cu-Ni alloys. The value for corrosion potential for pure Ni is 200 mV more negative regard to corrosion potential for pure Cu and Cu-Ni alloys.

The corrosion current values, as so as the anode and cathode Taffel inclinations was determinate aim to define this recycling anode stability in sulphuric acid solution. The results are presented in Table 1.

Table 1. Corrosion current and Taffel inclinations

| Description | $b_{cath.}$ (V dec$^{-1}$) | $b_{anod.}$ (V dec$^{-1}$) | $c_{corrosion}$ (μA cm$^{-2}$) |
|---|---|---|---|
| Cu-Ni, 10 % Ni | 0.080 | 0.050 | 6.0 |
| Cu-Ni, 7.5% Ni | 0.090 | 0.040 | 3.0 |
| Cu-Ni, 5% Ni | 0.200 | 0.040 | 6.0 |
| Pure Cu | 0.260 | 0.045 | 5.0 |
| Pure Ni | 0.120 | 0.060 | 12.5 |

The next values are obtained:

1. The values for Taffel inclination for anode reaction on pure Cu and alloys were about 0.040 V dec$^{-1}$ and. Those values are enough stabile. In a case of pure Ni, the obtained value was 0.060 V dec$^{-1}$.
2. The values for Taffel inclination for cathode reaction were in range from 0.080 to 0.260 V dec$^{-1}$. It was explanation by high potential of hydrogen evolution reaction on pure copper and copper alloys. This value is decreased with nickel content increasing. For the pure nickel this value is 0.120 V dec$^{-1}$.
3. All alloys have got the very low corrosion current values, up to 10 μA cm$^{-2}$.

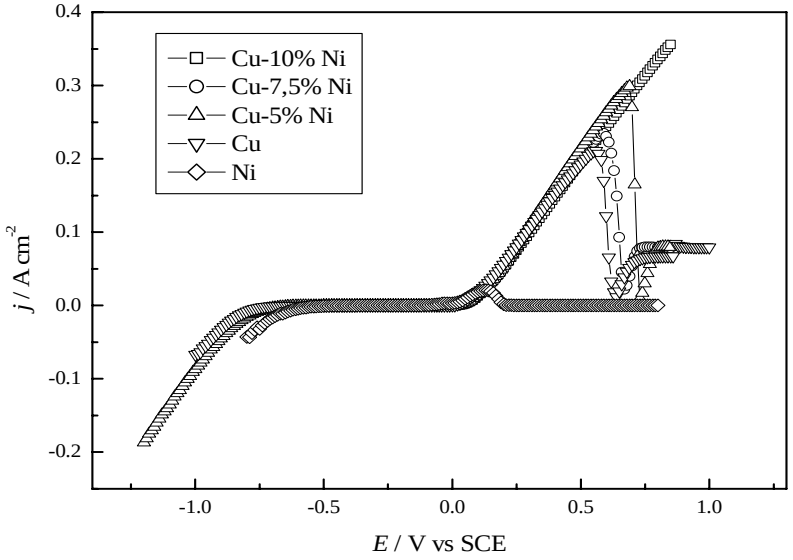



Figure 2. Current density versus voltage curve at a voltage scan rate of 2 mV/s

From the diagrams on Figure 2, could be seen that dissolution of pure Ni started before all other materials. For dissolution of pure is characteristic that the electric arc charge is the minimal and the area of active dissolution is terminated on potential of 0,2 vs SCE. The dissolution of pure copper started on more positive potential regarding to value of pure nickel potential. The quantity of electric arc charge is higher than for pure nickel. The electrolytic dissolution process of alloys: first started alloy with 5 % Ni, than alloy with 7.5 % Ni and than alloy with 10 % Ni. The characteristic of Cu-Ni alloy where the Ni content was 10 % is the highest quantity of electric arc charge and the value for potential on which started passivation is the most positive regarding to other materials.

## 4. CONCLUSION

Based on literature data, it is known that copper alloys with nickel content higher than 3 % become passivity in sulphuric acid solution.

The results of experimental investigation (Figure 2) are indicated that copper bearing alloys with nickel content from 5 to 10 % Ni and other alloying elements up to 1 % were not passivated in sulphuric acid solution. The results of the investigations also indicated that the values of electrolytic dissolution could be up to 200 mA/cm$^{-2}$.

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# SYNTHESIS AND CHARACTERIZATION OF A CATALYST FORMED BY DIRECT INCORPORATION OF SOME HETEROPOLYACIDS INTO MESOPOROUS MATERIALS

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Orsina VERDES, Livia AVRAM

Institute of Chemistry Timişoara, ROMANIA

**ABSTRACT**

The effect of incorporation of heteropolyacids species into organized mesoporous silica by using non-ionic and cationic surfactants were studied. The structure and texture of $H_3PMo_{12}O_{40}$ included on mesoporous silica were studied by XRD, FT-IR, BET and pore size distribution. The synthesis of silica molecular sieve containing HPAs was carried out in acidic media by using a mixture of cationic and non-ionic surfactants. FT-IR studies showed that HPAs anions preserved their Keggin structure after incorporation on molecular sieves supports. The values of specific surface area of HPAs were increased by deposition on molecular sieve supports.

## 1. INTRODUCTION

Heteropolyacids have attracted considerable attention as they present high acidity and favourable redox behaviour. Especially Keggin type heteropolyacids (HPAs) have been used extensively in acid-catalysed reactions as well as oxidation reactions both in the heterogeneous and homogeneous systems. Pure HPAs generally show low catalytic reactivity owing to their small surface area. In order to be more effective for catalytic reactions, HPAs are usually impregnated or incorporation on different porous materials with high surface area [1-6].

Direct incorporation of heteropolyacids (HPAs) $H_3PMo_{12}O_{40}$ (HPM) into mesoporous silica molecular sieve during the synthesis was studied. The synthesis of silica molecular sieve containing HPAs was carried out in acidic media by using a mixture of cationic and non-ionic surfactants, such as cetyltrimethylammonium bromide ($C_{16}$TMABr) and Triton (TX-100) or Tween 100 [7]. The obtained mesoporous materials were characterised by FTIR spectrometry, X-ray diffraction at low angles, thermal analysis (TG-DTA) and $N_2$ adsorption-desorption measurements.

FT-IR studies showed that HPAs anions preserved their Keggin structure after incorporation on molecular sieves materials. X-ray diffraction studies confirmed the uniformity of the distribution of active phase in the silica molecular sieve composites.

## 2. MATERIALS and METHODS

Molybdo phosphoric acid, $H_3[PMo_{12}O_{40}]\cdot 12H_2O$ (HPM) was purchased from Merck. The silicon source was tetraethoxysilane (TEOS) from Fluka. Two types of non-ionic surfactants were used in this study: polyethyleneglycol-4-tert-octylphenylether with 9-10 ethoxy groups (Triton X-100) from Fluka and polyethylene sorbitan-monostearate (Tween 60) from Merck. The cationic surfactant used is cetyltrimethylammonium bromide $C_{16}H_{33}(CH_3)_3$ NBr (CTMABr) from Fluka. As mineralizing agent it was employed sodium floride NaF, from Fluka.

Mesoporous molecular sieves-included HPAs (denoted HPA-in-TX 100 or Tween 60) with 15 % HPA loading, were prepared by the hydrolysis of tetraethyl orthosilicate using non-ionic and cationic surfactants. The procedure described by Toufaily et. al. [7] was applied

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with some modifications. In first synthesis we used a mixture of TX-100 and CTMABr surfactants, while in the second we used as surfactant only Tween 60.

First synthesis was performed with the following molar composition: $1SiO_2$:0.22 TX100:0.04 CTMABr:0.04 NaF:0.006 HPM:168 $H_2O$. In a first step, 7.4 g of TX-100 and 0.82 g of CTMABr were dissolved in 160 ml distilled water containing 4 ml of hydrochloric acid (HCl 37 wt.%). Then, after a clear solution was obtained, 11 g of TEOS were added and stirred until complete dissolution. Then a solution of 0.57 g HPM in 30 ml acidified (HCl) distilled water was added to first solution and stirred for 4 hours at room temperature. The solution was aged for 24 h at room temperature without stirring. A small amount of sodium fluoride (0.1 g) was then added in order to promote the hydrolysis of TEOS. The solution was furthermore aged at 60°C for 48h. The solid product was filtered, washed with distilled water and dried in air for 6h. Calcination for template surfactants removal was carried out under air by increasing temperature from 25 to 350°C with a rate of 2°C/min and heating at 350°C for 4h.

The second synthesis was performed by the same procedure but with Tween 60 as non-ionic surfactant. The following molar composition was used: $1SiO_2$:0.067 Tween 60:0.04 NaF:0.006 HPM:148 $H_2O$. The structure and texture of HPM and HPVM included on molecular sieves were studied by XRD, FT-IR and low temperature nitrogen adsorption technique. Powder X-ray diffraction data were obtained with a XD 8 Advanced Bruker diffractometer using the Cu $K_\alpha$ radiation in the range $2\theta$ = 0.5-5° at low angles and $2\theta$ = 5-60°.

Textural characteristics of the outgassed samples were obtained from nitrogen physisorption using a Quantachrome instrument, Nova 2000 series. The specific surface area $S_{BET}$, mean cylindrical pore diameters $d_p$ and adsorption pore volume $V_{pN2}$ were determined. Prior to the measurements the samples were degassed to $10^{-5}$Pa at 250°C. The BET specific surface area was calculated by using the standard Brunauer, Emmett and Teller method on the basis of the adsorption data. The pore size distributions were calculated applying the Barrett-Joyner-Halenda (BJH) method to the desorption branches of the isotherms. The IUPAC classification of pores and isotherms were used in this study.

The IR absorption spectra were recorded with a Jasco 430 spectrometer (spectral range 4000-400 $cm^{-1}$ range, 256 scans, and resolution 2 $cm^{-1}$) using KBr pellets.

## 3. RESULTS AND DISCUSSION

For all synthesized materials the $N_2$ adsorption-desorption isotherms exhibit a type IV isotherm (Fig. 1 a, b). The specific surface area, pore volume and pore diameter determined from the isotherm using the BJH method are given in Table 1.

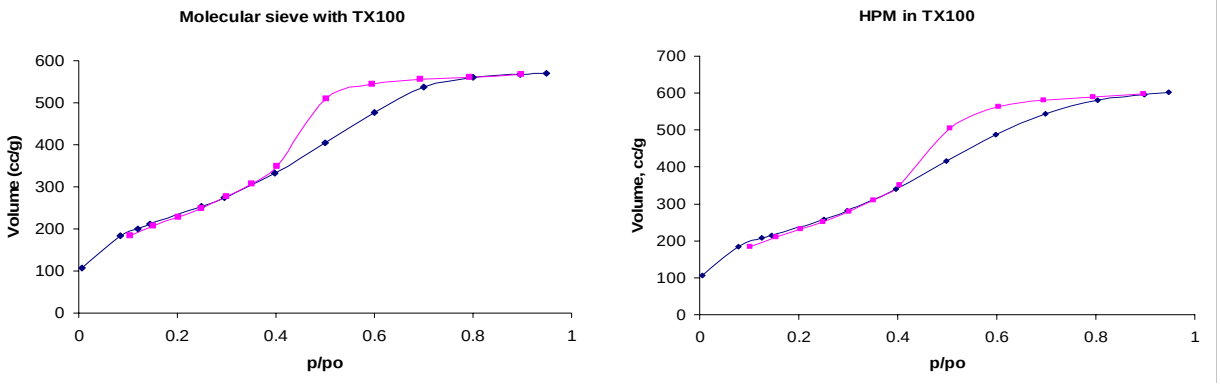



Figure 1. Nitrogen adsorption-desorption plot of molecular sieve with TX 100 (a) and HPM included on TX 100 (b)

Table 1 Textural properties of molecular sieves and included HPM

| Sample | Specific surface area ($m^2/g$) | Pore volume $BJH_{Des}$ (cc/g) | Average pore diameter $BJH_{Des}$ (nm) |
|---|---|---|---|
| TX 100 | 841.65 | 0.881 | 3.66 |
| Tween 60 | 877.67 | 1.012 | 3.64 |
| HPM in TX100 | 857.04 | 0.931 | 3.67 |
| HPM in Tween 60 | 762.01 | 0.867 | 3.66 |

The pore size distribution curves of parent molecular sieves with TX 100 plus CTMABr and Tween 60 respectively, have narrow pore size distribution within mesopore range with a maximum at 37 Å and 36 Å, respectively.

After HPM incorporation in molecular sieves matrix, the pore volumes of samples decreased with the increase of the concentration of active phase and also the surface area decreased with the increase in HPAs loading. The pore size distribution curves of HPM included on molecular sieves with TX 100 plus CTMABr and Tween 60 respectively, have one maximum within mesopore range at approximately the same values as in the case of pure molecular sieves.

The XRD patterns at low angles for the initial molecular sieves show a broad diffraction peak below 2.5° (2θ) for both materials prepared with TX 100 plus CTMABr and Tween 60, respectively (not shown).

For the two HPM included on molecular sieves the diffraction peaks at low angles are presented but with diminished intensity. The diffraction peak of included HPM appears like a shoulder. It can be asserted that the long – range order of molecular sieve is decreased evidently even for loading of 15 wt. % HPAs.

In order to confirm the presence of the Keggin anion on silica-HPA composites, the samples were analysed by FTIR. The $PMo_{12}O_{40}^{3-}$ Keggin ion structure consists of a $PO_4$ tetrahedron surrounding by four $Mo_3O_{13}$ formed by edge-sharing octahedra. These groups are connected each other by corner-sharing oxygen. This structure give rise to four types of oxygen, being responsible for the fingerprints bands of Keggin anion between 1200 $cm^{-1}$ and 700 $cm^{-1}$.

The pure HPAs show an IR spectrum with the specific lines of the Keggin structure containing the main absorption bands at 1064 $cm^{-1}$, 965 $cm^{-1}$, 864 $cm^{-1}$, 785 $cm^{-1}$ assigned to the stretching vibrations $\nu_{as}$ P -O, $\nu_{as}$ Mo=$O_t$, $\nu_{as}$ Mo-$O_c$-Mo and $\nu_{as}$ Mo-$O_e$-Mo [4, 5]. These bands are preserved on the molecular sieves - HPA composites, but they are broadened and partially obscured because of the strong absorption bands of silica (1090, 812 and 456 $cm^{-1}$) (Figure 2).

The introduction of heteropolyacids into the silica matrix slightly influenced the structure of resulted composite (Figure 2). The vibration band at ca. 1090 $cm^{-1}$ can be assigned to $\nu_{as}$(Si-O-Si) and decreased to 1072 $cm^{-1}$ by incorporation of HPAs into the structure of the silica. The band at ca. 966 $cm^{-1}$ present in the spectrum of included HPM sample can be assigned to the $\nu_{as}$ Mo=$O_t$ stretching vibration. The bands at 812 and 454 $cm^{-1}$ can be assigned to $\nu_s$ (Si-O-Si) and δ(Si-O-Si) bonds, respectively [6].

The bands of HPAs included on silica in the 1300-400 $cm^{-1}$ region are partially or completely overlapped by the bands of the silica matrix. The band assigned to the P –O asymmetric stretching vibration at 1064 $cm^{-1}$ is completely overlapped by the strong band at 1090 $cm^{-1}$ of the silica.

Two IR bands in the spectra of included HPM appeared at 966 and 660 $cm^{-1}$, which can be assigned to the $\nu_{as}$ Mo=$O_t$ stretching vibration and to δ (O-P-O) of the HPAs.

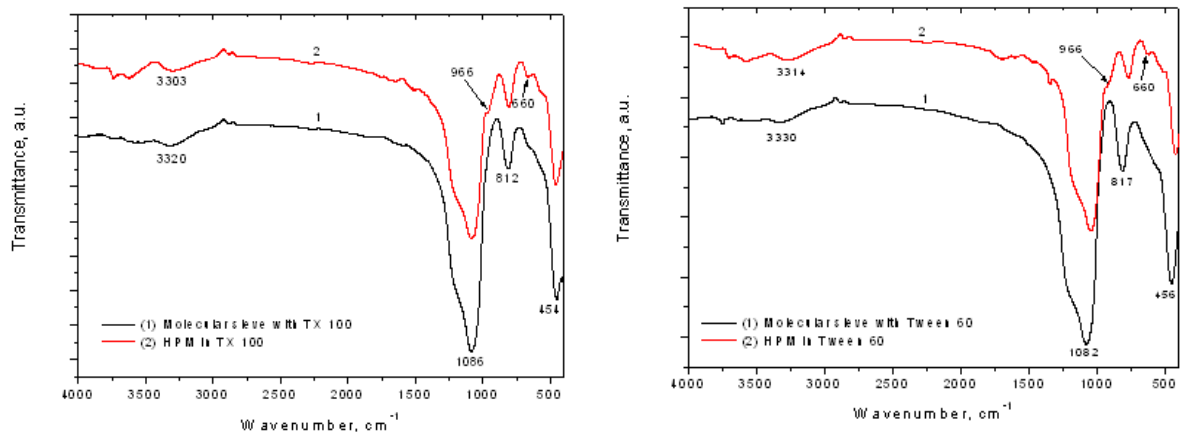



Fig. 2 FTIR spectra of molecular sieves - heteropolyacids composites

## 4. CONCLUSIONS

The HPAs anions preserved their Keggin structure on the surface of molecular sieves-HPA composites and forms finely dispersed HPAs species. The molecular sieves-HPM composites exhibit differential pore size distribution in the mesoporosity range.

It can be asserted that the long – range order of molecular sieve is decreased evidently even for loading of 15 wt. % HPAs.

The favourable effect of HPAs incorporation on silica molecular sieve is the increasing of pore volume and specific surface area, which in fact make the silica-HPA composites proper for heterogeneous catalysis.

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# THE HEAVY METALS MONITORING IN CANNED VEGETABLES MIX

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**Abstract**

The paper proposes some possibilities for heavy metals detection in canned vegetables mix: Cr, Fe, Pb, Cd, Sn, Al, Zn, As . The heavy metals concentrations have been determinate by AA spectrometry and electrochemical methods: cyclic voltammetry. The monitoring of heavy metals in canned vegetables mix can help evaluate and improve the insufficiently developed technology.

**Key words:**

vegetables mix, heavy metals, AA spectroscopy, cyclic voltammetry

## 1. INTRODUCTION

Vegetables mix and similar products are widely used for taste enhancement of various food products. Apart from their taste properties they also have a high nutritive value due to the content of easily retainable sugars, vitamin C, carotenoids and mineral salts.

Vegetables mix is a produce conserved through decrease in humidity, thus preventing the evolution of microorganisms. Microorganisms require a certain minimum amount of water to develop; bacteria require 35%, yeasts 25% and molds only need 10%.

## 2. EXPERIMENTAL

### 2.1. Samples preparation

Vegetables mix products have been weighed and treated by concentrated nitric acid (67%, Merck, heavy metals free). Samples digestion has been achieved in a 1000W MWS-2 – Berghof type microwave oven using a three-step program: $T_1$=160°C, $t_1$=15 min., $P_1$=40-60% from total power, $T_2$=210°C, $t_2$=15 min., $P_2$=60-80%, $T_3$=210°C →100°C, $t_3$=15 min., $P_3$=0%.Thus resulted solutions have been completed with ultrapure water (RO System Operating Barnstead apparatus) to equal volumes in 25 ml calibrated flasks.

### 2.2. Methods of analysis

#### 2.2.1. AA Spectrometry

The heavy metals content has been determinated by AA spectrometry (International Standard ISO 15586:2003) and cyclic voltametry (Koryta , 1993), i=f(E). AA spectrometry has been achieved with novAA 400 G type spectrometer - Analytik Jena - Germany, equipped with graphite furnace, WinAAS 3.17.0 software for evaluation, control and result presentation, a so-called cookbook, for every element, and a HS 55-1 hydride generator. Calibration curves have been plotted using standard solutions of metals in search.

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### 2.2.2. Electrochemical Methods

Heavy metals such as Sn, Fe, Zn at the electrode surface are affcted by characteristic redox phenomena with can be used to determine their concentration. The voltammograms i=f(E) are obtained using PGZ 402 Voltalab, with VoltaMaster 4, version 7 software (User's manual, *Voltalab®*,2008). A 50 $cm^3$ BEC/EDI X51 V001 electrochemical cell, from Radiometer Copenhagen is part of the Voltalab system. Platinum electrodes ($S_{work}$=7.85 $mm^2$, $S_{aux}$=50 $mm^2$) and standard calomel electrode (SCE) with 0.1M $HNO_3$ support electrolyte have been used in experiments. Recording speed was 50 mV/min. at an apparatus sensitivity of 10 mA. Calibration curves for Fe and Sn have been plotted using metals standard solutions as $I_{peak}$=f(conc.).

## 3. RESULTS AND DISSCUTIONS

Vegetables mix products are obtained through processing of fully mature tomatoes, beans, onions, papricas. Vegetables concentrates are used in the food industry to enhance the taste and nutritive value of various products. There are three phases in the vegetables mixt production technology: obtaining the brute vegetables mixt, conditioning and packaging the product (HOTARARE nr.1197, 2002; ORDIN 1050**,** 2006**)**. When packaging into metallic cans the heavy metals content may exceed the safety limits, and in turn may be detrimental to public health. The two proposed analysis methods have the advantage of being fast and reliable (result accuracy). Five types of these products have been studied, both local and imported: four of them packaged in metallic cans and one in glass bottle, for reference.

The heavy metal concentrations in vegetables mixt determined by AA spectroscopy are presented in Table 1. High values are noted in the case of Fe (which although beneficial to the human body may become an energetic catalyst for some chemicalor biochemical processes), of Sn and of Al, especially in the Italian products.

Table 1. The heavy metal concentrations

| No. | Sample | Concentration, ppm | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cr | Fe | Pb | Cd | Sn | Al | Zn | As |
| 1. | Vegetables mix *Sultan* ( Romanian product, Turkish licence, metalic can) | 0.20 | 29.5 | 0.02 | 0.009 | 4.45 | 33.45 | 7.1 | ** |
| 2. | Vegetables mix *Conserv frig* (Romanian product, metallic can)* | 0.15 | 218.00 | 0.20 | 0.034 | 70.78 | 36.1 | 4.03 | ** |
| 3. | Vegetable mix *Mib* (Romanian product, metallic can) | 0.13 | 16.93 | ** | 0.003 | 12.5 | 23.1 | 6.5 | ** |
| 4. | Vegetable mix *Maxim's*, (Italian product, metallic can)* | 0.18 | 41.31 | 1.9 | 0.109 | 14.8 | 80.2 | 9.0 | ** |
| 5. | Vegetables mix *Buftea* (Romanian product, glass bottle) | 0.26 | 27.61 | 0.16 | 0.017 | 8.24 | 48.56 | 8.79 | ** |

* before the samples were taken the vegetables mix was homogenized at 1500 rpm with an IKA-LABORTECHNIK stirrer, with adjustable rotations and display unit observation
** under limit detection

It has been remarqued the high Cd concentration in *Maxim's* vegetables mix (Italian product).

For the determination of heavy metals by electrochemical methods, the first step was plotting the calibration curves. The methods used for Fe and Sn by means of cyclic voltametry i=f(E) are presented in Fig.1., Fig.2., Fig.3. and Fig.4.

The electrochemical method has only been applied for the higher concentration of metals Fe and Sn. Extracting Fe from the vegetables mixt products using this method has had no results. (Fig. 5.). Note that the Fe voltamogram is lower than the base line of the support electrolyte.

Sn, on the other hand, is present in the Italian vegetables mixt canned in high concentrations Fig.6 and Fig.7. (samples were taken from right next to where the can is welded, for all samples).

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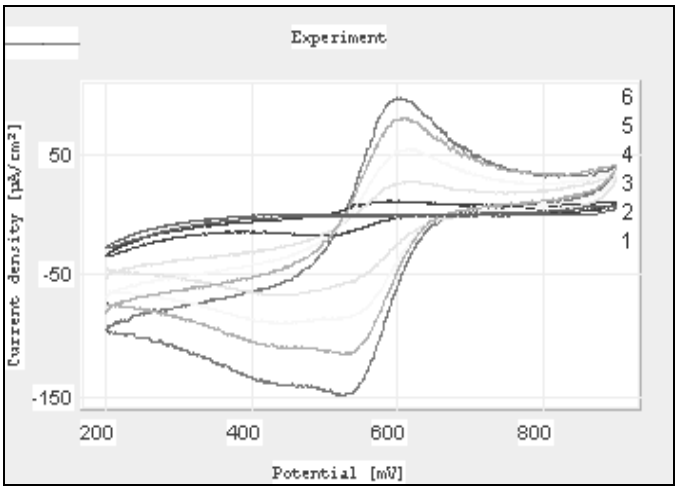



Fig.1. Cyclic voltammogrames for equilibrium $Fe^{3+} + e^- \rightarrow Fe^{2+}$. 1 – support electrolyte HNO3 0.1 M; 2 - c=25.64 mg/L; 3 - c=50.00 mg/L;4 - c=95.24 mg/L; 5 - c=136.36 mg/L; 6 - c=173.91 mg/L

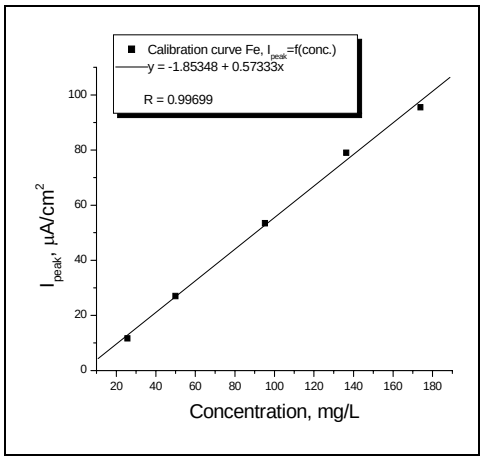



Fig.2. Calibration curve for iron concentration determination in canned vegetables mix, $I_{peak}$=f(conc.), $E_{ESC}$ = 608 mV

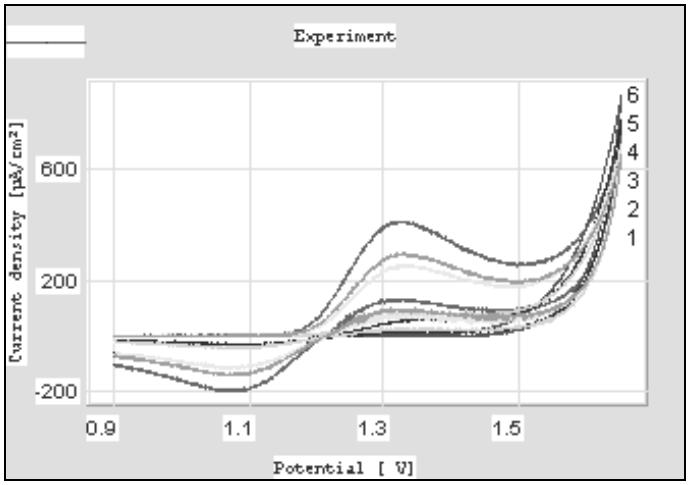



Fig.3. Cyclic voltammogrames for equilibrium $Sn^{4+} + 2e^- \rightarrow Sn^{2+}$. 1 – support electrolyte HNO3 0.1 M; 2 - c=6.8333 mg/L; 3 - c=13.5257 mg/L; 4 - c=20.0816 mg/L; 5 - c=26.5050 mg/L;6 – c=32.8000 mg/L

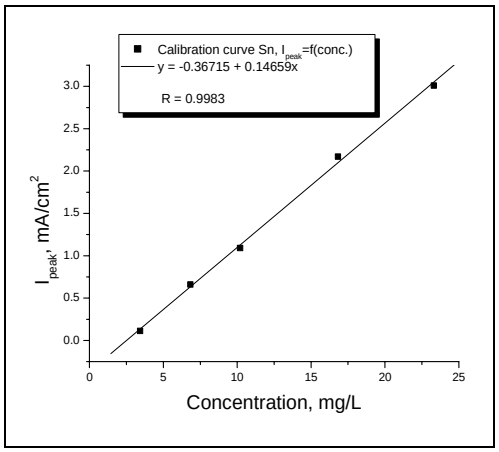



Fig.4. Calibration curve for tin concentration determination in canned vegetables mix, $I_{peak}$=f(conc.), $E_{ESC}$ = 1.375 V

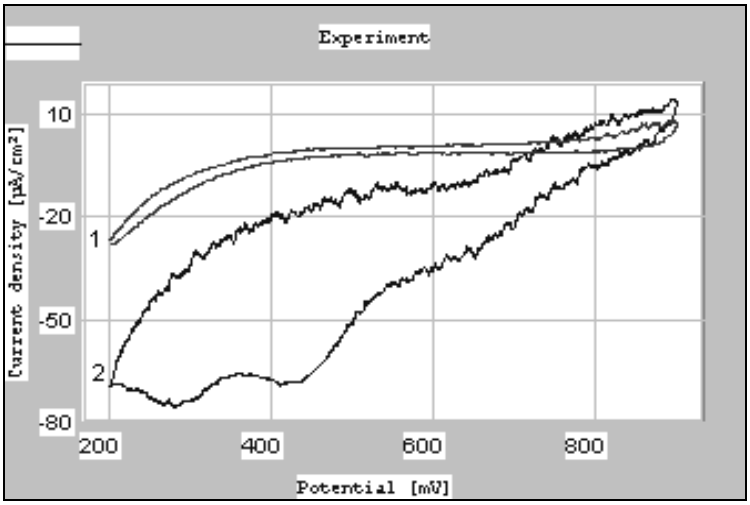



Fig.5. Fe determination in *Conserv frig* (vegetables mix)

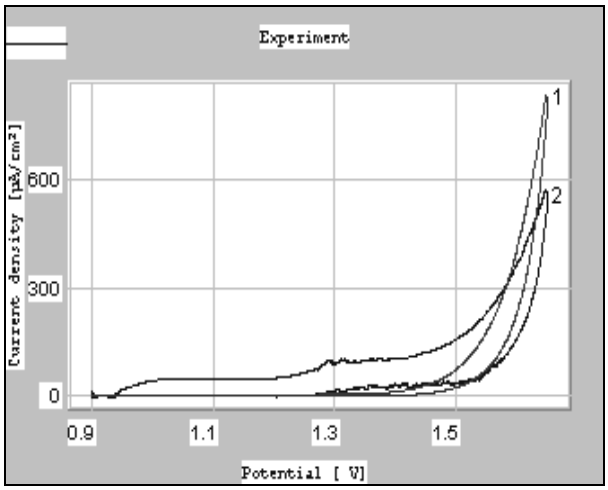



Fig.6. Sn determination in *Conserv frig* (vegetables mix), $E_{ESC}$ = 1.375 V

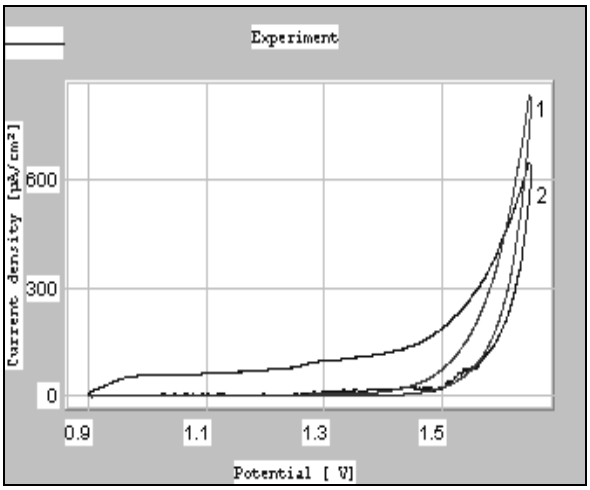



Fig.7. Sn determination in *Maxim's* (vegetables mix), $E_{ESC}$ = 1.375 V

The values obtained using the electrochemical method are c = 3.60 ppm Sn for *Conserv frig* ($I_{peak}$ = 0.1589 mA/cm²) and c = 3.40 ppm Sn for *Maxim's* ($I_{peak}$ = 0.1367 mA/cm²). There are obvious errors in using this method due to all the metal ions which can influence the electrochemical behavior.

## 4. CONCLUSIONS

The environment pollution with heavy metals (Cr, Ni, Pb, Zn, Al, As, Cd, etc.) is due mainly to the activity of humans. Two heavy metals (Sn and Al) showed higher concentrations then legally admitted in canned vegetables mix. Concentration of heavy metals from the polluted environment in vegetables is influenced by different factors and stopped through several mechanisms. The monitoring of heavy metals in canned vegetables mix can help to evaluate and improve the insufficiently developed technology.

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# BIOCOMPATIBLE MATERIALS REALIZED BY PLASMA THERMAL SPRAYING OF HYDROXYAPATITE ON METALLIC SUPPORTS

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ISIM Timisoara, ROMANIA

**Abstract**

In this paper is presented the thermal spraying process of the oxidic ceramic (hydroxyapatite) on metalic supports to obtain biocompatible materials with application in general medicine.
Two main applications are obtained by realizing of titanium base implants, dental and orthopedic.
The samples were examined by optical and electronic microscopy, finally the ceramic layers presented the roughness between 8 and 9 μm and the layer thickness between 90 şi 330 μm. No defects can be reported. The samples obtained by plasma thermal spraying were corrosion tested in simulated body fluid (SBF with pH 7,4 la 37°C).

**Key words:**

thermal spraying, biocompatible materials, oxidic ceramic, SBF

## 1. INTRODUCTION

The best materials used to the prosthesis fabrication in dental and orthopedic medicine are those which are similar with the composition of the humane bone, the repairing mechanism of the bone is the natural regenerations.

One approach to provide a strong, long-lasting adhesive interface between a bone replacement implant and the surrounding tissue involves the use of bioactive materials.

Hydroxyapatite (HA) is the most well known bioactive ceramic materials used in medicine. The inorganic constituent of bone is made up of biological apatites, which provide strength to the skeleton and act as a storehouse for calcium, phosphorus, sodium, and magnesium.

## 2. MATERIALS USED

For biocompatible layers deposition hydroxyapatite powders were used with the dimension of the particles between 10-30 μm and Ti-Mo-Al titanium alloy as substrate. The chemical composition of the titanium alloy is presented in table 1. The chemical composition of the two samples (substrates) is conform ASTM grade 11.

Table 1 The chemical composition of the titanium alloy used as substrate

| No. sample | Chemical composition % | | | | | |
|---|---|---|---|---|---|---|
| | Ti | Mo | Al | Mn | V | Fe |
| 1 | 97,70 | 1,641 | 0,3245 | 0,1048 | 0,0921 | < 0,032 |
| 2 | 97,75 | 1,626 | 0,2989 | 0,1060 | 0,0847 | < 0,034 |

In figure 1 and 2 the biphasic structure is presented (solid solution α enriched in titanium and intermetallic compounds of Ti-Mo, Ti-Al) of the titanium alloy used as substrate (BM) for the deposition of the hydroxyapatite layers by plasma thermal spraying.
In the base metal (BM) were developed fine macles due to the hot plastic deformation process of the Ti-Mo-Al alloy.

Hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$ is a oxidic ceramic which is used to realize the biocompatible layers by plasma thermal spraying or by other methods.

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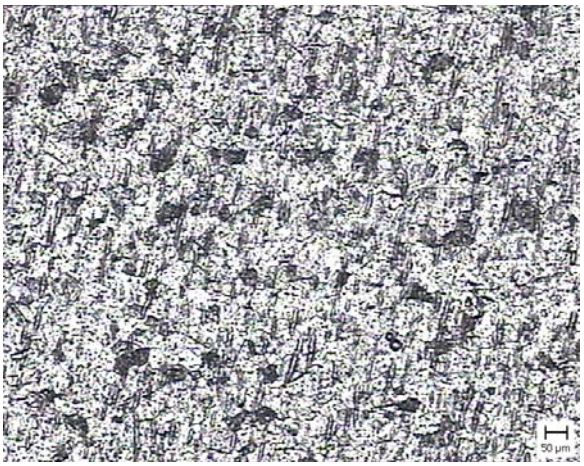


Figure 1. Titanium alloy substrate BM (cupric solution, 50 x)



Figure 2. Titanium alloy substrate BM (cupric solution, 100 x)

## 3. SAMPLES PREPARATION

Before thermal spraying, the titanium samples were blasted with electrocorindon with the granulation between 0,8 – 2 mm and the air pressure of 5 bar. The blasting distance was 50±5 mm.




Figure 3 The thermal spraying gun 3MB of the plasma thermal spraying installation

Because the powders presented a high agglomeration tendency the dehydration of the powder (heating to 60 $^{o}$C, time 12 h) was necessary.

The deposition of the hydroxyapatite powder on titanium alloy substrate was realized with the plasma thermal spraying installation from ISIM – Timisoara. In figure 3 is presented the thermal spraying gun 3MB of the installation.

The plasma spraying process was made in horizontal position the spraying gun position was perpendicularly on the titanium alloy support. In figure 4 is presented image from the plasma thermal spraying process.

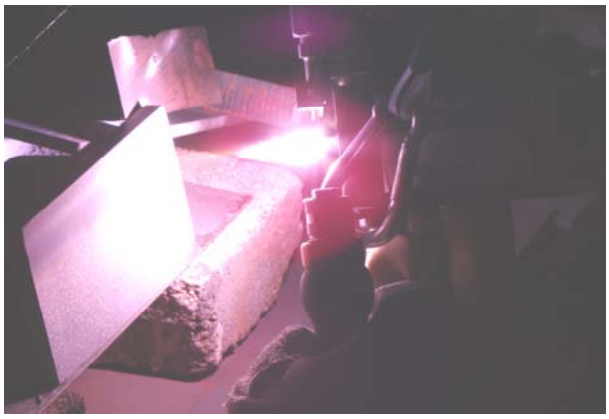


Figure 4. Image form plasma spraying process

In plasma spraying process of the hydroxyapatite the distance between the titanium surface and spraying gun was 100 mm .

The plasma spraying parameters used for the hydroxyapatite deposition are presented in table 2.

With the parameters from table 2 were made two samples:

- A sample (M1) with one hydroxyapatite layer, using Ti-Mo-Al alloy
- A sample (M2) with three hydroxyapatite layers, using Ti-Mo-Al alloy

Table 2. The plasma spraying parameters

| $I_p$ A | $U_a$ V | $Q_p$ l/min | $Q_{tr}$ l/min | $m_p$ g/min | $d_p$ mm | $N_n$ | Cooling |
|---|---|---|---|---|---|---|---|
| 500 | 60 | 40 | 6 | 15 | 100 | 3 | air |
| 500 | 60 | 40 | 6 | 15 | 100 | 1+1+1 | air |

## 4. EXPERIMENTAL RESULT AND INTERPRETATION

The macroscopic examinations show the deposited layers aspect of different thickness (table 3). The determination of the hydroxyapatite layer thickness was made with Leptoskop Pocket device from ISIM – Timisoara. On the examined surfaces no defects were observed.

Table 3. Layer thickness plasma sprayed

| No. Sample | No. Layers | Layer thickness [μm] | |
|---|---|---|---|
| | | Individual values, g | Average value, $\bar{g}$ |
| M1 | 1 | 90, 100, 111, 160, 120, 132, 122, 92, 101, 120 | 127,8 |
| M2 | 3 | 310, 310, 320, 330, 315, 318, 321, 310, 315, 318 | 316,7 |

Analyzing the thickness values of the sprayed layers is observed that the values of the sample M1 vary between 90 şi 160 μm and presents a high dispersion on the values with the average 127,8 μm, the sample M2 present values between 310 şi 330 μm with the average 316,7 μm, which attest a high compacting of the layers deposited by thermal spraying. The average roughness of the deposited layers measured with SJ-201P device is maximum 8,50 μm.

Microscopic examinations made according EN1321 show the microstructure of the deposited layers by plasma thermal spraying process, which consist from globular and acicular particles of apatite with the hardness 5 on Mohr hardness scale (figure 5, 6). On the examined sections by optical microscopy no defects were observed (pores, microcracks).




Figure 5 The microstructure of the hydroxyapatite ayer deposited by plasma thermal spraying (ferric chloride , 50 x)

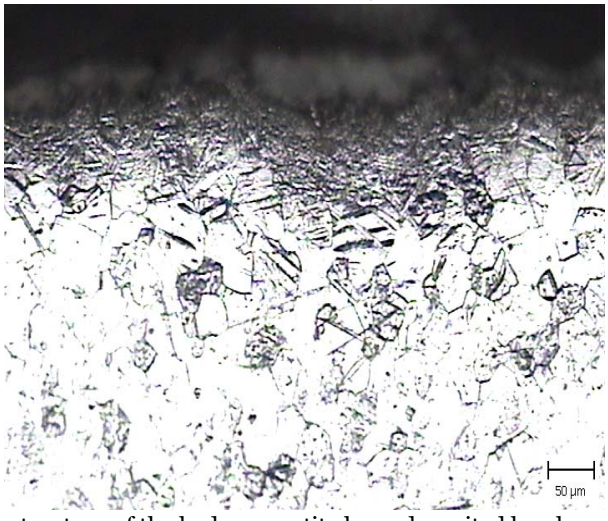



Figure 5 The microstructure of the hydroxyapatite layer deposited by plasma thermal spraying (ferric chloride , 100 x)

In figure 7 and 8 are presented the images of the deposited layer by plasma thermal spraying of the hydroxyapatite powder on titanium alloy substrate using SEM (scanning electronic microscopy).

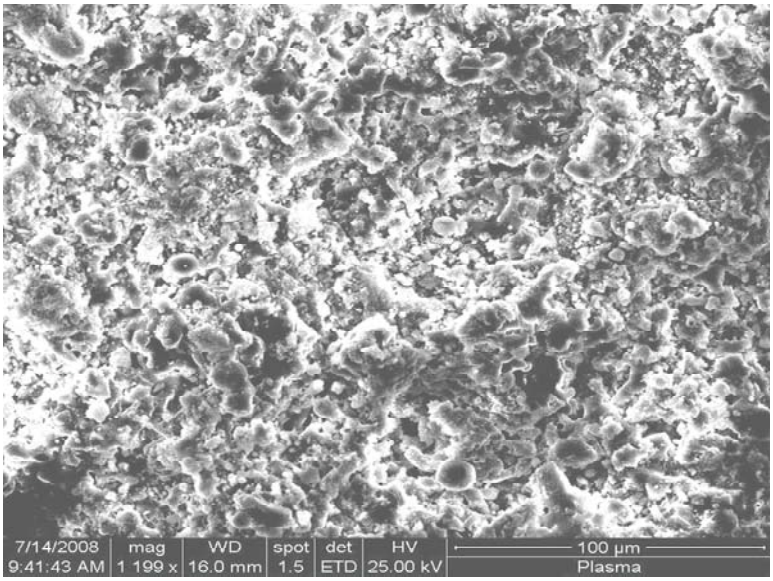



Figure 7. SEM image of the deposited layer (1200 x)

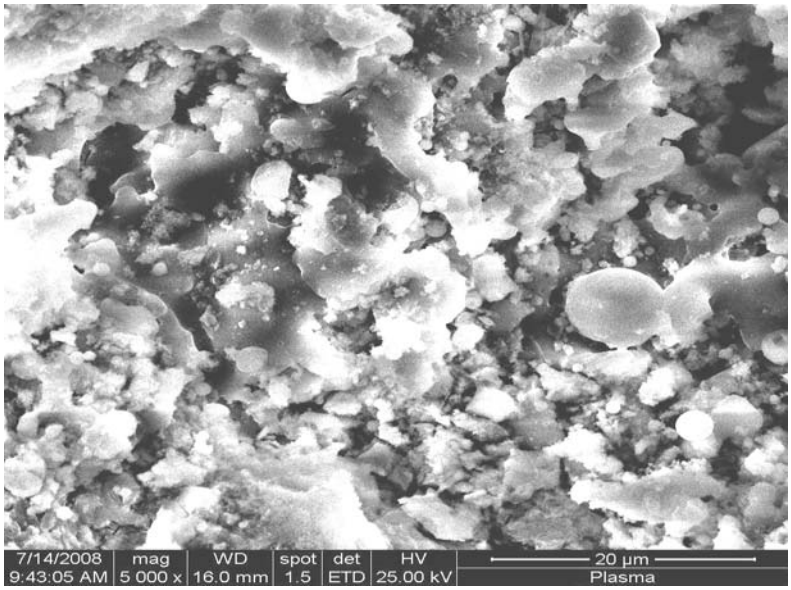



Figure 8. SEM image of the deposited layer (5000 x)

The SEM analysis of the deposited layer by plasma thermal spraying shows a characteristic morphology of the deposited layer by plasma thermal spraying with fine and big particles disposed uniformly on the surface.

## 5. CORROSION TESTS

The samples for corrosion tests deposited with hydroxyapatite layers have the aspect presented in figures 9 an 10.

Before the corrosion test the samples were weighed with an analytic balance and presented the values:

M1 = 9,8973 g

M2 = 11,7419 g

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The test samples were introduced in simulated body fluid (SBF). In table 3 is presented the chemical composition of the corrosion testing solution.

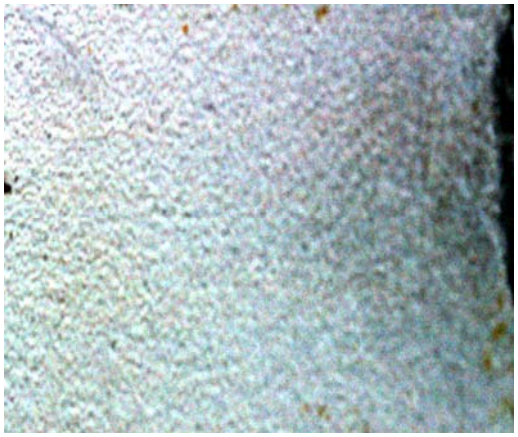


Figure 9. Sample M1

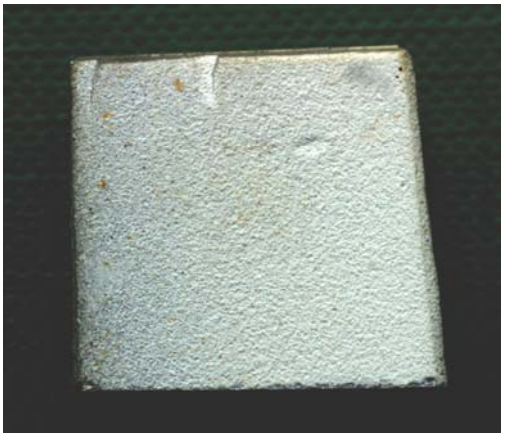


Figure 10. Sample M2

Table 3 Regents for preparing SBF (pH7.4, 1l)

| Order | Reagent | Amount |
|---|---|---|
| 1 | NaCl | 7.996 g |
| 2 | $NaHCO_3$ | 0.350 g |
| 3 | KCl | 0.224 g |
| 4 | $K_2HPO_4 .3H_2O$ | 0.228 g |
| 5 | $MgCl_2.6H_2O$ | 0.305 g |
| 6 | 1M-HCl | 40 mL |
| (About 90 % of total amount of HCl to be added) | | |
| 7 | $CaCl_2$ | 0.278 g |
| 8 | $Na_2SO_4$ | 0.071 g |
| 9 | $(CH_2OH)_3CNH_2$ | 6.057 g |

The corrosion test is realized on 28 days, after every 7 days is verified the mass losing of the samples. In the first step was not observed cracks on the surface of the tested samples.

## 6. CONCLUSIONS

6.1 The best materials used to the prosthesis fabrication in dental and orthopedic medicine are those which are similar the composition of the humane bone, and the repairing mechanism of the bone is the natural regenerations. One approach to providing a strong, long-lasting adhesive interface between a bone replacement implant and the surrounding tissue involves the use of bioactive materials.

6.2 Macro and microscopic examinations of the realized combination show specific structure of the materials used, without plasma spraying defects (pores, cracks, microcraks).

6.3 The generalized corrosion tests are made in simulated body fluid (SBF) by the determination of the mass losing in the tests cycles. The test results confirm the corrosion resistance of the investigated specimens.

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# THERMAL SHOCK BEHAVIOR OF THE COATS DEPOSITED BY PLASMA SPRAYING OF THE $TiO_2$

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**ABSTRACT**

For the coats made by using the $TiO_2$ powder (type Metco 102) on a martesitic stainless steel substrate, the thermal shock testing conditions consist in: fast heating to 800°C (or 500°C) (10s) and water cooling without maintaining to maximum temperature.

After 20 cycles to a maximum temperature of 800°C we noticed the appearance of pattern fine cracks, which is developed along the next 20 cycles but with no scorching.

For a maximum temperature of the 500°C of the thermal shock, after 180 cycles we not observed the appearance of the scorches on the coats surface.

**KEYWORDS**

Thermal Shock, $TiO_2$ coatings, plasma deposition

## 1. INTRODUCTION

Plasma spraying of materials such as ceramics and non-metallic, which have high melting points, has there fore become well established as a commercial process. Such coatings are increasingly used in aerospace, automobile, textile, medical, printing and electrical industries to impart proprieties such as corrosion resistance, thermal resistance, wear resistance, etc [1,2].

One of the most important characteristics of thermal barrier coatings is the ability to undergo fast temperature changes without failing; the so called thermal shock resistance.

The thermal shock resistance is defined as the number of thermal shock a thermal barrier coating withstands without failing.

This paper describes the results of tests conducted to determine the thermal shock behavior of the coats deposited by plasma spraying of the $TiO_2$.

## 2. EXPERIMENTAL PART

### 2.1. Experimental conditions at the $TiO_2$ coatings spraying in plasma

The substrate is the martensitic stainless steel Z12CNDV12.

The powder used is Metco 102, with 99% $TiO_2$ and particle size between 7,8 and 88 μm.

The coatings have been made using plasma generator GPPR-400 equipment.

There have been working using the following parameters:

- intensity of the current at the generator: 500 A;
- voltage: 70 V;
- spraying distance: 50 mm;
- plasma gas flow: 36,6 l/h;
- coating thickness: 0,3 mm;

**Thermal shock testing**

For the coats made by using Metco 102 powder on a martensitic stainless steel substrate, the thermal shock testing consist in: fast heating to 800°C or 500°C (10 s) and water cooling (600°C/s) without maintaining to maximum temperature.

## 3. RESULTS AND DISCUSION

Some results of the experimental determination are shown in table 1.

TABLE 1. RESULTS OF THE THERMAL SHOCK DETERMINATION

| Cod sample | The number of thermal cycles | The maximum temperature cycle [°C] | Cooling medium | Observation |
|---|---|---|---|---|
| 48 | 20 | 800 | water | The appearance of scorches |
| 50 | 30 | 800 | water | The appearance of scorches |
| 54 | 25 | 800 | water | The appearance of scorches |
| Medium | | 59 | | |
| 3 | 180 | 500 | water | No cracks, No scorches |

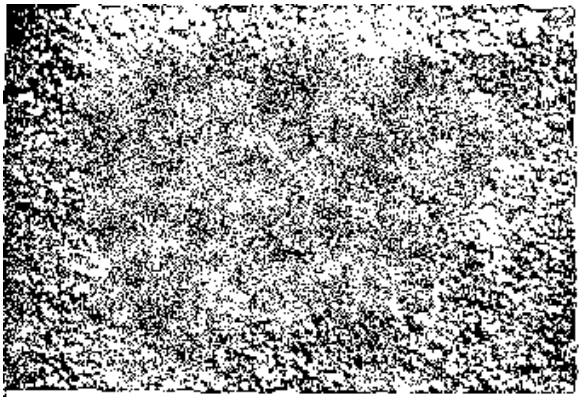
Figure 1 shows some images for the coats made using Metco 102 powder, in a different moments of the determination.

Samples were examined by optical microscopy using a stereo microscope

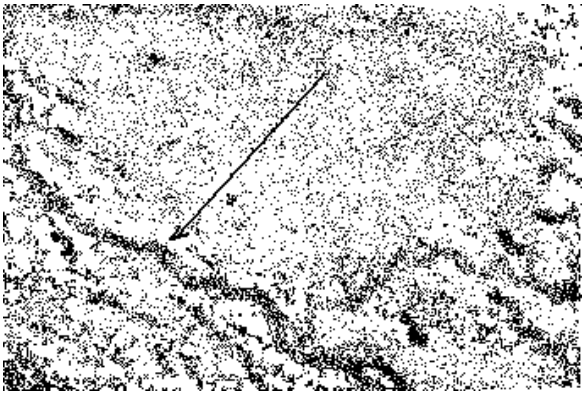
As was expected, the evidence submitted $TiO_2$ have a reduced resistance to heat shock at 800°C (25 cycles).

Layers, in its original state, have a characteristic ceramic deposition, with a pronounced roughness without visible cracks to the naked eye or to the optical microscope at low zoom. The images in Figure 1 reveals the fact that a smooth network of cracks is formed after the first set of 22 set of cycles. The cracks increase is fast, showing in this way the extended cracks and the exfoliations detected on the sample number 54.The breaking surface is highlighted by the glossy appearance of the detachment surface limits. The observed cracks have the propagation way perpendicular to the longitudinal axis of the sample, highlighting the direction with maximum stretching tensions during the experiment. Also, the cracks orientation on the layer thickness is from the substrate towards the deposit surface determed by the tensions in the substrate during the experiment.

Because the treatment chose in the first step was considered excessively harsh for the ability of $TiO_2$ to take thermal shocks, the experiment was resumed on a new set of samples covered in the same conditions at a maximum temperature of the thermal cycle 500°C with a cooling speed of 600°C/s. After running 180 cycles do not show any exfoliations. The network of cracks appears to form at a higher number of cycles (54) and extends slowly, increasing the number of cycles. The number of cracks expands significantly at over 135 cycles. At the limit of 180 cycles the apparition of the first dislocation of the coverage layer on the limits of the cracks can be notified. Images for the coats made by using the Metco 102 powder at the thermal shock are presented in following samples.



Sample 50, 40x, Initial state



Sample 50, 800°C/water/322 cycles Cracks

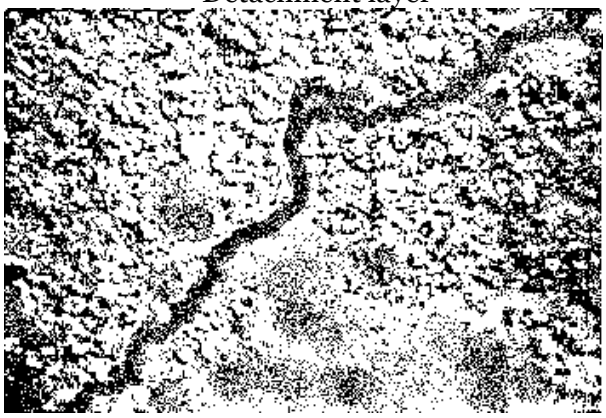
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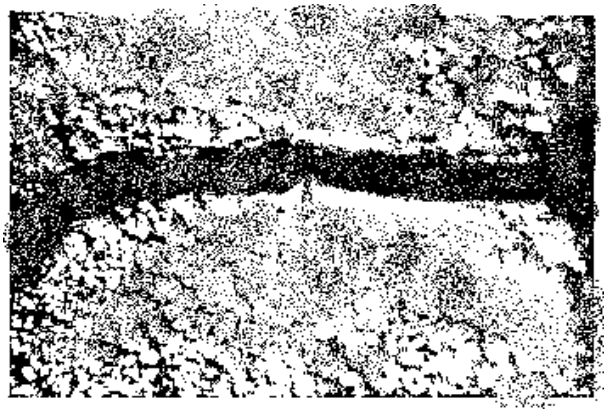
Sample 50 (70x), 800°C/ water / 19 cycles
Detachment layer



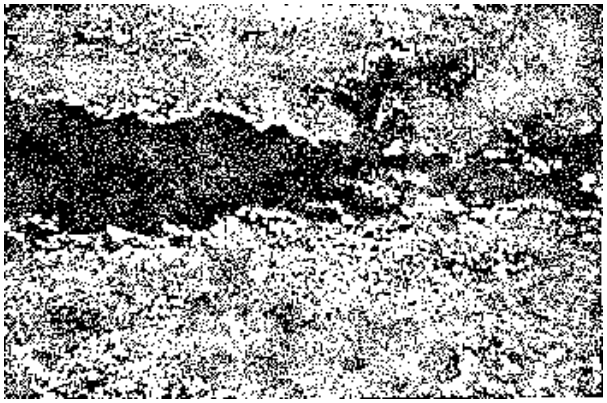
Sample 50 (70x), 800°C/ water / 31 cycles
Cracks



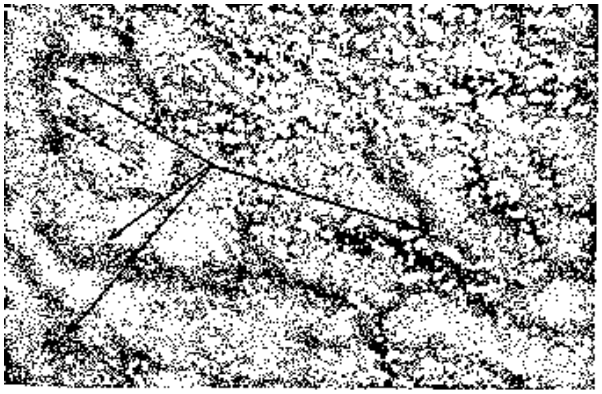
Sample 54 (70x), 800°C / water / 25 cycles
Cracks



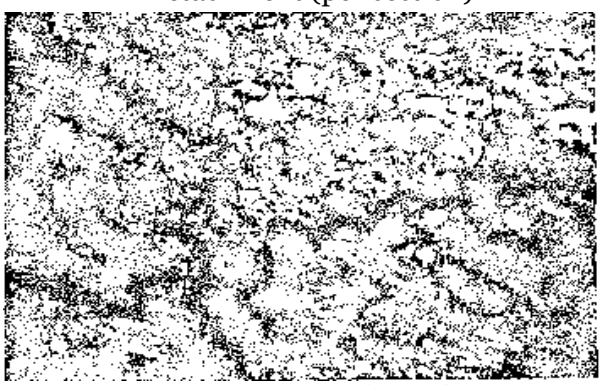
Sample 54 (70x), 800°C / water / 31 cycles
Detachment layer



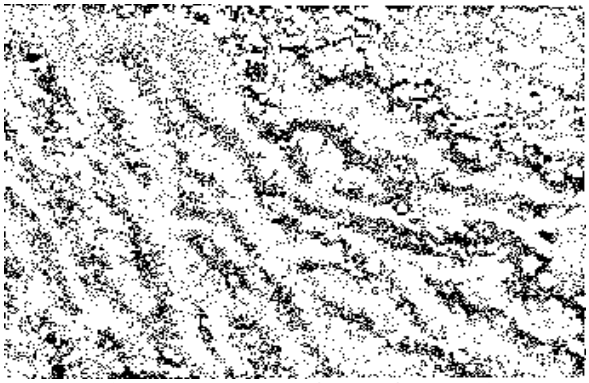
Sample 54 (70x), 800°C / water / 31 cycles
Detachment (per section)



Sample 3 (70x), 500°C/water/104 cycles
Cracks



Sample 3 (70x), 500°C/water/130 cycles
Cracks



Sample 3 (70x), 500°C/water/156 cycles
Network of cracks

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Sample 3 (70x), 500°C/water/180 cycles
Cracks and layer displacement

glossy limits of the detachment surface;

- The cracks that have been seen have the sense of propagation perpendicular to the longitudinal axis of the sample attempted at 800°C, highlighting the maximum stretch tension during the experiment;
- The orientation of the cracks on the coating layer thickness tested at 800°C is from the substrate to the surface the deposit, this is determined by the tension of substrate during the experiment;
- Particularly in the first stage of the experiment is considered over harsh for TiO2's capacity to take heat shock;
- At a maximum temperature of thermal cycle of 500°C and a cooling of 600°C/s after running a number 180 cycles, no samples presented peeling;
- The network of cracks is formed from a larger number of cycles and expands slowly when increasing the number of cycles;
- The maximum temperature of thermal cycle of 500°C, the cracks are not extending significantly at more than 135 cycles;
- The apparition of the first displacement of coverage layer on the edge of the cracks is notified at the limit of the 180 cycles with the maximum temperature of 500°C.

## 4. CONCLUSIONS

Conclusions that results from analyzing the results of determination the resistance to thermal shock of the $TiO_2$ layers are:

- The $TiO_2$ samples have a low resistance at thermal shock at 800°C (25 cycles);
- It has already formed a network of cracks after the first set of 22 cycles performed at 800°C;
- The growth of cracks is rapid, revealing the extended cracks and the exfoliation uncovered on the sample number 54;
- The breaking surface is highlighted by the

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# PREPARATION AND CHARACTERIZATION OF GOLD NANOCLUSTERS WITH COADSORBED METALS

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**ABSTRACT**

Au and their coadsorbed layers with Mo and Rh were produced on titania surfaces and characterized by LEIS, XPS, AES and STM. The data indicated that the deposition of Au on the Mo-covered $TiO_2$(110) surface enhanced the dispersion of gold. The driving force for the disruption is that Au-Mo bond energy is larger than the Au-Au bond energy. In case of Au-Rh bimetallic system, Au disruption was not observed. Rh atoms impinged onto Au clusters pregrown on $TiO_2$(110) became covered by by gold atoms by place exchange. The incorporation of rhodium led to an enlargement of gold clusters.

**KEYWORDS**

nanocluster, gold, molybdenum, rhodium, $TiO_2$, bimetal

## 1. INTRODUCTION

The preparation and characterization of metal nanoparticles on oxide surfaces is of great technological importance in catalysis, gas-sensorics and in different fields of material science. $TiO_2$ has excellent properties as a support material, affecting the catalytic activity of the supported particles in an advantageous way in many cases. Both the metal-support electronic interaction, and particle restructuring can influence the reactivity [1-3].

The presence of a second metallic component can significantly improve the catalytic performance in several cases, assigned frequently to “ensemble” or “ligand” effects [4], as it was experienced for example in the catalytic reduction of NO on supported Rh-Ag [5], in the steam reforming of methane on supported Ni-Au [6] or for the oxidation of CO on Pd-Au/$TiO_2$ [7]. Segregation or dissolution of surface atoms are key issues in bimetallic systems. Low energy ion scattering spectroscopy (LEIS), applied in the present work with He ions, is particularly useful to follow the surface composition, because it gives information only about the outermost atomic layer.

Previous studies concluded that the growth of gold and rhodium adlayers on clean $TiO_2$ followed Volmer-Weber mechanism, while XPS measurements showed that there is no chemical interaction between stoichiometric $TiO_2$ and the gold or rhodium particles [2-3, 8-10]. In the case of Mo growth on $TiO_2$(110), we found that the outermost atomic layer comprises of considerable amount of molybdenum and oxygen both at low and high metal coverages [11]. The reaction between $TiO_2$ and Mo is also evidenced by the shift in the Ti2p and Mo3d XPS lines, revealing that Ti is reduced, while Mo is oxidized. The oxidation state for titanium was 4, 3 and 2, in harmony with previous findings [12].

In our former study it was demonstrated by scanning tunneling microscopy (STM) and LEIS that addition of Mo to Au/$TiO_2$(110) resulted in the disruption of gold nanoparticles [11]. This led to the increase in the dispersion of gold. In the present work we compare the behavior of Au-Mo system with that of Au-Rh system, both on $TiO_2$(110). Note that the interaction of rhodium with titania is much weaker than that of Mo, corresponding to the lower activity of Rh towards oxygen.

## 2. EXPERIMENTAL

The experiments were performed in two separate ultrahigh vacuum (UHV) systems (base pressure $<5 \times 10^{-8}$ Pa). One chamber was equipped with facilities for LEIS, AES, and XPS measurements. In the second one, STM and AES techniques were applied.

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A Specs IQE ion source was used for LEIS. $He^+$ ions of 800 eV kinetic energy were applied at a low ion flux. The ions and electrons were analyzed by a Leybold hemispherical energy analyzer. The STM imaging was performed by electrochemically etched W-tips conditioned in situ by voltage pulses in a commercial room temperature STM system (WA-Techology).

The rutile $TiO_2$(110) single crystals were products of PI-KEM. The samples were attached to a Ta plate with a UHV compatible oxide glue (AREMCO, ceramobond 571), and could be heated with a filament placed behind the Ta plate. The sample temperature was measured by a chromel–alumel thermocouple, attached to the side of the sample with the same adhesive material. The cleanliness, composition and morphology of the surface were controlled by AES, LEIS, XPS and STM methods.

Rh, Mo and Au were deposited by an EGN4 e-beam evaporator of Oxford Applied Research at a substrate temperature of 300 K. The amount of the deposited metals is expressed in equivalent monolayers (eqML). In the STM chamber, the surface concentrations of the deposited metals were estimated from the volume of the nanoparticles separated clearly from each other.

## 3. RESULTS AND DISCUSSION

Rh formed predominantly two dimensional (2D) clusters on titania at small coverages ($\Theta_{Rh} \leq 0.2$-0.3 ML) at room temperature according to STM and LEIS results, while 3D nanoparticles were formed at higher amounts of Rh (with a typical diameter of 1.8 nm and a height of 0.5 nm at $\Theta_{Rh}$=0.5 ML). Gold clusters were significantly larger (diameter of 3.2 nm at $\Theta_{Au}$=0.5 ML). Deposition of Rh on the Au/$TiO_2$(110) surface led to a decrease in the Ti and O LEIS peaks due to the shadowing effect of Rh. In contrary, a significant *increase* in the LEIS signal was detected for Au, which means that the number of Au atoms on the topmost layer of the metal clusters was enhanced (figure 1A). It was observed in a broad coverage range ($\Theta_{Au}$=0.25-0.8 ML), the effect being somewhat stronger at higher gold concentrations. Deposition of Mo on Au/$TiO_2$ resulted in rather similar changes in LEIS spectra (figure 1B).

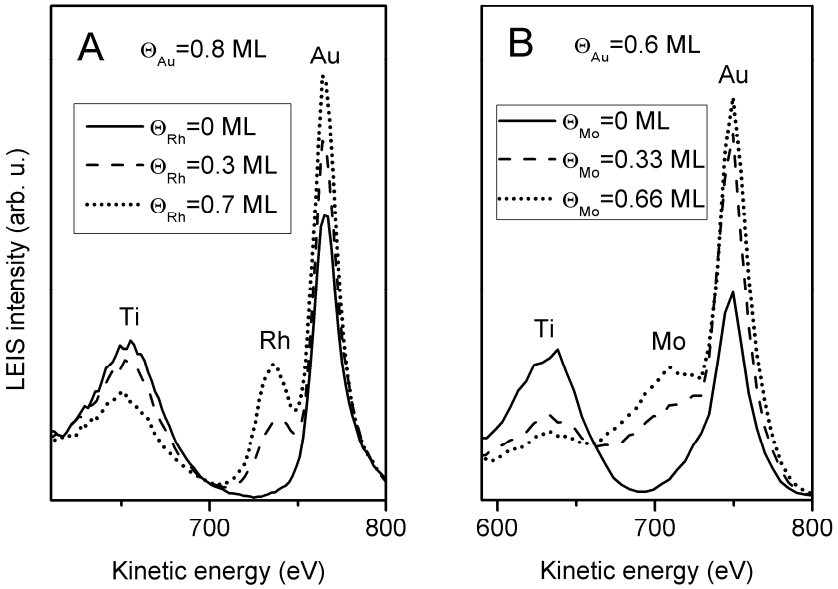



Fig.1 (A) Ti, Rh and Au LEIS signals as a function of Rh deposition time and (B) Ti, Mo and Au LEIS signals as a function of Mo deposition time, both recorded on Au-precovered titania.

STM measurements indicated that in the case of similar coverages ($\square_{Au}$ and $\square_{Rh}$ appr. 0.5 ML) the number of Au nanoparticles did not change on the effect of the deposition of Rh. Gold clusters became larger after Rh deposition (figure 2 A, B, C), in contrary to what was observed for post-deposition of Mo on Au/$TiO_2$ (figure 2 D, E, F). The statistical evaluation, in which a raised attention was paid to tip-shape effects, exhibited an average increase of the volume of the Au particles by 60-80 % on the effect of Rh post-deposition. According to the analysis of the images, a simple attachment of Rh atoms landing on Au nanoparticles during evaporation can account for an increase in the volume of the Au particles by only 20-25 %. The unexpected enhancement of the average volume suggests that a fraction of rhodium atoms impinging on the free oxide surface in the vicinity of Au clusters is trapped by gold nanoparticles, while the rest of Rh formes separate rhodium clusters. Comparing LEIS and STM data, the increase in the Au LEIS peak indicates that a part of rhodium atoms evaporated on top of the gold clusters, moved to subsurface sites of gold particles. One plausible mechanism is place

exchange. Both thermal and non-thermal place exchange was previously observed, when Rh was deposited on Au(111) [13,14], resulting also in the, formation of subsurface Rh atoms, though the two metals are immiscible in bulk. Note that the surface energy of Au is much smaller than that of Rh. Alternatively, it seems probable that those rhodium atoms on the surface of gold clusters, which do not take part in place exchange can be covered by Au atoms diffusing on the cluster surface. Both mechanisms involve the incorporation of rhodium into the gold clusters and lead to an increase in the cluster diameter, and a concomitant enhancement in the Au LEIS signal.

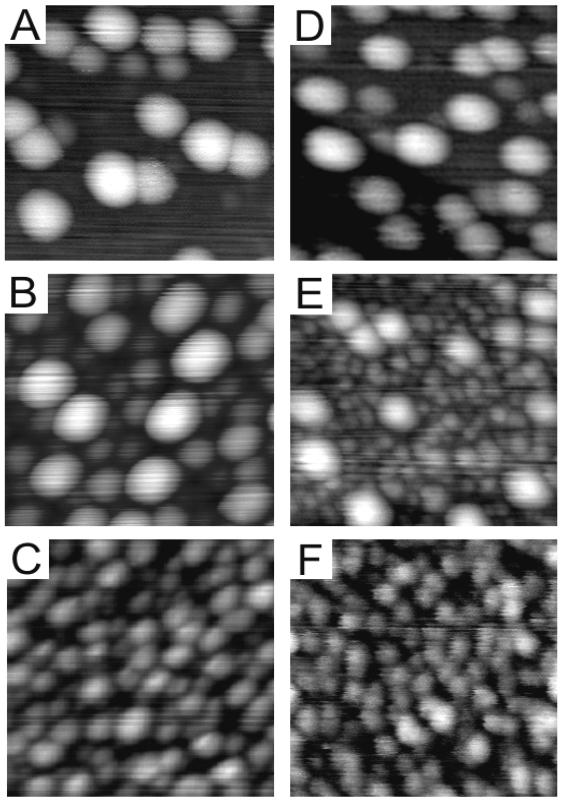



Fig.2: STM images recorded after deposition of (A) 0.6 ML of Au; (B) 0.6 ML of Au followed by 0.6 ML Rh; (C) 0.6 ML of Rh; (D) 0.6 ML of Au; (E) 0.6 ML of Au followed by 0.3 ML Mo; (F) 0.4 ML of Mo. The size of the images: 20 x 20 nm².

In contrary, for the Mo-Au system another mechanism may operate. As the STM pictures show (figure 2 D,E,F), the Au particles are disrupted due to Mo deposition. The question arises why the behaviour is different for the Au-Rh and for the Au-Mo systems. Rh and Mo have similar characteristics in their relation with Au. Both metals are practically immiscible with gold [15] and–have much higher surface free energies than Au (at room temperature 1.63 J/m² for Au, 2.83 J/m² for Rh and 2.88 J/m² for Mo [16]). A substantial difference between Rh and Mo is, however, that Mo reacts strongly with titania. As Mo reduces $TiO_2$ even at room temperature, evidenced by XPS, the reduced centers formed are responsible for the enhanced gold dispersion, since these can bind gold atoms stronger. The energy released during the reaction between Mo and surface O also may contribute to the activation of this process.

## 4. CONCLUSION

It was found by LEIS and XPS that Rh atoms impinged onto Au clusters grown beforehand on $TiO_2$(110) were covered by gold atoms through place exchange and/or surface diffusion already at room temperature. The driving force for the process is related to the surface free energies of the components. At the same time, separate Rh clusters are also formed on the gold-free oxide surface as revealed by STM measurements. In the case of Au-Mo system on titania, Mo deposition causes the disruption of gold nanoparticles. The present work clearly suggests that the parallel application of LEIS and STM techniques is very effective to explore the fine details of the supported bimetallic systems.

**ACKNOWLEDGEMENT**

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# POSSIBLE USE OF METAL COMPLEXES OF POLYAMINOPOLYPHOSPHONIC ACIDS

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**Abstract**

The development of nuclear resonance (NMR) imaging techniques as a clinical diagnostic modality has prompted the need of compounds, which enhance the image contrast between normal and diseased tissue and/or indicate the status of organ or blood flow. Complexes of paramagnetic transition metal and lanthanide ions with polyamino-polycarboxylic acids have been studied earlier in this respect in detail.

Owning to the structural similarities between the polyamino-polycarboxylic acids and polyamino-polyphosphonic acids, the lanthanide and transition metal complexes of the later ones were prepared and studied. The ethylenediamino-tetramethylene-phosphonic acid (EDTMP) and 1,3-propanediamine-tetramethylene-phosphonic acid(PDTMP) were chosen as ligand, and lanthanide ions (Eu(III), La(III), Gd(III), Sm(III)) or transition metal ions (Fe(III), Zn(II), Cu(II), Ni(II), Mn(II), VO(II)) used for preparation of metal complexes. The preparation of complexes were performed at different pH (pH= 1, 3 and 5). The composition of the complexes was determined by metal ion analysis and the complexes were studied by thermal analysis and IR spectroscopy.

The thermal behaviour of the transition metal complexes of EDTMP and PDTMP permit a suggestion for their use as a precursor compound to prepare different phosphate compounds, having interesting magnetic properties.

**Keywords:**

polyamino-polyphosphonates, lanthanide complexes, transition metal complexes, MRI agents, precursors for metal phosphates

## 1. INTRODUCTION

Throughout history, metals and metal compounds have been used in medicine to treat a variety of ailments. An even more recent development is the use of paramagnetic metal complexes for enhancing contrast of magnetic resonance imaging (MRI) in the non-invasive diagnostics of diseases and tumours. Paramagnetic metal ions function as contrast agents by increasing the relaxation rates of the observed water protons near the ion, through interactions between the electron spins of the paramagnetic centre and the nuclei of the water hydrogens [1–2].

Numerous complexes with polyaminopolycarboxylic acids have been studied as potential contrast agents [3–10]. The structural similarities between the polyamino-polycarboxilic and polyaminopolyphosphonic acids determined the study of these ligands as chelating agents. Replacement of the carboxylic groups by organophosphonic acid groups determines the specific nature of the polyamino-polyphosphonic acids due to the presence of tetrahedral phosphonic group as compared to planar carboxylic group and greater polarisability of the PO bond [11, 12].

Our studies had been focused to the synthesis and characterization of some lanthanide and transition metal complexes with two of the polyamino-polyphosphonic acids (EDTMP, PDTMP), because exchange reactions between the lanthanide complexes used as contrast agents in MRI and end transmetalation by transition metalions may place in the human body. By this way a dangerous free lanthanide ions could be appeared [13-14] and owning to

this phenomenon the use of lanthanide complexes of the EDTMP and PDTMP, as an MRI agents reagents, will forms a new problem.

An another practical importance of the polyamino-polyphosphonic acids and their metal complexes is the use of them as a precursor of different metalpolyphosphates. For instance in the last 10-20 years an increased interest could be observed against the new iron phosphates, pyrophosphates, alkali-iron phosphates- pyrophosphates as compounds having special magnetic properties. The metal complexes of polyamino-polyphosphonic acids were proofed as a candidate as precursors for preparation of the above mentioned metal phosphates, pyrophosphates[15].

In the present work the complexes of different lanthanide-, transition metal complexes of EDTMP and PDTMP were isolated from solution having different pH and their IR spectra and thermal stabilities were studied in order to determine their compositions, their stability and the binding mode of the water molecules in the complexes.

## 2. EXPERIMENTAL

### Preparation of the ligands

The investigated polyamino-polyphosphonic acids (EDTMP and PDTMP) were synthesized by us via a Mannich reaction of 1,2-ethylenediamine or 1,3-propanediamine with phosphorous acid and formaldehyde, as described earlier [16, 17].

### pK values of the ligands(EDTMP, PDTMP)

The protonation constants and the complex stability constants were determined by potentiometric titration [20]. The pK values of the ligands determine the possible composition of the metal complexes prepared at different pH and different ligand metal ratio. At low pH (1-3), 2-5 proton could be replaced by sodium and other metal-ion. At higher pH all proton could be replaced by sodium ion and different metal-ion.

Table 1.
pK values of the EDTMP and PDTMP ($H_8L$) determined by us [18].
The pK values of the EDTMP[] and PDTMP [18]

| Ligand | $pK_1$ | $pK_2$ | $pK_3$ | $pK_4$ | $pK_5$ | $pK_6$ | $pK_7$ | $pK_8$ |
|---|---|---|---|---|---|---|---|---|
| EDTMP | <1 | 1.5 | 3.02 | 5.2 | 6.4 | 7.85 | 10.00 | 11.00 |
| PDTMP | <2 | <2 | 4.05 | 5.10 | 5.89 | 6.85 | 10.00 | 11.40 |

### Preparation of the metal complexes

The preparation of the complexes was performed as followings:

The ligands (EDTMP and PDTMP) was mixed with the appropriate metal nitrate or acetate in ratio 1:1, 1:2 and the pH of the solution was adjusted by adding sodium hydroxide solution. The formed precipitate was filtered, washed, dried and stored in exsiccatore. The metal-ion and sodium contents of the complexes were determined.

### The composition of the complexes

The composition of the investigated complexes is shown in Table 2. Comparing the pK values of the ligands and the pH values of the preparation of the complexes, the gained composition of the complexes could be interpret easily.

Table 2.
The general composition of the investigated metal complexes of EDTMP and PDTMP[18,19]

| Ligand (L) | Composition | Metal ions (M) |
|---|---|---|
| EDTMP | $M_4(H_4L)_3\ xH_2O$ | La(III), Sm(III) |
| EDTMP | $MH_5L\ xH_2O$ | La(III), Sm(III) |
| EDTMP | $MNa_5L\ xH_2O$ | La(III), Sm(III) |
| PDTMP | $MNa_5L\ xH_2O$ | Eu(III), La(III), Gd(III), Sm(III) |
| EDTMP<br>PDTMP | MH5L xH2O,<br>$MNa_2H_3L\ xH_2O$<br>$MNa_5L\ xH_2O$ | Fe(III) |
| EDTMP, PDTMP | $MH_6L\ xH_2O$<br>$M_2H_4L\ xH_2O$ | Co(II), Ni(II), Zn(II), Cu(II), VO(II) |

**The IR spectra of the ligands and of the metal complexes**

The characteristic bands of the ligands are presented in Table 3-4.

Table 3
Characteristic bands of EDTMP and their assignation [18]

| Band maximum($cm^{-1}$) | Assignation |
|---|---|
| 3402s, 3246s | ν(OH, water) |
| 3026s,3014s | ν(≡$NH^+$) |
| 2954s, 2924vs, 2854s | $\nu_{as}$ and $\nu_{sym}$ of $CH_2$ |
| 2767m, 2611m, 2308m | ν (OH, POH) |
| 1653m, broad | δHOH |
| 1461m, 1438m, 1413w, 1379, 1321w | δ$CH_2$ or/and ν(C–N) |
| 1261s,1207s, 1121vs,1008vs, 953vs | ν (P=O, P–O(H)) |
| 838w, 792w, 776w,748w | ν(C–P) |
| 573m, 532m, 487m | ν (OH, POH) |

Table 4
Characteristic bands of PDTMP and their assignation [19]

| Band maximum($cm^{-1}$) | Assignation |
|---|---|
| 3372s | ν(OH, water) |
| 3024s,3005s | ν(≡$NH^+$) |
| 2950s, 2921vs, 2849s | $\nu_{as}$ and $\nu_{sym}$ of $CH_2$ |
| 2773m, 2612m, 2288m | ν (OH, POH) |
| 1657m, broad | δHOH |
| 1485m, 1437m, 1411w, 1344 | δ$CH_2$ or/and ν(C–N) |
| 1248s,1167s, 1050s, 980s, 944s | ν (P=O, P–O(H)) |
| 838w, 792w, 776w,748w | ν(C–P) |
| 602m, 585m, 548m, 512m, 482m | ν (OH, POH) |

The IR spectra, characteristic bands of metal complexes changed, related to the IR spectra of the ligands, showing the formation of complex between the metal ion and ligands [18, 19].

## 3. THE THERMAL BEHAVIOUR OF THE EDTMP, PDTMP AND THEIR METAL COMPLEXES

Both the EDTMP and PDTMP ligands have 2 water molecules, as a crystal water, which release the solid material on heating in two steps (below 150 °C and between 150 and 200 °C, 1.5 and 0.5 mole water, respectively)[16,17].

The thermoanalytical studies of the metal complexes of EDTMP, PDTMP show that the complexes of EDTMP, PDTMP contain two types of water molecules. This fact is very important from point of view of possible medicinal use of these complexes.

From the thermal decomposition of the metal complexes of EDTMP, PDTMP several conclusions could be drawn:

1. One of the final decomposition products is the metal-pyrophosphate, sodium-pyrophosphate.
2. The free OH groups of the EDTMP, PDTMP losses water molecules on heating, so they form polyphosphates with different composition and probably with different structure.

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# DEGRADATION OF PURE AND WASTE PVC AND PET IN THE PRESENCE OF MODIFIED POROUS CATALYSTS

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**ABSTRACT**

The catalytic degradation of pure and mixed polymers such as poly-(vinylchloride) (PVC) and poly-(ethylenterephthalat) (PET) was followed by thermal analytical method (TA) and was performed in a laboratory batch system (LBS) using modified ZSM-5, MCM-41 and hydrotalcites based catalysts. In degradation of PET, the acidic H-ZSM-5 resulted in less liquid products and more gaseous components than the other, transition metal containing catalysts. The degradation of PVC takes place in two steps, the first is the departure of HCl at about 300 $^{o}$C followed by formation of aromatic hydrocarbons. Minimal residue could be obtained over Fe,Mg,Al-hydrotalcites and mixed oxide catalyst. From the results obtained it can be concluded that not only the catalyst structure but also the polymer structure determines the activity of a micro- or mesoporous material in the catalytic degradation of plastics or plastic wastes. Therefore, different optimal conditions (catalyst and reaction temperature) can be applied for each plastics studied (pure, mixed and waste) in thermal treatment.

**Keywords:**

plastic pyrolysis, porous catalysts, degradation, polymer waste, PVC, PET

## 1. INTRODUCTION

The total amount of plastic wastes generated by our society is growing rapidly. The main source of plastic is the municipal solid waste. Plastics contained in the municipal solid wastes can be estimated about 10% of total waste by weight and the amount goes up to 20% when consider in volume. The low biodegradability of different plastics creates a serious environmental problem that is directing the governments and environmental organizations and enterprises to propose a hierarchy to solve the problem of plastic wastes based on source reduction re-use and recycling. Up to now and considering the case of European Union only ~10 wt.% of plastic wastes have been recycled, while ~73 wt.% have gone to landfills and ~17 wt% have been incinerated [1].

While incineration can be used to recover the waste as energy, the loss of a potential chemical source and negative public acceptance limit the extend of this solution. If we accept that landfill storage is not a rational solution and can only be considered as provisional, then one is left with the most desired primary and secondary waste recycling. The primary recycling however, are limited to pure thermoplastics, therefore secondary technologies used for treatment of mixed plastic wastes is of growing importance. In this way plastic wastes are converted into monomers, fuels or valuable chemicals for petrochemistry [2].

Traditional thermal cracking, i.e. pyrolysis can be applied to transform both thermoplastics and thermosets into gases, liquid hydrocarbons and solid residue [3]. Thermal cracking and hydrocracking have been studied at laboratory and pilot plant level, and some commercial installation have been built for treatment of mixed plastic wastes, even those containing chlorine [4]. However, thermal cracking yields low value unstable hydrocarbons within a very broad range of molecular weight. Catalytic degradation can operate at lower temperatures and can produce products with better quality (much narrower boiling point distribution and much higher stability) [5].

A large number of laboratory studies have been conducted for direct catalytic degradation of polymers, especially for pyrolysis of polyolefins, however, there are a lot of study deal with the degradation of PET and PVC. A high variety of catalysts have been used that even if performing well, they can be uneconomical due to the price of catalyst and to the high energy demand. Among the catalysts studied acidic zeolites and mesoporous materials performed special activity in the temperature range of 300-500 $^{o}$C [6-10].

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The objective of this work is to study the potential of modified ZSM-5 zeolite, MCM-41 mesoporous silica, hydrotalcites (HD) and HD originated mixed oxides as catalysts for degradation of PET and PVC using thermal analytical measurements and laboratory reactor experiments.

Table 1: Properties of catalysts

| Prepared catalyst sample | Structure (XRD, IR, TEM) | BET surface area, $m^2/g$ |
|---|---|---|
| $CaCO_3$* | - | 3.3 |
| CaO* | - | 1.5 |
| Na-ZSM-5 | ZSM-5 | 360 |
| H-ZSM-5 | ZSM-5 | 385 |
| Fe-ZSM5 | ZSM-5 | 346 |
| Cu-ZSM-5 | ZSM-5 | 352 |
| Ni-ZSM-5 | ZSM-5 | 370 |
| Fe-MCM-41 | MCM-41 | 890 |
| Ti-MCM-41 | MCM-41 | 1010 |
| Cr-MCM-41 | MCM-41 | 960 |
| Mg-Al-LDH | hydrotalcite | 20 |
| Fe-Mg-Al-LDH | hydrotalcite | 25 |
| Cr-Mg-Al-LDH | hydrotalcite | 12 |
| Cu-Mg-Al-LDH | hydrotalcite | 32 |
| Ca-Mg-Al-LDH | hydrotalcite | 16 |
| Mg-Al-MO | Mg- + Al-oxide | 40 |
| Fe-Mg-Al-MO | Mg- + Al- + Fe(III)-oxide | 42 |
| Cr-Mg-Al-MO | Mg- + Al- + Cr(III)-oxide | 50 |
| Cu-Mg-Al-MO | Mg- + Al- + Cu(II)-oxide | 27 |
| Ca-Mg-Al-MO | Mg- + Al- + Ca-oxide | 21 |

*commercial product (MOLAR RT, Hungary)

## 2. EXPERIMENTAL SECTION

### Catalysts

The catalyst samples were prepared in our laboratory except $CaCO_3$ or CaO (MOLAR RT, Hungary).

The synthesized Na-ZSM-5 zeolite was modified by conventional or solid state ion-exchange to form H-, Fe-, Cu-, Ni- and Ti-ZSM5 samples [11].

The Ti- or Fe-MCM-41 specimen was prepared from sodium silicate, CTMA-Br and $Ti(SO_4)_2$ or $Fe(NO_3)$ solution at pH 12 [12]. The crystallization was carried out at 373 K for 2 days followed by calcination at 823 K for six hours.

The Fe/Al/Mg-hydrotalcite ($M^{II}/M^{III}$ = 2, and $M^{III}$: 0.9 Al and 0.1 Fe) was prepared by coprecipitation at constant pH = 10 ± 0.2 of an aqueous solution of $Mg(NO_3)_2$, $Al(NO_3)_3$ and $Fe(NO_3)_3$ with a solution of NaOH and $Na_2CO_3$ [13].

The structure of the catalysts was characterized by X-ray diffraction, IR-spectroscopy and transmission electron microscopy, their thermal stability was followed by thermal analytical method. The specific surface area and pore size distribution of the samples were determined by nitrogen adsorption isotherms.

The properties of the samples have corresponded to the data of literature. The physical characteristics of the catalysts used are shown in Table 1.

### Methods

Commercial plastics: HDPE, PP, PET and PVC in granulate form have been used as model feed. The degradation of pure polymers was followed using either by utilizing of thermoanalytical method (*MOM Derivatograph Q, Hungary*) or in a laboratory batch reactor system with gaschromatographic product analysis (*Shimadzu GC2010, Japan*).

## 3. RESULTS AND DISCUSSIONS

### TG experiments

The TG analysis for pure PET - as it is show non Fig. 1 - proves a relatively sharp, one steep weightloss with a maximum in the DTG curve placed at 480 °C. This behavior corresponds with the thermal degradation of this polyester of narrow molecular mass distribution. Figures 2 and 3 show TG analysis of PET/H-ZSM5 and PET/Ti-MCM41 catalyst mixture with 10 % catalyst content.

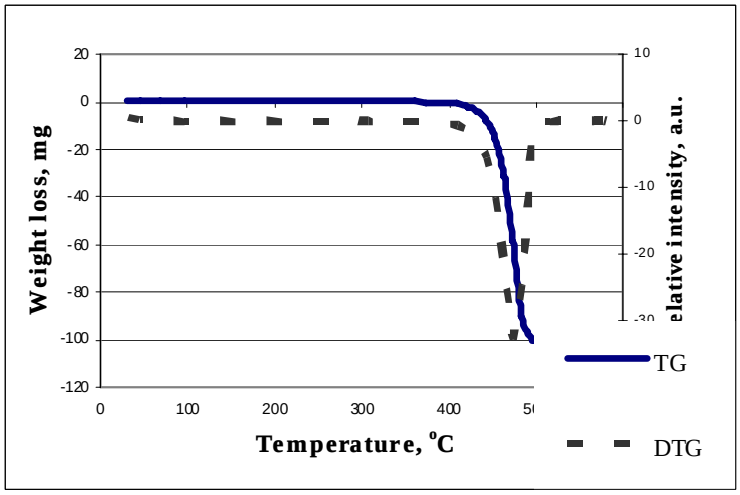



Figure 1: Thermal analytical study of PET degradation without catalyst

In the case of the PET/catalyst mixture it is clearly observed that the polymer degradation takes place at a quite lower temperature, due to the polymer catalytic cracking. In the presence of this catalyst, the weight loss starts at temperatures between 400 and 425 °C, indicating that a significant reduction occurs in the threshold temperature compared to the pure thermal degradation (with DTG maxima as characteristic temperature at 485 and 480 °C, respectively). Moreover, clear differences could be observed in regards to this temperature among the catalysts; the data can be seen in Table 2.

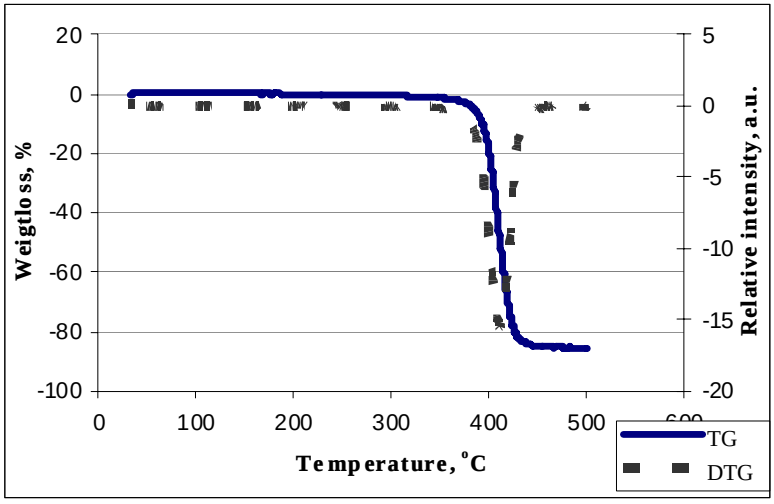



Figure 2: Thermal analytical study of PET degradation over H-ZSM-5 catalyst

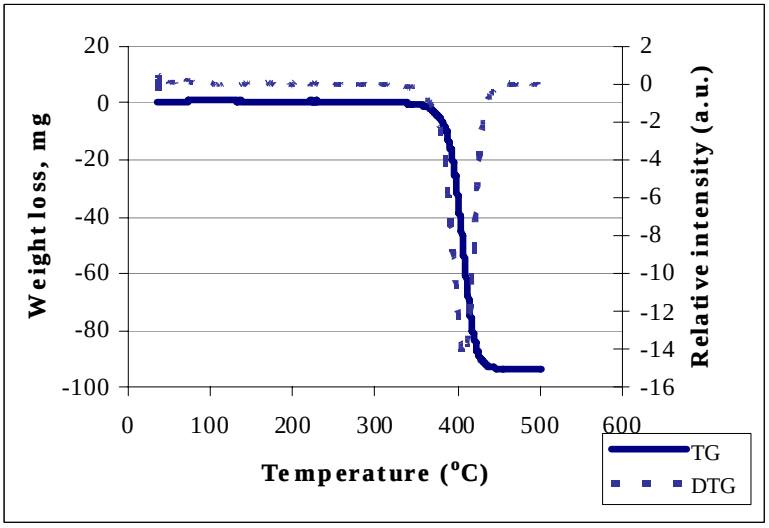



Figure 3: Thermal analytical study of PET degradation over Ti-MCM-41 catalyst

The difference of the PET and the PVC in the catalytic degradation can be seen in Figs. 4 and 5. The decomposition of PVC takes place at least in two steps, the first is due to the release of HCl with ~ 300 °C characteristic temperature, the second peak corresponds to the pyrolysis of the residual hydrocarbon framework (440 - 470 °C temperature range).

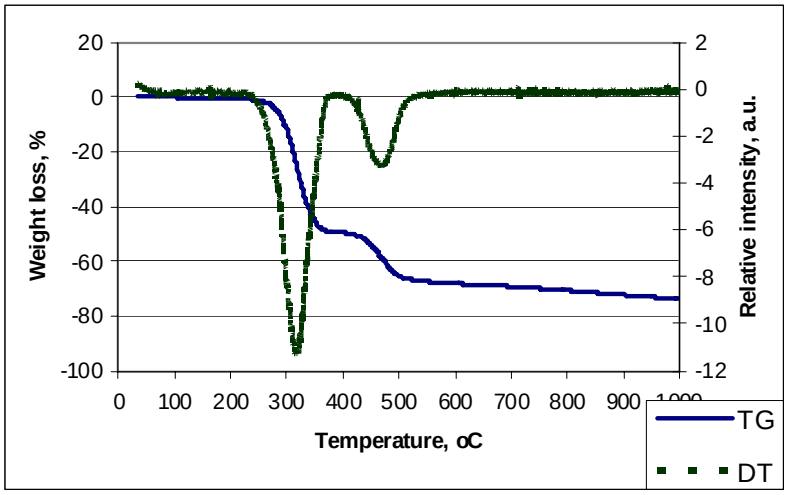



Figure 4: Thermal analytical study of PVC degradation over Fe-ZSM-5 catalyst

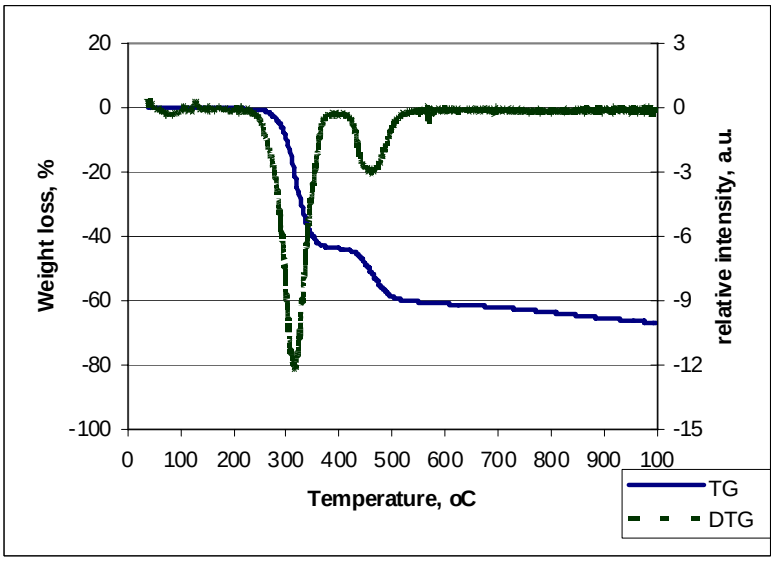



Figure 5: Thermal analytical study of PVC degradation over Ti-MCM-41 catalyst

Table 2: Characteristic temperature of plastic decomposition
(DTG peak maxima)

| Catalyst | DTG peak maximum, °C | |
|---|---|---|
| | PET | PVC* |
| none | 473 | 320, 478 |
| CaO | - | 310, 459 |
| $CaCO_3$ | - | 313, 460 |
| Na-ZSM-5 | 465 | 316, 470 |
| H-ZSM-5 | 412 | 313, 423 |
| Fe-ZSM-5 | 423 | 310, 452 |
| Cu-ZSM-5 | - | 312, 460 |
| Ti-ZSM-5 | - | 305, 456 |
| Fe-MCM-41 | 461 | 269, 443 |
| Ti-MCM-41 | 458 | 275, 450 |
| Mg,Al-oxide | 452 | 281, 475 |
| Fe,Mg,Al-oxide | 447 | 292, 471 |
| Cr,Mg,Al-oxide | 445 | 310, 456 |
| Cu,Mg-Al-,oxide | 456 | 304, 442 |
| Ca,Mg,Al-oxide | - | 290, 445 |

**for PVC two peaks can be identified to characteristics*

## 4. CATALYTIC DECOMPOSITION OF PET AND PVC IN THE BATCH REACTOR

Considering the solid residual (in mass %) determined at 400 °C at the end of the reactions (after two hours) could be calculated the nominal conversion and the relative amounts of gaseous (crack), liquid (oil) and solid (residue) products. These data can serve for characterization of the process and there are collected in Table 3. In the case of PVC the amount of HCl collected in a trap with NaOH solution can be seen in this Table, as well.

Table 3: Conversion of plastic decomposition in the different catalysts at 400 °C

| | PET | | | | PVC | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | conv. | crack % | oil % | resi-due % | conv. | crack % | oil % | resi-due % | HCl % |
| none | 0.853 | 23.1 | 36.7 | 40.2 | 0.726 | 3.0 | 28.5 | 58.5 | 72.9 |
| CaO | - | - | - | - | 0.894 | 4.5 | 52.8 | 42.7 | 36.6 |
| $CaCO_3$ | - | - | - | - | 0.896 | 6.3 | 55.7 | 38.0 | 27.4 |
| Na-ZSM-5 | 0.733 | 18.7 | 43.4 | 37.9 | 0.872 | 6.8 | 36.4 | 43.2 | 76.8 |
| H-ZSM-5 | 0.882 | 55.5 | 22.7 | 21.8 | 0.875 | 43.7 | 33.8 | 22.5 | 53.5 |
| Fe-ZSM-5 | 0.836 | 23.4 | 46.7 | 29.9 | 0.965 | 30.1 | 44.2 | 25.7 | 63.9 |
| Ti-ZSM-5 | 0.874 | 34.6 | 43.2 | 22.2 | 0.909 | 24.2 | 46.1 | 29.7 | 52.9 |
| Fe-MCM-41 | 0.756 | 32.6 | 46.6 | 20.8 | 0.889 | 11.4 | 56.9 | 32.7 | 62.9 |
| Ti-MCM-41 | 0.873 | 28.5 | 44.4 | 27.1 | 0.842 | 16.8 | 44.9 | 38.3 | 65.8 |
| Mg,Al-oxide | 0.740 | 32.0 | 35.2 | 32.8 | 0.936 | 10.1 | 62.7 | 27.2 | 37.3 |
| Fe,Mg,Al-oxide | 0.943 | 20.3 | 47.5 | 32.2 | 0.843 | 16.6 | 54.7 | 28.7 | 65.6 |
| Cr,Mg,Al-oxide | 0.866 | 37.1 | 42.4 | 20.5 | 0.912 | 21.3 | 60.1 | 18.6 | 60.3 |
| Cu,Mg,Al-oxide | 0.857 | 26.2 | 56.4 | 17.4 | 0.886 | - | - | - | - |
| Ca,Mg,Al-oxide | 0.953 | - | - | - | 0.826 | - | - | - | - |

The H-ZSM-5 catalyst possessing strong acid sites resulted in less liquid products and more gaseous components than the other, transition metal containing catalysts. These results are in agreement with the fact that acidic sites catalyze the degradation/cracking of heavier hydrocarbons.

The Cl balance can be calculated from the relative amount of HCl, and it is clerly seen that the basic catalysts react with the HCl formed in the pyrolysis. This reaction could results the deactivation of the catalyst, however, its importance is the possible mineralization of chlorine.

The effect of the temperature for the reaction of PET in the presence of Al-Mg-oxide catalyst can be seen on Fig. 6. On higher temperatures the formation of gaseous products are preferential.

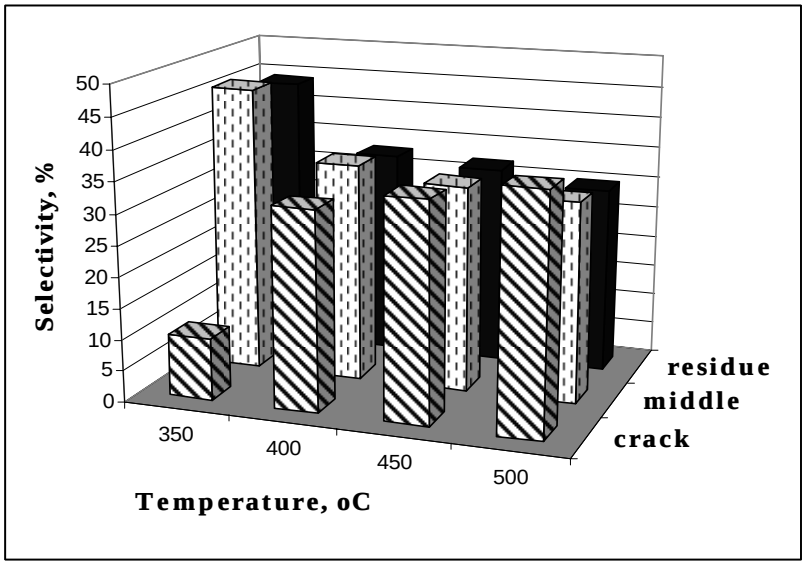



Figure 6: Product distribution in PET degradation at different temperatures in the present of Al-Mg-oxide catalyst

## 5. CONCLUSIONS

For PET degradation the non-acidic Na-ZSM-5 and the Fe-ZSM-5 samples product liquid hydrocarbons with yields about 90 % which is higher than that of non-catalytic thermal degradation. while the H-ZSM-5 sample enhances the formation of low molecular weight (gaseous) products.

The catalytic degradation of PVC takes place at least in two steps: the first one is the leaving of HCl. In this reaction. The catalysts with basic character (CaO, $CaCO_3$, hydrotalcites and Mg-Al-mixed oxides) have definite activity, principally due to the stabilization of the system by the reaction with the releasing HCl.

From the results obtained it can be concluded that not only the catalyst framework but also the polymer structure determinate the activity of porous materials in the catalytic degradation of plastic wastes. The polymer chain ends are able to penetrate into the pore system of the catalyst, reaching the active sites into the channel system.

Polymer with aromatic ring. i.e. PET show lower activity in the case of catalysts with smaller pore sizes (ZSM-5). By other hand, the higher pore size resulted in higher initial reactivity, but the coke deposition was improved in the catalysts of large pores, can lead to a fast deactivation.

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# STEAM REFORMING OF ETHANOL ON ALUMINA SUPPORTED NOBLE METAL CATALYSTS

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**ABSTRACT**

The increasing demand for alternative energy sources drew a great attention to the steam reforming of ethanol to produce $H_2$. From environmental point of view the use of ethanol is preferred because it can be readily produced from renewable biomass

Recently it has been found that supported noble metals are active catalysts of $H_2$ production in the ethanol reforming. It was found that while the selectivity of hydrogen decreased in time, the formation of ethylene increased parallel to it on all alumina supported noble metals at 723 K. This trend was resumed by increasing the following parameters: water concentration, metal loading and reaction temperature. By means of infrared spectroscopy and TPD measurements it was found that after the ethanol adsorption not only different types of ethoxy species but significant amount of adsorbed CO and acetate group were present on the surface. The latter species were stable even above 700 K. During the reaction at 723 K not only acetate but adsorbed CO was found. It is surprising to detect CO well above its desorption temperature. It means that the formation rate of the CO is higher than its desorption or further reaction rate.

It was presumed that the surface acetate species bonded mainly to the support. In spite of the location of these species we stated that the surface acetate hindered the reaction to hydrogen on the metal.

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# DIODE LASER BASED PHOTOACOUSTIC INSTRUMENT FOR AMMONIA CONCENTRATION AND FLUX MONITORING

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**ABSTRACT**

A diode laser based near infrared (1532 nm) photoacoustic ammonia monitoring instrument was combined with a preconcentration unit in order to reach sub-ppb detection limit with a compact, automatic measuring instrument. The system has no measurable cross-sensitivity to common atmospheric gases, most importantly to water vapor and carbon dioxide. The minimum detectable amount of ammonia is 2.9 ng, which means a minimum detectable concentration of 0.5 ppb with a 30-minute measurement time. The instrument was calibrated with the widely accepted, wet-chemical AMANDA instrument, and was tested in several inter-comparison campaigns with various instruments. Results of the inter-comparison campaigns show that the instrument is highly reliable even under harsh field conditions and accurate enough for environmental ammonia concentration monitoring.

The instrument can be operated with three sampling inlets and thus can be used for ammonia flux measurements with the gradient method. The instrument was successfully tested in a measurement campaign on an agricultural field near a cattle farm, the purpose of which was to quantify ammonia load to the field originating from the cattle farm, taking use of the wide dynamic range of the instrument. In a second campaign, long term flux measurements were carried out for several months above semi-natural grassland, where the stability of the instrument was tested. In this campaign, ammonia emission was observed during the day (with a typical maximum of about 220 $\mu gN/m^2 \cdot h$) and deposition during the night (-10 $\mu gN/m^2 \cdot h$ on average), and the measured flux values were within the theoretically estimated range.

**Keywords**

ammonia, concentration, flux, photoacoustic spectroscopy, preconcentration

## 1. INTRODUCTION

Ammonia is the most important alkaline gas in the troposphere, therefore plays a crucial role in atmospheric acid-base chemistry. Increased ammonia load might alter the pH of soil and water and thereby damage sensitive ecosystems. Besides this, ammonia is the third-most abundant nitrogen-containing compound in the atmosphere, which means that higher amounts of ammonia mean an increased nitrogen load and might cause eurtophication. Furthermore, ammonia contributes to atmospheric fine aerosol formation, through its reactions with sulfur and nitrogen oxides, and effect global radiation budgets and has adverse effects on human health.

Due to the above mentioned facts, ammonia is considered as an air pollutant; however its importance has been discovered only recently. The Gothenburg Protocol of the UN Convention on Long-Range Transbounday Air Pollution in Europe was the first international convention regulating ammonia emissions.

Besides its concentration, fluxes of ammonia are also important from the environmental point of view, since this provides information about the direction and magnitude of ammonia exchange between the atmosphere and biosphere.

Several ammonia monitoring instruments have been developed in the past few decades, however, none of them is ideal for long-term ammonia flux monitoring in the field, therefore developing ammonia monitoring instrument remains an unsolved problem.

We have developed a compact, automatic instrument based on diode laser based photoacoustic spectroscopy, combined with chemical preconcentration of the sampled air, which ensures the high sensitivity and selectivity. The instrument can be supplemented with more sampling inlets which make it suitable for flux measurements based on gradient methods.

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## 2. EXPERIMENTAL

We have combined a near-infrared diode laser based photoacoustic ammonia monitoring system described in Ref. 1 with preconcentration sampling (Ref. 2). The instrument can be supplemented with more sampling inlets and therefore used in flux measurements. The main characteristics of the instrument are the following: detection limit of 0.5 ppb, time resolution between 5 and 30 minutes, no measurable cross sensitivity to water vapor, carbon dioxide and aerosol particles, compact design and capability of unattended, automatic operation.

## 3. RESULTS

Long term ammonia flux measurements were carried out with the instrument in Bugac, above semi-natural grassland in the Hungarian Great Plain. A cattle farm is located near the monitoring station that causes relatively high ammonia concentration during the day.

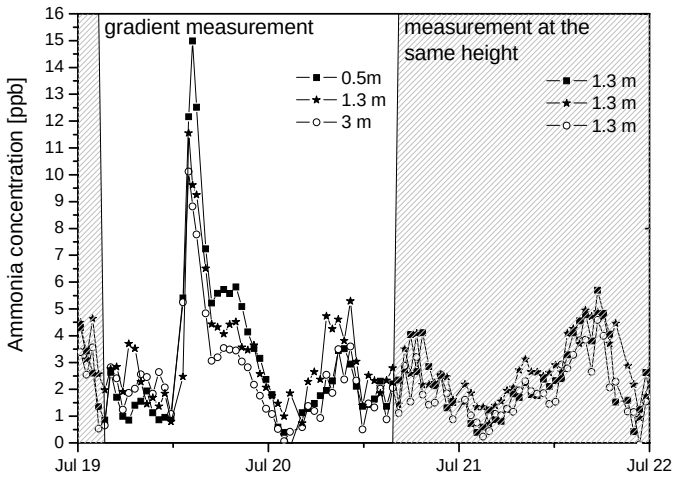



Figure 2: Ammonia concentration measured by the three inlets of the photoacoustic instrument in Bugac. Shading indicates when all three inlets were placed at the same height

Figure 2 shows a 3-day part of the measurements. White area indicates when the three sampling inlets of the instrument were placed at 0.5, 1.3 and 3 m, respectively for gradient measurements. Shading indicated when the inlets were brought to a common height (1.3 m) for self-checking and determination of correction factors if necessary. The Figure shows that in case of gradient measurements higher concentrations were observed closer to the ground, which indicates emission of ammonia.

Ammonia fluxes were calculated from the concentration data measured at three different heights using the aerodynamic gradient method. Fluxes were averaged to determine the average daily variation of the ammonia flux. Figure 3 shows this daily variation for the period 2nd July – 5th October, 2008.

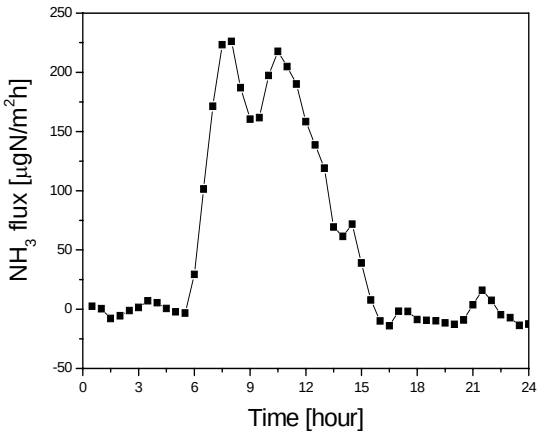



Figure 3: Average daily variation of ammonia flux, calculated from the measurement data from three different heights for the period between 2nd July and 5th October, 2008

The Figure shows that ammonia is emitted during the day and weakly deposited during night. The net balance of ammonia is positive, the site is an emission source of ammonia, which is a result of the nearby cattle farm.

## 4. CONCLUSION

We have developed a novel ammonia monitoring instrument that is suitable for measuring ammonia concentration at three different heights simultaneously. The obtained data can be used for ammonia flux calculation based on the gradient method. Several months of test measurements show that the instrument is well suited for long-term environmental monitoring.

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# DEMONSTRATION OF THE APPLICABILITY OF NOVEL PHOTOACOUSTIC AEROSOL MONITOR FOR OPTICAL ABSORPTION COEFFICIENT DETERMINATION – LABORATORY AND FIELD TEST

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## ABSTRACT

Despite of its importance, the possibilities to determine the direct radiative forcing by atmospheric aerosols is very limited due to lack of the reliable on-line instruments. Therefore there is an increasing concern for novel methods promising more accurate and reliable results in this field. The accuracy and reliability of the available on-line instruments like SP2 (Single Particle Soot Photometer), MAAP (Multi Angle Absorption Photometer), are limited by the weakness of the spectral resolution or the sampling artefact of filter matrix during the light attenuation measurement on the deposited filter. These methods neither suitable for direct determination of the light absorption by aerosols nor dispose the capability of the source apportionment.

In this work we present a novel photoacoustic based instrument for direct light absorption measurements in the atmosphere and demonstrate the suitability of that both in laboratory and field circumstances.

We have developed a novel Multi Wavelength PhotoAcoustic System (WaSul-MuWaPas) based on the diode laser pumped, high repetition rate, Q-switched Nd:YAG laser and its frequency converted harmonics for direct determination of light absorption by aerosols.

This instrument has designed to make *in situ* measurements at four different wavelengths simultaneously from the NIR to the UV wavelength range (1064nm, 532nm, 355nm, 266nm). The Wasul-MuWaPas measures directly the optical absorption coefficient on airborne particles, not belong to the integrated plate type technique (filter-free operation), operating at wide wavelength range (source apportionment possibilities), due to the possibilities of the wavelength independent cell constant determination the measurement method is absolute. Because of these the Wasul-MuWaPas system may become one of the best candidates for absorption measurements of various atmospheric aerosols such as black carbon, mineral dust, and secondary organic and inorganic aerosols as well as for source apportionment studies.

The present system was successfully tested both under the laboratory and field circumstances. The results of these studied, demonstrated here, is shown excellent agreements with reference methods and presents the main characteristic performances of the system verifying the potential of Wasul-MuWaPas to characterizing the spectral properties of atmospheric aerosols.

These researches were funded by Hungarian Ministry of Economy and Transport NKFP_07_A4_AEROS_EU.

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# ENVIRONMENTAL IMPACTS OF NITRATE AND NITRITE

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**Abstract:**
The natural nitrogen cycle is significantly influenced by the human activity – principally by agriculture and transport. The excessive fertilizing, the organic matter content of sewage waters, and the emission of nitrogen oxides to the atmosphere – caused by vehicles and industrial activities – are unsettling the biosphere's nitrogen balance. The anthropogenic nitrogen surplus in soils, water bases and atmosphere means great problem, and its indirect effect is observable in our environment and daily life. Nitrite and nitrate pollutions are important and serious risks in spite of being relegated to the background in global environmental protection.

**Keywords:**
nitrate, nitrite, fertilizer, eutrophication, methemoglobin

## 1. SIGNIFICANCE OF NITROGEN

The nitrogen is present in the environment in many various forms and considerable amount. Nitrogen compounds are especially important from environmental, ecological and physiological aspect because they are indispensable constituents of e.g. proteins, nucleic acids or humus; they can be found in the atmosphere, in soils or in any living organism. The wide interval of nitrogen's oxidation state (-3 - +5) indicates the high number of the – essential, toxic, neutral or anthropogenic - components nitrogen can form. Among these numerous compounds nitrate and nitrite mean significant environmental risk and can cause long-term natural damages.

## 2. THE NITROGEN CYCLE

The elemental nitrogen of the atmosphere – because of its inert structure – highly resists chemical reactions; hence the most of organisms are disable to use it for biological processes. Only some microorganisms (e. g. Rhizobium, Azotobacter, Clostridium) can fix and convert nitrogen to accessible form for plants (ammonia, ammonium). Ammonia is oxidized by Nitrosomonas and Nitrococcus bacteria to nitrite which is converted to nitrate by Nitrococcus and Nitrobacter species during the nitrification process. These nitrogen forms are also available for the flora. Nitrogen compounds of organic residues are converted to ammonia in the course of ammonification then nitrified as well. A part of nitrite/nitrate content of the soil is returned to the atmosphere as elemental nitrogen and dinitrogen oxide by the activities of e.g. Pseudomonas, Paracoccus species (denitrification) (Figure 1).

Accordingly the presence of nitrate and nitrite in the soil is evident; these forms are the main nitrogen sources of plants and indirectly animals and mankind too. However natural nitrogen cycle is significantly influenced by human activities – principally by traffic and agriculture. The biosphere's nitrogen balance is affected by the overfertilizing, the high organic matter content of sewage or nitrogen oxide emissions of traffic and industry. Anthropogenic nitrogen surplus in the soils, water bases and atmosphere are both sources of environmental problems; the impact to the nature is clearly noticeable.

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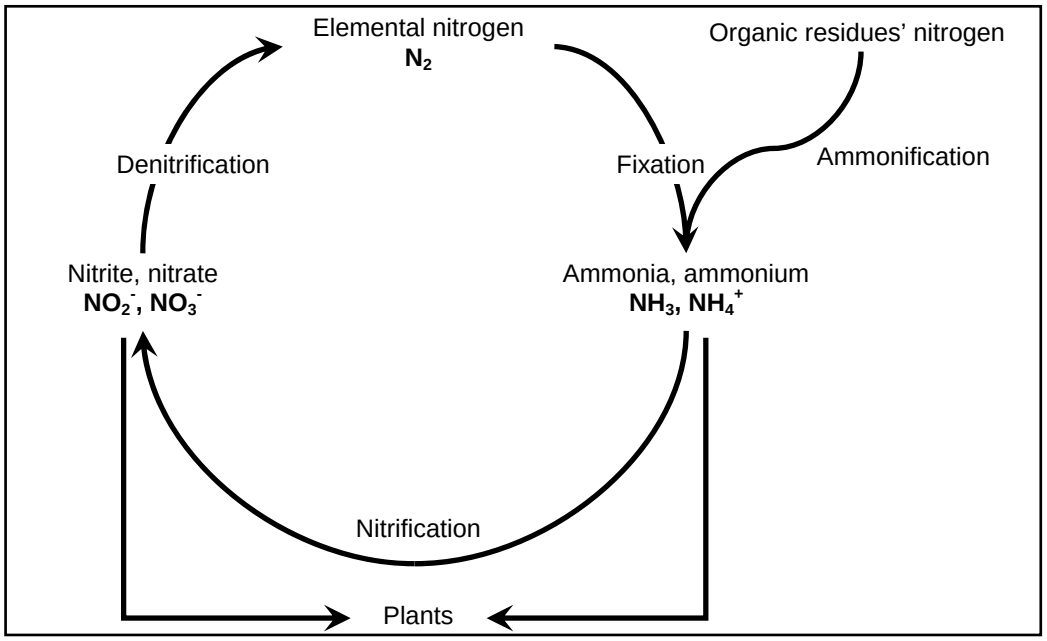



**Figure 1.** The nitrogen cycle

## 3. FERTILIZERS

Usually the nutrient content of soils does not correspond with the demands of cultivated plants; hence fertilizers are basic materials in nowadays' agriculture to increase the crop yields. However added nutrients influence the ion mobility and chemical attributes in soils and the components of soil water, the considered and responsible application of fertilizers not necessarily endangers the environment. Besides proportional nutrient supply can be ensured for the plants with fertilizers, some soil parameters can be optimized, such as alkalinity or structure.

However the irresponsible usage of fertilizers can entail serious environmental and financial risks; incorrect dosaging can disturb the existing balance of nutrients, can cause the elements' immobilization and might reduce the product's quality and yield. Soil accepts and stores nutrients only in limited rate; if it is encumbered with fertilizers beyond this limit, nutrients will concentrate in the soil solution, soil water will be polluted and even salt accumulations will evolve. The surplus of organic matter might reach the drinking water bases by erosion, leaking of groundwater or surface runoff and threatens their quality and causes eutrophication.

Nitrogen fertilizers can be especially harmful because of their possibly high solubility; leaching rate of fertilizers' nitrogen content can reach 80% depending on weather, characteristics of soil, amount of fertilizer and vegetation.

Further risk of soil's high nitrogen level is the nitrate accumulation in vegetables. Under optimal circumstances organic acids – derived from oxidation of carbohydrates – form amino acids with ammonia enzymatically reduced from nitrate. These amino acids are essential components of vegetal proteins. If the nitrogen metabolism suffers disturbance, biosynthesis of proteins will slow down and nitrates and amino acids will accumulate in the plant organism. The accumulated nitrate can worsen the vegetable's tissue attributes, lasting and even its taste. High nitrate levels can be measured in e.g. lettuce, kohlrabi, radish, colewort and spinach.

## 4. NITRATE IN WATERS

Eutrophication of surface waters is caused by increased organic matter content – basically nitrogen and phosphorus compounds – originated from sewage or leaking from fertilized agricultural areas. Great amount of nutrients offsets the balance between photosynthesis and plant breathing: the water's oxygen concentration rises and the flora

starts to proliferate. The multiplied species of fitoplanctons and algae further increase the nutrient amount of water however during their degradation processes the water's dissolved oxygen resource is consumed. Finally the lack of oxygen leads to almost complete disappearance of flora and fauna, decreasing biodiversity and the water loses its self-cleaning capability (Figure 2). Under natural conditions eutrophication occurs much more slowly (e.g. lake succession); the intensive organic matter input significantly speeds up the process.

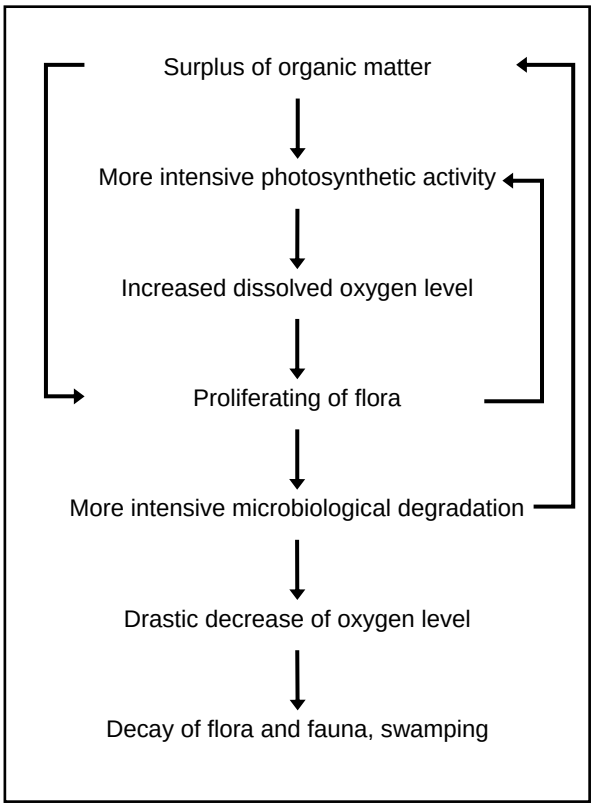



**Figure 2.** Process of eutrophication

High nitrite and nitrate content means direct risk where drinking water is supplied from polluted water bases. Leaked to groundwater, nitrogen compounds of fertilizers endanger the water quality of drilled wells and other water sources. The amount of nitrate ions stays unchanged during the conventional water cleaning processes; hence the nitrate content of consumed water is equivalent with the water base's.

## 5. NITROGEN COMPOUNDS AS AIR POLLUTANTS

Besides elemental nitrogen other nitrogen compounds are formed in the course of denitrification that harm the atmosphere. The gas phase losses of fertilizers can get to the atmosphere as nitrogen oxides (e.g. $N_2O$, $NO_x$) and take part in generating acid rains and tropospheric smog and thinning ozone layer. The great amount of organic matter can make the denitrification more intensive and considerable part of the fertilizer's nitrogen amount can get in the air. Flue gases are main sources of these types of air pollutions; the magnitude of fertilizer's impact is minor, but confirmed and not negligible.

## 6. NITRATES AND NITRITES IN FOODS

Nitrite and nitrate get in foods partly as a result of not suitable producing or handling processes and partly as additives. Food industry applies nitrite and nitrate components (e.g. E249 – $KNO_2$, E250 – $NaNO_2$, E251 – $NaNO_3$, E252 – $KNO_3$) primarily with conservation purpose. Most of meat products contain added nitrate and/or nitrite preventing appearance of pathogen microorganisms and ensuring the bright color of the meat. As mentioned, some vegetables' nitrate content can be high as well such as dairy products, cheeses, wines or flour.

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## 7. PHYSIOLOGICAL EFFECTS

Nitrate and nitrite content of foods and drinking water can induce various medical problems – however most of these components usually leave human organism fast and without evolving any deleterious effect. Nitrite – reduced from nitrate mainly in stomach and small intense – can transform to nitrous acid that oxidizes the ferro-ion of hemoglobin and causing methemoglobinaemia. In the case of methemoglobinaemia blood's oxygen carrying capability decreases and even death can occur. Under normal circumstances 1-2% of human organism's hemoglobin is present in methemoglobin form; if this scale is about 10% symptoms of languor and concentration disturbance will be observable; 50% of methemoglobin is lethal. Nitrite poisoning is really rare in adult population because a special enzyme transforms back the methemoglobin to hemoglobin (Figure 3); however babies are highly endangered because in early age the methemoglobin reductase is not working adequately yet. Therefore the babies' nutriments and drinking water must not include nitrate or nitrite in even trace amount because in lack of medical help anoxic state ("blue baby" disease) is probably deadly.

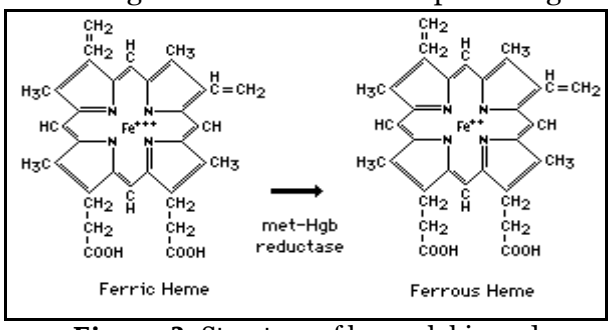



**Figure 3.** Structure of hemoglobin and methemoglobin [6]

Another problem related with nitrite presence is the formation of nitrosamines and nitrosamides. These carcinogen N-nitroso compounds are particularly evolved in the acidic media of stomach through reactions of amides and amines with nitrite [2].

## 8. REGULATIONS

Because of the above environmental and physiological dangers controlling the nitrate and nitrite emissions and monitoring their concentration in foods and waters is important and required. Regulations, decrees and limit values exist to avoid the unnecessary, dangerous or harmful application of these compounds. The directives and regulations of the EU assign fertilizing parameters, limit values for drinking waters, vegetables, meat products etc., and lay emphasis on the protection of nitrate sensitive regions (areas where nitrates can easily reach drinking water bases). Unfortunately national rules not always correspond to the international requirements.

## 9. CONCLUSIONS

Fast and effective solving of environmental problems caused by anthropogenic nitrite and nitrate is difficult task because of its complexity. The only long-term solutions seem to be the reasonable fertilizing and the adequate wastewater treatment. The environmental and medical risk can only be reduced with controlled emissions and international co-operation. Nitrate and nitrite pollutions are critical however often hidden problems of nowadays that should be taken much more serious.

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# NITRATE IN TOBACCO - ANOTHER SOURCE OF DANGER OF SMOKING

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**Abstract:**
Despite of the well-known health-damaging consequences, 40-45% of Hungarian adult population is smoking. Numerous publications reported presence of $NO_x$ gases in tobacco smoke [1, 2] that can be transformed to destructive nitric acid in the human organism. The origins of these dangerous gases are the nitrogen compounds of vegetal proteins or – in other opinions – nitrates and nitrites from oxidizer additives. We determined the nitrate content of different types of cigarettes and detected 5-30 mg nitrate in 1 gram tobacco. It is doubtful how nitrate is generated into cigarettes because it is not included on the list of the licensed tobacco additives [3].

**Keywords:**
nitrate, additive, tobacco, cigarette

## 1. INTRODUCTION

Tobacco smoke is very complex mixture with over 4000 identified constituents – included lots of hazardous – harmful, toxic, carcinogen and mutagen – compounds. $NO_x$ gases are one fraction of these compounds and by transforming to nitric acid during the burning process they can cause serious injury in the tissues of the lungs and in other mucous membranes. We tried to verify that the sources of these $NO_x$ gases are – at least partly – nitrates and nitrites. We determined nitrate content of 20 different tobacco products according to the Hungarian standards' colorimetric methods [4].

## 2. MATERILAS AND METHODS

Each sample was made from one cigarette's tobacco amount (~0.5-0.6 g) that was mixed with 20 $cm^3$ distilled water at 300 revolutions per minute then filtered with paper filter. Ideal soaking time (5 minutes) was measured by sharing the tobacco content of a single cigarette to about 0.1 g portions (Figure 1.) because of the relatively high differences between nitrate concentrations of the cigarettes from same box (Figure 2).

The nitrate measurements are based on the reaction of sodium salicylate and nitric acid (issued from the reaction of nitrate and cc. sulphuric acid) that results a yellow nitro-compound of which's absorbance is proportional to nitrate concentration in the sample. During the procedure after 1 $cm^3$ 0.03 M sodium salicylate was added to 5 $cm^3$ of the sample, water was evaporated on water bath at 95°C. The dry residual was wetted with sulphuric acid, and after 10 minutes the solution was diluted with 30 $cm^3$ distilled water, finally the medium was alkalized with 7 $cm^3$ 10 M sodium-hydroxide. Then the volume was completed to 50 $cm^3$ with distilled water and in one hour we measured the absorbance of the solution spectrophotometric at the wavelength of 410 nm. The exact nitrate concentrations were read from a calibration graph, recorded with different concentrations of potassium nitrate solutions (Figure 3).

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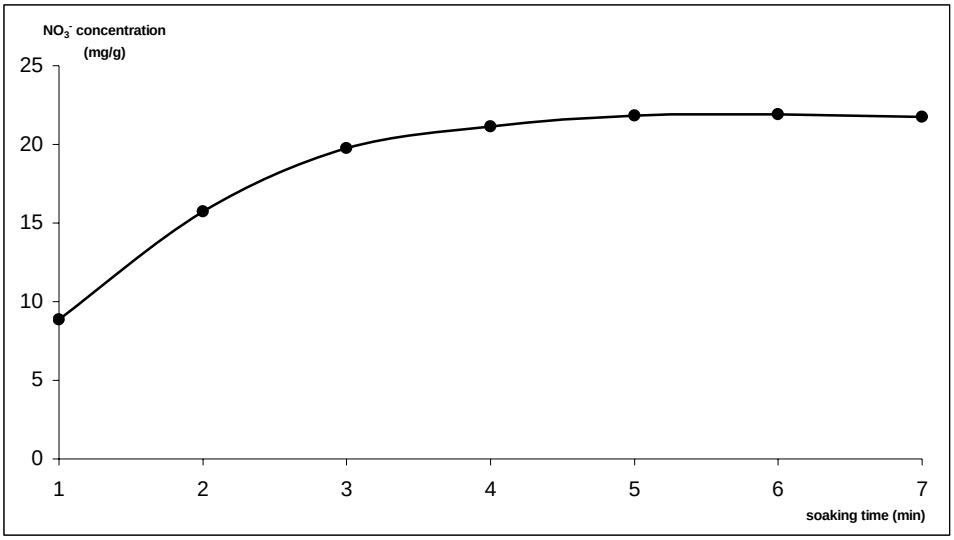



**Figure 1.** Changing of tobacco's nitrate content in relation of soaking time (Bond Street, red) – the tobacco content of a single cigarette was shared to 7 portions (~0.1 g).

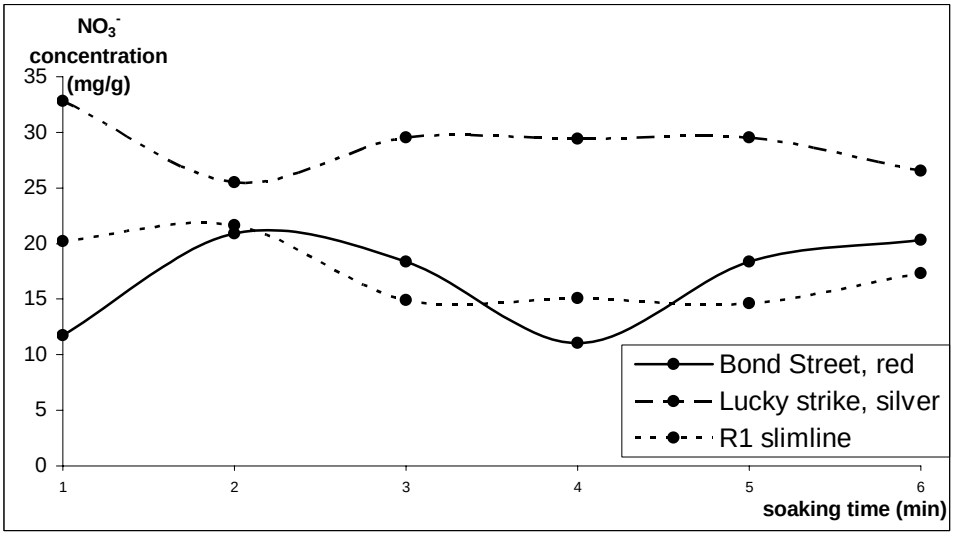



**Figure 2.** Changing of tobacco's nitrate content in relation of soaking time – samples were made of entire tobacco content of 6 cigarettes of same brand.

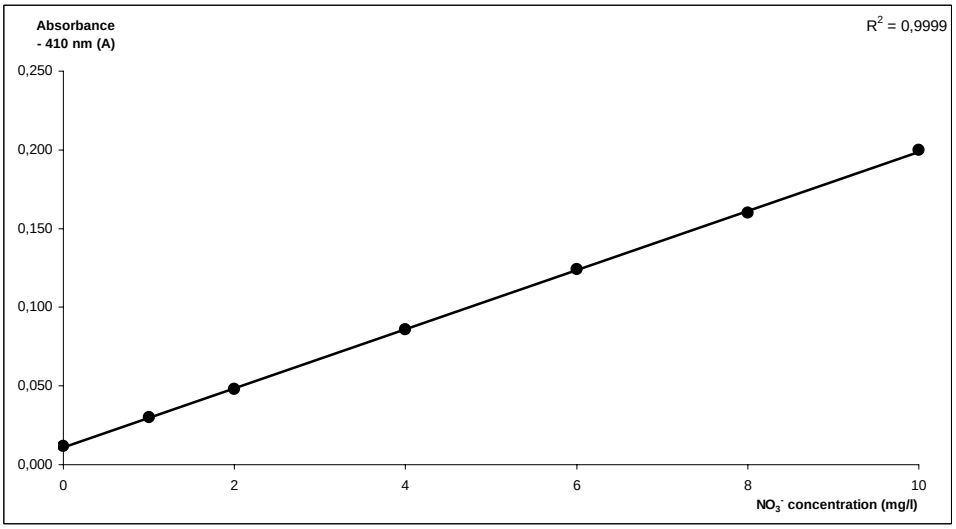



**Figure 3.** Calibration graph of nitrate determinations

## 3. RESULTS

However results varied between comparatively wide limits (6.1-29.5 mg/g), presence of nitrate was general; nitrate was detected in every examined tobacco product. One cigarette's average content was 10 mg nitrate. Concentrations of cigar and pipe tobaccos were similar to the cigarettes' results. The results are summarized in Figure 4.

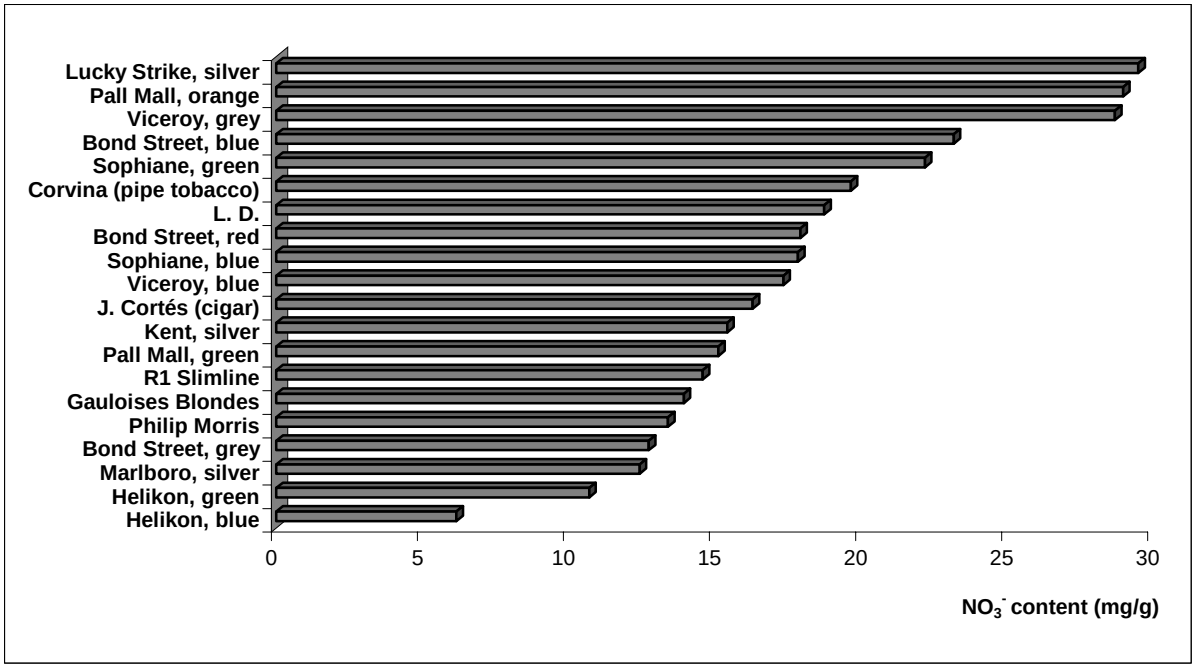



**Figure 4.** Nitrate content of tobacco products

## 4. CONCLUSIONS

Both nitrate accumulation (as a consequence of chemical fertilizing) and burning booster additives (e.g. potassium nitrate) are possible sources of the tobacco products' nitrate content. The second assumption seems to be confirmed by the fact that nitrate concentration of tobacco solution is permanent after 5 minute of soaking; nitrate content of the vegetal cell can not be solved so fast without some kind of cell destructive mechanism. This inference can be justified if we examine the nitrate content of the cigarettes from the same box: the high differences (~30%) can be explained with the unbalanced distribution of the oxidizer nitrate compounds sprayed on tobacco leaves or added to the pickle. Considering the above it is very notable that nitrate compounds are not included in the list of permitted additives of tobacco products [3].

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# ROCK EVAL PYROLYSIS AS A TOOL FOR CHARACTERIZATION OF ORGANIC MATTER IN SOIL SAMPLES

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**Abstract:**
Rock-Eval (RE) pyrolysis was designed for petroleum exploration to determine the type and quality of organic matter in rock samples. The aim of our work was to present new fields of application of the RE pyrolysis for assessing the proportion of the organic components of different thermal stabilities, and also to apply this method for characterization of organic matter dynamics in polluted sediments, soil and paleosoil profiles.

**Keywords:**
Rock-Eval pirolysis, organic matter dynamic, paleosoil

## 1. INTRODUCTION

The geological organic matter is present in the atmosphere, in the water, in the soil, in the recent sediments and in the rocks equally. Organic matter of sediment rocks is studied comprehensively, but we have less knowledge from geochemical of organic matter in soils and recent sediment, although it should be justified because of mass and the important role in the global carbon cycle.

SOM plays a significant role in the $CO_2$ content of atmosphere and in controling of global earth temperature. Wearing-away of rocks and pedogenesis processes are influenced by SOM. Adsorption characteristic of organic matter in soils and recent sediments determine the mobility of organic and inorganic pollution thus effects the quality of water in surface and groundwater.

SOM is not homogenous but is a mixture of many organic matters with different chemical compositions and physical qualities. This chemically and kinetically heterogeneous material comprises a mixture of plant and microbial residues of various compositions and with different decomposition rates, as well as their transformation products, in addition to refractory, long-residence-time macromolecular organic substances (kerogen, black carbon). Humification of biopolymers is determined by those environmental parameters (relief, climatic conditions), which define soil types too.

RE pyrolysis was designed for petroleum exploration to determine the type and quality of organic matter in rock samples. Nevertheless, this technique can be used for bulk characterization of the immature organic matter in soil samples and recent sediments.

Either aim of our work was to examine the soil conditions of an archeological site. This study is restricted to introduction of new investigation methods in paleosoil examination, using the example of the Neolithic archeological site. For determination of the original soil type of the examined area we adopt sedimentological, micromorphological and pedological investigations as a first step. For supplement this we made an attempt to apply a new method for characterization the soil organic matter.

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## 2. MATERILAS AND METHODS

Samples were collected from the A and B horizons of chernozem braun forest soil from West-Hungary and we analyzed buried paleosoil samples from an archeological site from North-Eastern Hungary. The development of the soil horizon was finished in the Neolithic Age, when the soil was covered so the evolution of the soil horizon broke off. After this period the soil transformed a transition form of soil and sediment. Accordingly reconstruction the original type of the soil is possible only by complex analysis.

We described the soil profile, measured the content and distribution of grain size, the content and relative proportion of organic matter and carbonate. For sedimentological analysis the composition and distribution of grain size we applied Micromeritics SediGraph 5000ET X-ray sedimentograph. Applied method for measure content of organic matter and carbonate was Dean-method the "loss on ignition" [1]. The measured parameters were depicted on profile diagrams for evaluation purposes.

The Rock Eval data of the soil samples were determined with Delsi Oil Show Analyzer (Hetényi et al., 2005). The following parameters can be obtained from one single measurement: **S1** amount of thermovaporized free hydrocarbons - present in the rock as free or adsorbed compounds - expressed in mg HC/g of rock. **S2** the current potential of a rock sample, represents the total amount of oil and gas a source rock can still produce during subsequent complete thermal maturation in an open system. (expressed in mg HC/g of rock). $\mathbf{T_{max}}$ the temperature (°C) which is recorded for the maximum of the S2 peak varies as a function of the thermal maturity of the organic matter. **TOC** (total organic carbon) content (expressed in weight %) is defined as the sum of the pyrolysed organic carbon content and organic carbon residue content. **HI** (hydrogen index) is defined as carbon normalized S2 and expressed in mg HC/gTOC. **PI** (production index) S1/S1+S2.

The experimental conditions of Rock-Eval pyrolysis were chosen that all of the hydrocarbonaceous compounds yielded by soil organic matter are recorded as one single peak. Pyrograms of our samples can be described by a combination of four elementary Gaussian components: F1, F2, F3 and F4. These four components are related to major classes of organic constituents differing in origin and their resistance to pyrolysis: labile biological constituents (F1), resistant biological constituents (F2), immature non-biotic constituents (F3) and a mature refractory fraction (F4). F1/F2 ratio illustrate the relative evolution of the two ""bio-macromolecule" classes. The log[(F1+F2)/F3] index quantify the degradation of immature OM [2].

## 3. MATHEMATICAL DECONVOLUTION

In an immature organic matter, like soil, a wide range of components may be present simultaneously and each of them is represented by a Gaussian curve on the pyrogram (S2 peak) with characteristic mean (M) and standard deviation (σ) values. Each pyrogram is a complicated overlap of several normal distributions curves. In order to define discrete components of the multicomponent mixture, the pyrogram has to be decomposed mathematically. The well-known normal distribution curve is symmetric to the mean having one inflexion point on each side. A composite curve, may exhibit complicated shape with several inflexion points along it. It can be assumed, that in case of this special class of composite curves a mean value of at least one component falls within the interval of the two smallest inflexion points. This feature was utilized during the recursive decomposition algorithm applied in the project.

The first step is smoothing the originally rough pyrogram using moving average method. Moving the window and calculating the means over the whole temperature range result in a smooth data distribution of equal density. After several loops a 5°C interval was found large enough to get pyrogram without unrealistic peaks and ditches.

In the second step of the procedure numerical derivation was fulfilled twice to get the inflexion points of the smoothed composite curve. Without using an effective smoothing algorithm, there is no chance to get inflexions of real meaning. Afterwards, the two smallest inflexion points ($T_{i,1}$, $T_{i,2}$) were chosen, which surround the mean ($M_i$) in question. In the next

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step a two-dimensional search of ($M_i$, $\sigma_i$) was carried out using a Monte Carlo type simulation by computing numerous data pairs so that

$$M_i \in (T_{i,1}, T_{i,2}), \text{ and} \quad (1)$$

$$\sigma_i \in (1/(S2T_{i,1}\sqrt{2\Pi}),), (1/(S2T_{i,2}\sqrt{2\Pi}),), \quad (2)$$

where $S2T_{i,j}$ denotes S2 values at $T_{i,j}$ temperatures.

Finally, each ($M_i$, $\sigma_i$) pair was used for calculating model S2 curves, and a least square best-fit algorithm is applied to get the best $M_i$ and $\sigma_i$ among them. Best model curve is determined when ε is minimized so that

$$\varepsilon=\Sigma(S2_{observed} - S2_{calculated})^2, \quad (3)$$

where summation goes from 180°C up to $T_{i,1}$ in each case.

After subtracting the model curve from the original S2 composite curve, the process was repeated recursively to the residuum from the second step (numerical derivation) [3].

## RESULTS AND DISCUSSION

$T_{max}$ values of approximated Gauss curves belong three category: original biopolymers (180-340°C), partially docomposed biopolymers (340-420°C), humic substances (420-600°C). Calculated values are in accord with measured series of stepwise Rock-Eval analyses. Consequently, we can estimating the poportion of original biopolymers well.

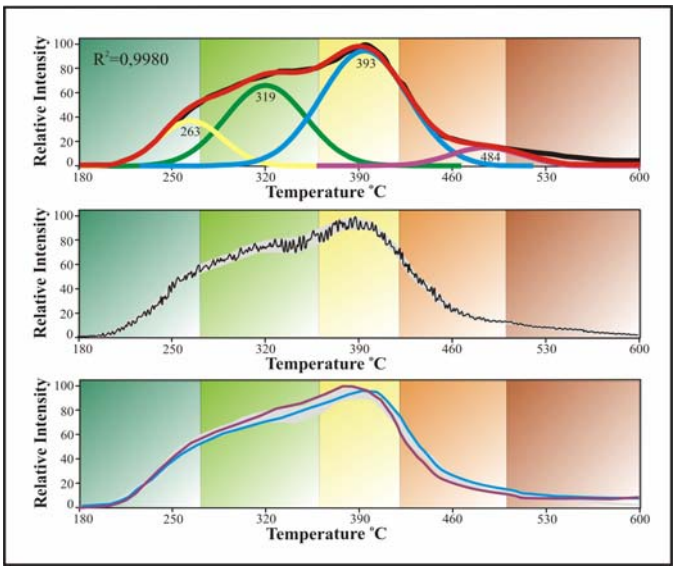



**Figure 1.** Steps of SOM "fingerprint" analysis

We use a modified application of Rock-Eval pyrolysis approach for estimating the proportion of the components with different thermal stability and the measure of humification. On a pyrogram each unique organic matter is represented by a normal distribution curve with characteristic mean and standard deviation. As a consequence, a pyrogram is a sum of numerous single Gauss curves what can be decomposed using a proper algorithm. In order to calculate possible composite curves, first the uncertainty of mean and standard deviation of RE measurement was determined by 20 independent runs. On this basis using a Monte Carlo type simulation 1000 different realizations were calculated. The envelope of all these curves defines the stripe what is the typical "fingerprint" of the SOM in question. We examined four chernozem-brown forest soil samples. We accepted that the unknown sample belongs into the specified soil type if it's pyrogram concide 90% with the soil type's envelope (Fig. 1). This method should be suitable for define soil type of „unknown" samples [4].

On buried soil's study we have to pay attention to the processes which passes off after the coverage of soil. Soil life breaks off; ventilation stops or decreases and the accumulated sediments increase the pressure. These processes are able to change the original properties of the soil therefore only time-independent, steady-state characteristics are adequate for pedological-morphological description. These are texture, type of soil structures, fabric and porosity. We applied Rock-Eval Pyrolysis to get new details of soil organic matter, which can indicate the soil type. Mathematical decomposition of the S2 peaks was used to determine the rate of partially decomposed biopolymers, humic substances. The rate of organic carbon accumulation and decomposition rate of biopolymers were interpreted as function of environmental effects.

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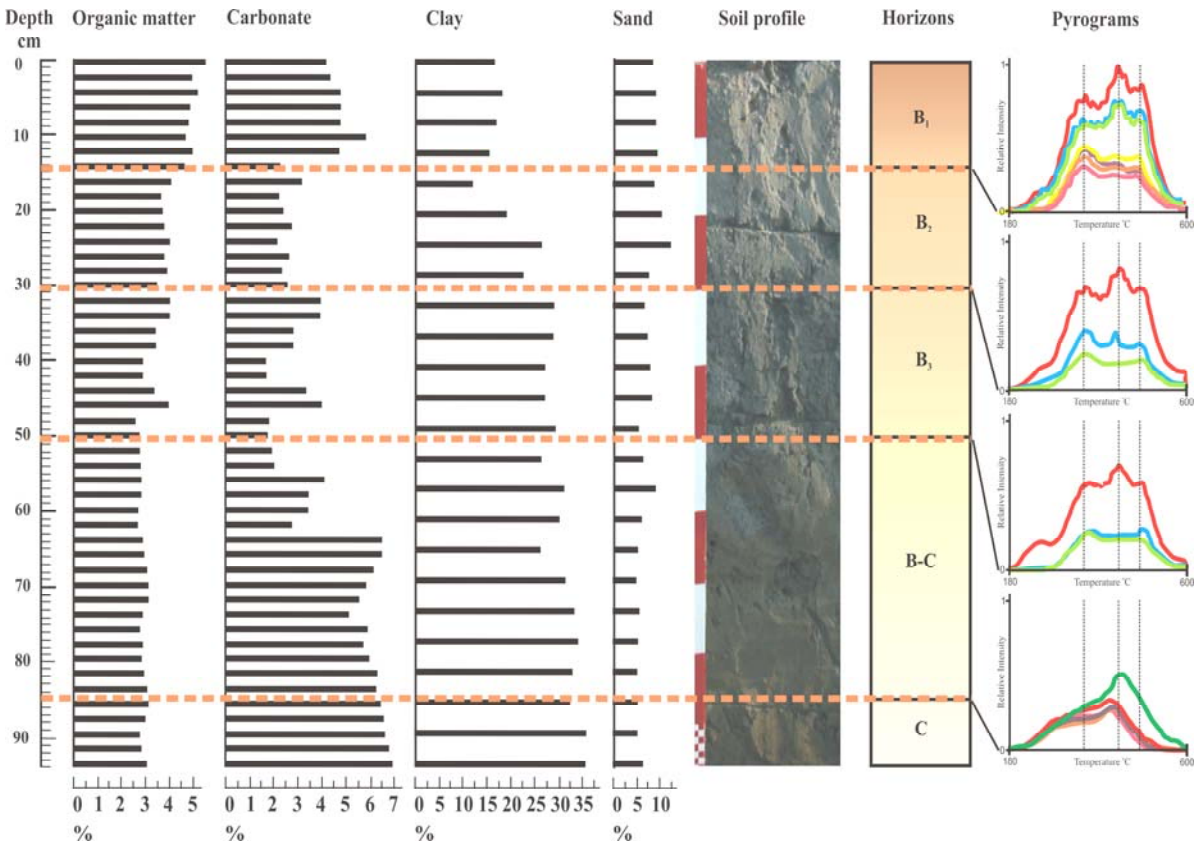



**Figure 2.** Profile of the monolith and the measured parameters

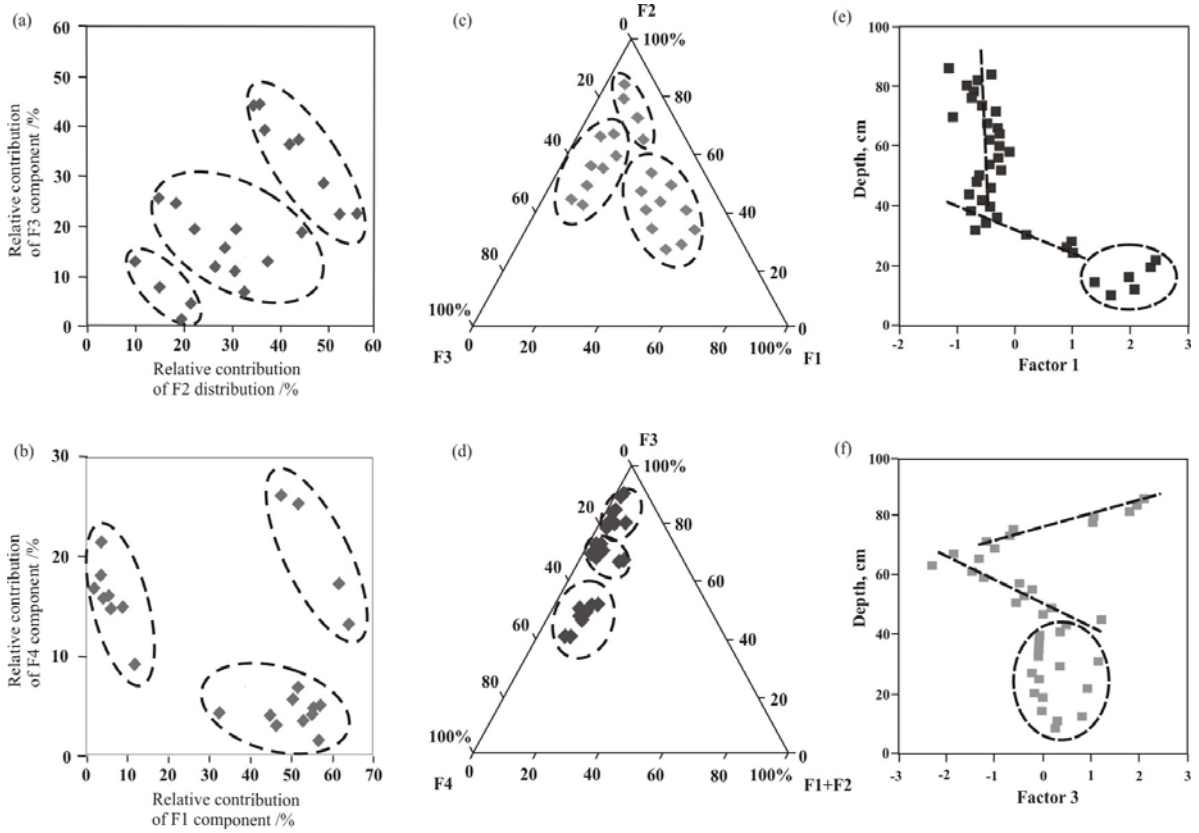



**Figure 3.** Functionalities of the four constituents (a), (b), (c), (d) and diagrams factors versus depth. (Ellipces do not represent confidence intervals, but are for guidance.)

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All measured parameters from RE Pyrolysis and pedological analysis were depicted on profile diagrams for evaluation purposes (Figure 2). The results of the analysis indicate an obvious mobilisation process, which worked downwards the profile, and leads to the formation of a clay accumulation zone within the profile. This shows strong hydromorphic effect in the soil.

According to relationship between (a) stabile bio-macromolecules (F2) and immature geo-macromolecules (F3); (b) labile bio-macromolecules (F1) and refractory geo-macromolecules (F4); (c) relationship between components F1, F2, F3 and (d) F1+F2, F3 and F4 components three zones can be well separeted. Consequently the horizons prognosticated by pedological description are identifiable from RE details as well.

Every measured parameters (all measured and calculated values from Rock Eval pyrolysis and pedology routine) were fed into SPSS 11.0 programme. The Factors were composed of strong correlated parameters. As following step we depicted these ones versus depth (put back in the original soil profile). Factor 1 involves clay, S1, S2, $T_{max}$ and organic matter (measured by Dean method); Factor 3 contains sand and HI values (Figure 3). We can separate three point set in this way, which correlate with the pedological details.

We compared pedological details with the results of Rock-Eval analysis. Consequently we can state, that the soil formed in an environment in which the effect of cyclical fluctuating water could influent the soil development. This phenomenon suggests determination the paleosoil as Fluvisol. We established Rock-Eval pyrolysis is suitable to soil classification. We found, it is able to provide new details to explanation paleosoil horizons.However results varied between comparatively wide limits (6.1-29.5 mg/g), presence of nitrate was general; nitrate was detected in every examined tobacco product. One cigarette's average content was 10 mg nitrate. Concentrations of cigar and pipe tobaccos were similar to the cigarettes' results. The results are summarized in Figure 4.

## CONCLUSIONS

Rock-Eval pirolysis proved to be suitable for efficient examination of soil organic matter and estimation the measurement of humification. Further advantages, slight sample need to measure (0.1 g), doesn't require preparation (if the sample is carbonate-free), fast measure (25 min.), and we can detect six parameters from one single measurement (S1, S2, TPI , TOC, Tmax, HI) which we can use perfectly in evaluations. We can escape the lengthy and many chemicals requiring laboratory separates.

Rock-Eval pyrolysis is useable new method for determination paleosoil type, supplements the routinish classical measurement techniques. The method gives us excess-informations compared to traditional organic matter measure. In the course of known type paleosoil pyrolysis can provide new details according to the former details. Rock-Eval pyrolysis is capable define parameters, which help determination of unknown paleosoil type and allow identify minor occurences within genetical horizons. Statistical evaluation of details assists the complex explanation of the measured values, accordingly determination of paleosoil type.

**Acknowledgements**
This work was supported by the Hungarian Science Research Found (OTKA T-48325). Thanking for the financial support to the National Research and Development Program NKFP – OM 000248/2002: Paleohistory of Hungary during Holocene.

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# SUPPORTING THE REASONABLE AGRICULTURAL PRODUCTION WITH A NEWLY FOUNDED ENVIRONMENTAL LABORATORY IN THE SOUTH EASTERN REGION OF HUNGARY

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**Abstract:**
An agricultural and environmental laboratory was founded within the framework of Baross Gábor Program in the summer of 2008 in Mórahalom, South-East Hungary, South Great Plain region. The primary aim of this initiative is making the countryside's agriculture more effective and environmentally aware, and assisting the dynamic development of the region. The laboratory helps agricultural production – the primary financial source of the region's villages – with analytical measures of soil and water samples, counseling about nutrient dosing, organized presentations, and cooperating with local enterprises and with another laboratory analyzing chemical residues in the produced crops. One significant deficiency was compensated by the establishment of SoilChem Laboratory – meeting the conditions set forth by directives of the European Union –, due to the lack of environmental laboratories in the region.

**Keywords:**
soil and water analyzing laboratory, agriculture, environmentally aware,
food safety and technology network

## 1. INTRODUCTION

With the help of the Baross Gábor Program, conducted by the Homokkert Small-regional Integration Public Company consortium a research and development network and a food safety and food technological subcenter has been set up in the South Great Plain region in Hungary. It is structured around up-to-date technological and metrological solutions and results cooperation of scientific institutions, researcher non-profit organizations and the entrepreneur sector.

The micronetwork and the soil- and water analysis laboratory – coordinated by the Homokkert Public Company – provides agro-innovative services for the cooperatives and partner organizations (DATÉSZ Rt., Mórakert Cooperative). By doing so it improves the local products' competitiveness and the standard of nutrition and quality assurance.

## 2. THE IMPORTANCE OF AGRICULTURE IN THE REGION

45,000 people live in the area of Mórahalom, which is considered the center of the Homokhát Small-region. Most of the people work in agriculture, thus their living is exposed to the competitiveness of the vegetable and fruit grown by them. Agriculture uses 72% of the small-region's land. The rate of forests is high, resulted by the afforestation in the beginning of the last century. The rate of lawns is also high because of the previously existing vast meadows and mowing fields. However vegetable growing is typical in arable farming and in the garden cultivation branches and its economical importance is unquestionable, it occupies relatively small area from the region's land. The volume of land used for pomology and vineyards shows the characteristics of sand farming. Non-cultivated lands and waste lands are the signs of uncertainty of farming and marketing and the disarrays about the ownership of the tenures (Figure 1).

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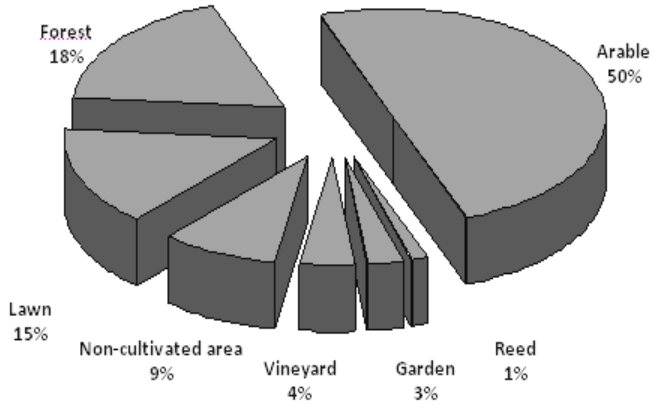



**Figure 1.** Distribution of cultivation branches of the small-region's area

The integrators, the cooperatives and other significant economic operators have to make sure the compliance with the market requirements, which means producing clear, healthy and high quality products. The most significant such integrator is Mórakert Cooperative founded in 1995 and declared as the first fruit and vegetable producer realizer organization by the Ministry of Agriculture and Rural Development in 2002. Its turnover and number of members has increased significantly in the last 10 years (Figure 2).

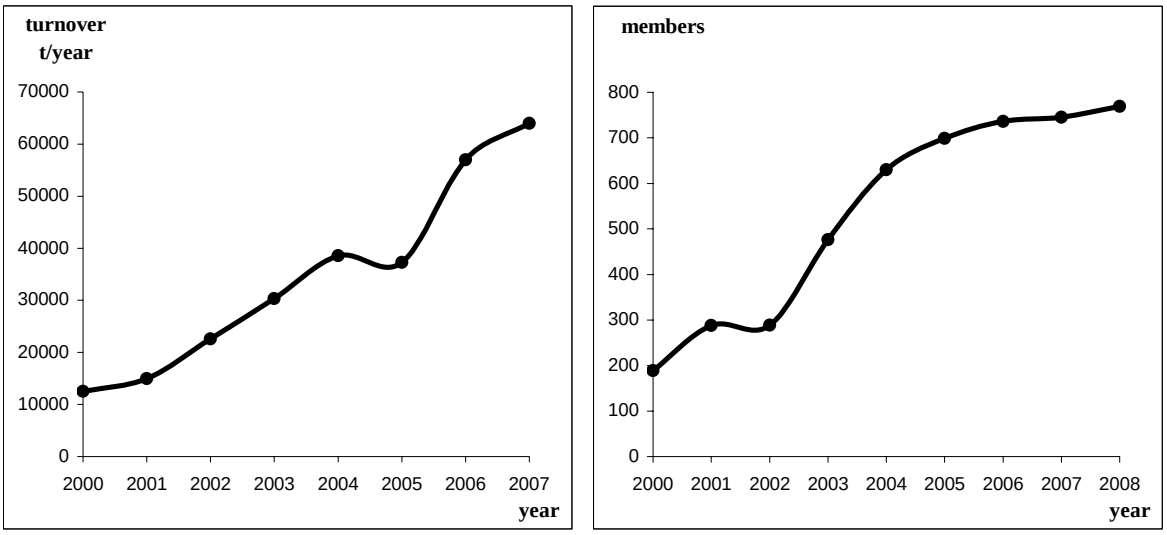



**Figure 2.** Growth of turnover and number of members of Mórakert Cooperative

## 3. HOMOKKERT PUBLIC COMPANY

The Hommokkert Small-regional Integration Public Company was corporated in 2000 by 9 agrarian cooperatives and the local authority of Mórahalom. The company was comprising producer and marketing cooperatives until the conversion in 2004 when the main profile of the company changed and two strategical directions were developed in connection with the agricultural priorities. These focus on the improvement of the living and income conditions of the rural population.

**International connections**

The Homokkert Public Company cultivates good relations with international partners. Seeking the possibility of cooperation with neighboring countries and participating in common projects are important parts of the company's activity. A recent collaboration was the establishment of a Borderland Commercial Center with Topolya and Temerin, two towns in Vojvodina, within the framework of an inter-regional project in 2008. The primary aim of this center is helping the cross-border trade of the agricultural products in the region.

**Profiles of the Homokkert Public Company**

On the one hand the main profile of the Company is encouraging alternative income activities – the so-called Renewable Energy Information Center was built in support of this objective – and on the other hand the research and development, innovation and innovation intermediation services. The Regional Food Safety and Technological Micronetwork needs to be highlighted here, which was set up in the framework of the Baross Program. The Network was evolved by the partnership of the Homokkert Public Company and Mórakert Cooperative

in Mórahalom, the DABIC Public Company in Szentes and the College of Kecskemét (Figure 3). Its goal is to establish an accredited institute complying with the international standards and placed near big producer-realizer cooperatives (e.g. Mórakert Cooperative).




**Figure 3.** Centers of the Regional Food Safety and Technological Micronetwork

**Aims of regional food safety and technological micronetwork**

a) establishing a regional food safety and technological subcenter with the utilization of results and experiences of the regional center and network maintained by DABIC Public Utility Company
b) founding an agrarian research workshop with the collaboration of acknowledged researcher-teachers with scientific degree and local experts, and developing an academic practicing section in connection with garden cultures and the safety of horticultural products
c) establishing an experimental soil and water analyzing laboratory and the publication of results
d) achieving experimental developments in relation with product innovation and changing production structure in vegetable, fruit and ornamental plant growing
e) starting continuous horticultural research and development activity based on regional demands
f) evolving a research and development and innovation micronetwork – with thousands of members - considering the specifics of producer-realizer cooperatives (TÉSZ) and the conditions of local product structure
g) establishing a consultant network and educational activity
h) experimental developing of analytical methods, e.g. for fast determination of chemical residues
i) founding an agrarian research workshop that conduces to the production of high added-value or new products (bioproducts, functional foods) with developing growing methods and technologies

## 4. REASONABILITY OF MICRONETWORK

### Directives of the EU – Food safety

Establishing and maintaining the Regional Food Safety and Technological Micronetwork is reasoned by directives and regulations of the EU. In hygienic overseeing of food producing, the European Union put emphasis on supervision of producing environment instead of the former final product checking in the last years. Therefore application of new analytical methods is required. SoilChem Laboratory – part of Regional Food Safety and Technological Micronetwork – wishes to keep pace with this continuous vocational improvement. Developing analytical procedures to support the development of new technologies – that result healthy and safe food – is one of SoilChem Laborarory's primary goals. Nowadays food safety is number one priority of agrarian economy: organizations in agriculture and food industry must correspond to the higher and higher requirements of food safety and environmental protection, and must meet the consumers' increasing demands.

Considering food safety regulation of the European Union, configuring quality insurance systems and helping producing activity at agrarian small and medium enterprises became indispensably necessary by now. In the interest of competitiveness of these enterprises preventive self-checking food safety systems must function effectively „from field to table", ensuring the transparency of food chain. Successful food politic demands the absolute traceability of crops, food and their components. This enables the enterprises to

withdraw hazardous forage or food from the market in case of consumers' health is endangered. Healthy and safe food can only be ensured by continuous monitoring of critical points of the producing process and by running quality insurance systems. It is reasonable to establish and upkeep accredited food safety and technological centers and subcenters, placed near farmers in the interest of quantitative and qualitative determinations of health-damaging chemical and microbiological compounds.

**Functions of centers:**

Instrumental tests are indispensable to obtain knowledge of environmental factors and their impacts. Thus we can collect data that help us to intervene in the process of cultivation. Precision nutrition replenishment can be attained only in possession of the knowledge on the soil's current nutrition level. Therefore soil analysis is necessary both before and during every single cultivation process. More detailed information is needed of soil and irrigation water in case of horticultural crops (nutrient rate and quantity, harmful elements).

a) monitoring chemical residues (pesticides, pharmaceutics etc.) of crops and food
b) detection of metal pollutants (lead, cadmium, mercury, arsenic, aluminium, copper, zinc, nickel) in food of plant and animal origin
c) determination of nitrate in vegetables susceptible for nitrate accumulation
d) complete analysis of soil and water
e) microbiological monitoring to increase the hygiene of food processing technologies
f) forage-safety monitoring
g) issue accredited certificates

**Economic advantages**

The building up of the Micronetwork is appropriate concerning its economic advantages as well. The current international and domestic consumer habits seem to prefer products with known origin; customers appreciate the value derived from the specific circumstances of the production. Thus the quality advantages in the production lead to market advantages. With the characterization of agricultural and food industrial products grown on excellent soil, using adequate technology and defining the relating quality features and with the conscious perpetuation of these benefits these products can obtain market advantages.

## 5. CONCLUSIONS

The whole sector and region profits from the database of materials endangering food safety, building up and operation of preventive indication systems, meeting the requirements of identification and traceability, and applying new, conventional sampling methods. The Micronetwork's indirect economic effects can be measured in the improvement of competitiveness of the analyzed products, the prevention of the damages caused by loss of consumer trust, and the recognition of the network's trademark.

The operation of SoilChem Laboratory as a service provider, accredited institute makes the non-profit investment self-supporting in the future.

**ACKNOWLEDGEMENTS**

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# ADSORPTION OF ARSENIC COMPONENTS ON LAYERED DOUBLE HYDROXIDES AND MIXED OXIDES FOR WATER PURIFICATION

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**Abstract**

Aim of this research was the removal of toxic and carcinogenic arsenate ($AsO_4^{3-}$) ions from drinking water with different metals (Mg, Mn, Al, Fe) content layered double hydroxides (LDH). The efficiency of the MgAl LDHs in the arsenic removal is increased with increasing nitrate content in LDH. The basal spacing of LDH was decreasing with 0.085 nm after ion-exchange. The calcinated form of each adsorbent resulted less arsenic removal, but less dissolution of metal from the oxide compared to the uncalcinated LDH. Increasing the manganese content in the MnFe LDH resulted in enhanced arsenic removal efficiency.

**Keywords:**

arsenic removal, drinking water, layered double hydroxide, adsorption, calcination

## Introduction

Arsenic is a human genotoxin and chronic exposure is associated with development of cancers, including skin cancer [1]. The inorganic arsenic forms are metabolically inhibitors. Arsenate ($As^{5+}$) displaces the phosphate ion from the energy source ATP molecule, arsenite ($As^{3+}$) bonds with sulfhydril group of the proteins (e.g. glutathione) and it inhibit their function. By United States Environmental Protection Agency (USEPA) 0.3 μg/kg/day sanitary threshold of arsenic was accepted on the basic of statistics data. The Europen and World Health Organization (WHO) limit of arsenic content of drinking warter is 10 μg/L. The arsenic accumulate in some groundwater and mineral by natural process [2, 3, 4, 5]. The arsenic atom displaces silicium, iron and aluminium atoms in the crystal latice and this fact causes the high arsenic content of minerals. In the Pannonian basin the arsenic accumulate in the Pleistocene sediments by the rivers and the subsurface flows [6]. This arsenic content resolving into the groundwater from the 100-300 m deep strata. In our days the arsenic contamination in the groundwater is serious problem all over the world [7, 8]. An estimated 57 million people may be drinking high arsenic content water in Bangladesh and West Bengal, India. The strong antropogenic effect (e.g. mining, agriculture) is increasing the arsenic content of surface water, groundwater and soil [9]. The pH of groundwaters is between 6.5-9.5, the non-dissociated ($H_3AsO_3$) and monovalent anionic ($H_2AsO_3^-$) natural forms of arsenite are and arsenate exits in anionic forms ($H_2AsO_4^{1-}$, $HAsO_4^{2-}$) in this mildly alkaline range [10]. The arsenic forms and the geochemical components of groundwater determinate the applicable water treatment technology. In Hungary the removal of arsenic from drinking water with iron (III)-hydroxide is one of the current methods. The average efficiency is 60-80 % that can increase up to 95 % with optimized parameters. Granulated iron hydroxide (GEH) column is applied in numerous water plants. Goethite (FeOOH) and iron hydroxide are the component of GEH column. Arsenic removal efficiency of natural or synthetic iron oxides and hydroxides are examined in number of publications [11, 12, 13, 14]. T. Tuutijärvi et al. investigated the arsenate adsorption capacity of different size maghemite nanoparticles in a wide pH range [15]. Large advantage of these superparamagnetic is that the nanoparticles can be easily removed with magnetic field from treated water. Zero-valent iron particle removes arsenate and arsenite with high efficiency in natural groundwaters by adsorption, surface precipitation, and co-precipitation with various corrosion products [16, 17, 18]. Membrane processes (nanofiltration) are suited for arsenate release,

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but are not efficient by the arsenite content groundwaters [19, 20]. The arsenic removal is enhanced by the hybrid membrane treatments [21, 22]. The layered double hydroxides (LDH) are one group of layered structured minerals in the nature. The sheets of the layered double hydroxide are formed from divalent metal ions ($M^{2+}$: $Mg^{2+}$, $Ca^{2+}$, $Mn^{2+}$, $Co^{2+}$) and trivalent metals ions ($M^{3+}$: $Al^{3+}$, $Fe^{3+}$) and exchangeable anions ($A^{n-}$: $CO_3^{2-}$, $SO_4^{2-}$, $NO_3^-$, $Cl^-$) compensate the positive surface charge between the layers ($[M_{1-x}^{2+}M_x^{3+}(OH)_2]A^{n-})_{x/n} \cdot yH_2O$). LDHs are applied as adsorber [23], catalyst [24], support in medicine [25], thin film component [26]. The positively surface charged LDH is suited for adsorb the negatively charged arsenic ion forms [27, 28, 29].

## Materials

Magnesium nitrate hexahydrate ($Mg(NO_3)_2$ $6H_2O$, puriss., Fluka), aluminium nitrate nonahydrate ($Al(NO_3)_3$ $9H_2O$, puriss.), iron (III) chloride hexahidrate ($FeCl_3$ $6H_2O$, analytical grade, Reanal Hungary), manganese sulphate hydrate ($Mn(SO_4)$ $H_2O$, analytical grade), sodium hydroxide (NaOH, analytical grade), and sodium nitrate ($NaNO_3$, puriss.) were used to prepare layered double hydroxide. Potassium iodide (KI, puriss.), ascorbic acid ($C_6H_8O_6$ analytical grade), pyridine ($C_5H_5N$, analytical grade), potassium carbonate ($K_2CO_3$, puriss., MOLAR Hungary), and sodium borohydride ($NaBH_4$, purum), silver diethyldithiocarbamate, Ag-DDTC ($C_5H_{10}AgNS_2$, puriss., Fluka) were used for arsenic(V) determination. Arsenic removal measurements employed the natur arsenic content groundwater and aqueous solution of disodium hydrogenarsenate heptahydrate ($AsHNa_2O_4$ $7H_2O$, puriss., Fluka). The model groundwater originates from Gyula, town of Békés Country, in Hungary (**Table 1**).

Table 1 The chemical analysis of groundwater from Gyula

| | Groundwater analysis | |
|---|---|---|
| | 07. 2005. | 05. 2006. |
| pH | 8.33 | 8.69 |
| General hardness,°dH | 2.0 | - |
| General hardness[a] | - | 17.0 CaO |
| Conductivity, µS | 681 | 528 |
| Sodium[a] | 100 | - |
| Potassium[a] | 1.0 | - |
| Calcium[a] | 10.0 | 9.2 |
| Magnesium[a] | 2.0 | 1.6 |
| Chloride[a] | 27.7 | - |
| Hydrocarbonate[a] | 360 | - |
| Sulfate[a] | 7.7 | - |
| **Arsenic[a]** | **0.105** | **0.100** |
| Ammonium[a] | - | 0.60 |
| Nitrite[a] | - | <0.01 |
| Nitrate[a] | - | <0.07 |
| Iron (II)[a] | - | 0.043 |
| Manganese (II)[a] | - | 0.010 |
| Boron[a] | - | 0.38 |
| Total Phosphor[a] | - | 0.56 |
| Alkalinity[a] | - | 6.4 |
| Dry matter[a] | 396.6 | - |
| COI | 5.6 | 3.6 |

[a] concentration in mg/L

## Methods

Arsenic content was determined by silver diethyldithiocarbamate (Ag-DDTC) spectrophotometric methods. Reduction of As(V) by potassium iodide produced arsenic hydride ($AsH_3$), which was transferred to the pyridine solution of Ag-DDTC by the generated carbon dioxide. The reaction of $AsH_3$ and Ag-DDTC led to the formation of a colourful compound, whose absorbance was determined in an UVICON UV-VIS spectrophotometer ($\lambda_{max}$=540 nm). XRD experiments were carried out in a Philips X-ray diffractometer (PW 1930 generator, PW 1820 goniometer) with CuK-α radiation (λ = 0.15418 nm), 40 kV, 35 mA. Basal spacing was calculated from the reflection angle using the Bragg equation. The amounts of $Mg^{2+}$ and $Al^{3+}$ ions constituting the octahedral layers of double hydroxides were determined in a Jobin Yvon 24 sequential Inductively Coupled Plasma-Atomic Emission spectrometer. For nitrate anion determination, nitrate ($NO_3^-$) ions were converted to yellow nitrobenzene to be determined by photometry [30]. Carbonate ($CO_3^{2-}$) anions were determined by volumetric in the form of carbon dioxide. The amount of carbon dioxide was calculated by the gas law from the volume of the gas generated within the closed system [31].

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**Synthesis of layered double hydroxides and oxides**

The salt of divalent ion ($Mg^{2+}$ or $Mn^{2+}$) and trivalent ion ($Al^{3+}$ or $Fe^{3+}$) were dissolved in 30 mL water at a $M^{2+}$:$M^{3+}$ molar ratio of 2:1. The MnFe LDH was synthesized at 1:1 and 0.5:1 molar ratios. 25 g of sodium hydroxide and 20 g of sodium nitrate were also dissolved in 170 mL water. Under vigorous stirring, alkaline solution was added dropwise to divalent and trivalent ion content solution in 3 min. The slurry was stirred at 25 ºC for 20 minutes. The sediment was centrifuged, washed once with distilled water and centrifuged again; the product was then dried at 65 ºC. The pH of the MgAl-LDH dispersion was adjusted to 9.1, 9.6 and 13.1 using 0.1 M NaOH and 0.1 M $HNO_3$. One portion of LDHs was calcinated in air atmosphere at 500 ºC during 10 hours.

**Arsenic removal experiments in column**

We used both open ended glass tube (250 mm long and 22 mm diameter). The similar amount of adsorbent was top of the filter bad (fibreglass, 5.0 g ion-free sand, 5.0 g quartz with 270 mm diameter). The treated groundwater circulated with 33-42 mL /min flow speed by peristaltic pump. 4.0 litre of groundwater was in the closed system and the residual arsenic concentration was determined every third hours. The treated groundwater was exchanged to fresh water then the arsenic concentration achieved the limit. The measured arsenic concentration stop indicated that the arsenic removal column saturated.

## Results and discussion

In many places from Hungary arsenic content exceeds the health limit in drinking water. The arsenic content of water produced in commercially available sodas is illustrated in **Fig. 1**. In more than half of sodas from the Dél-Alföld arsenic content are above 10 μg/L, and in one of the samples is 10 times of the limit. In Hungary all settlements should be 10 μg/L of the arsenic content in drinking water till 2009.

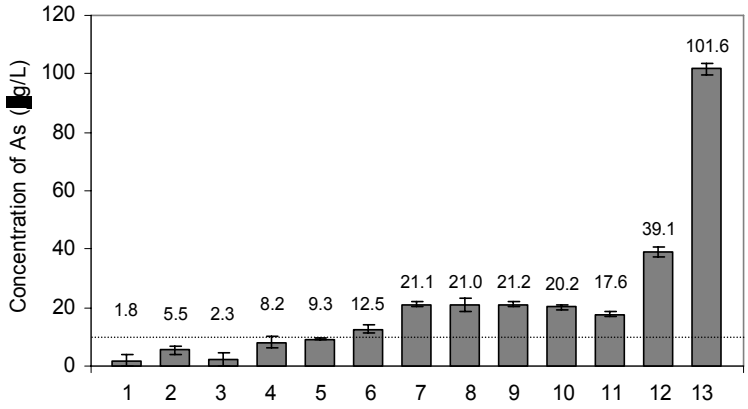



Figure 1. Arsenic content of different commercial sodas from Hungary

In each of a series of 100 ml aliquots of arsenic content solution and 0.01-0.1 g of the adsorbent was suspended; after 5 min of intensive stirring, the adsorbent was removed by filtration. The equilibrium concentration of arsenic in the filtrate was determined. The specific excess adsorption of arsenic ($n^{\sigma(v)}$) was calculated by the (1) equation where V is the total amount of water, $c_o$ and $c_e$ are the initial and equilibrium concentrations, of arsenic respectively, and m is the mass of the adsorbent.

$$n^{\sigma(v)} = V\,(c_0-c_e)/m \qquad (1)$$

The 2:1 MgAl-LDH was investigated at 0.1 and 150 mg/ L arsenic initial concentration in distilled water. The As(V)-containing dispersed LDH particles were dried at room temperature after adsorption and studied by X-ray diffraction in an air-dry state (**Fig. 2**). When the amount of adsorbed As(V) increased, the basal spacing gradually decreases with 0.085 nm and this clearly indicates the ion exchange taking place between the LDH layers. The reason for the decrease in basal spacing with increasing arsenate content is that an increasing number of nitrate anions are exchanged in the interlamellar space and the incorporating As(V) species also displace water molecules.

Different amount of 60 °C dried MgAl-, MnAl-, and MnFe-LDHs and the calcined adsorbents were added to the groundwater from Gyula. The groundwater was left in air atmosphere five days before the arsenic removal experiments in order to oxidise the total arsenite content to arsenate form. In case of the 2:1 MgAl-LDH at pH 13.1 the sample obtained nitrate/ carbonate ratio of 0.1, while the pH was 9.6 or 9.1, these values show 0.8 or 1.8. The molar ratio of Mg and Al ions constituting the octahedral layers was nearly 2:1 in the samples and could not influence the ion exchange of arsenate. The MgAl molar ratios are 1.91, 2.06 and 2.13 with increasing nitrate/carbonate molar ratio. Effect of nitrate/carbonate molar ratio between the layers was investigated by the 2:1 MgAl-LDH. The arsenic removal efficiency in percentage calculated by the (2) equation where $c_o$ and $c_e$ are the initial and equilibrium arsenic concentrations.

$$As\ removal\ (\%) = [(c_0-c_e)/c_0]\,100 \qquad (2)$$

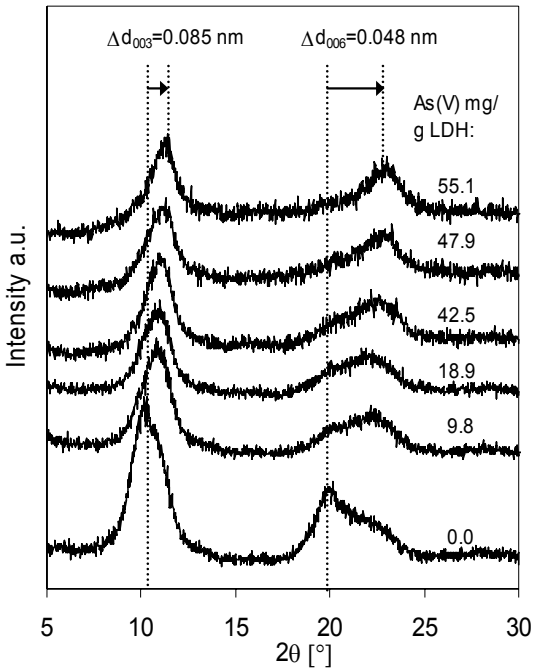



Figure 2. XRD pattern of adsorbed arsenic containing 2:1 MgAl-LDH

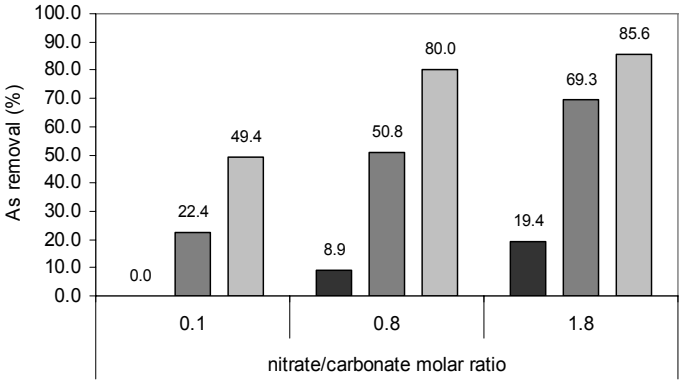



Figure 3. Arsenic removal efficiency of 2:1 MgAl-LDHs at different nitrate/carbonate molar ratio in the groundwater (0.1 ■, 0.5 ■, 1.0 ■, g LDH /L)

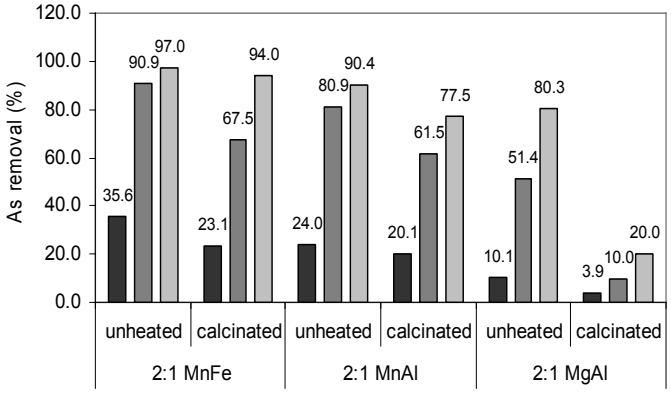



Figure 4. Arsenic removal efficiency of several type of 2:1 LDHs and oxides in the groundwater (0.1 ■, 0.5 ■, 1.0 ■, g LDH /L)

The arsenic adsorption capacity is increasing with increasing nitrate content of LDH (**Fig. 3**). At the lowest 0.1 $NO_3^-/CO_3^{2-}$ ratio the adsorption capacity is less than 1.8 ionic ratio, because carbonate may be irreversibly bound. The explanation is that greater atmospheric carbon dioxide is dissolved during the synthesis of LDH at higher pH. When the type of metal ions at 2:1 molar ratio LDH sheets were changed than different specific arsenic removal efficiencies were obtained in the treated water (**Fig. 4**). The results show that the 2:1 composition MnAl-LDH is adsorbed 1.5 times more arsenic amount, than the MgAl-LDH at 0.5 g/L adsorbent concentration. The manganese content LDH was bound twice as much arsenate than the magnesium content LDH at larger amount of adsorbent (0.5 and 1.0 g/L). The most successful MnFe-LDH reduced the arsenic content below the limit value in the treated water with 0.5 g/L amount of adsorbent. Calcinations of the various metal ion containing LDHs decreased the efficiency of arsenic removal with less degree than the unheated adsorbent, on contrary to the literature [32, 33]. The adsorbed arsenic content decreases to one fourth through calcination at 1.0 g/L MgAl content adsorbent. This difference decreases between the unheated and calcinated forms of MnAl and MnFe adsorbents. In case of 1.0 g/L of MnFe oxide 13 times more arsenic amount was removed from groundwater compared to that of MgAl oxide. One of the aims was the lower industrial cost; therefore LDHs were synthesized not only in distilled water, but in drinking water. The 2:1 MnAl-LDH adsorbent produced in drinking water removed the less on average 25% of arsenic from the treated water than in distilled water produced form (**Fig. 5**). In the drinking water synthesized sample can contain other components (e.g. calcium, magnesium) from the drinking water so has less efficiency than the distilled water prepared LDHs. The most arsenate adsorbing MnFe-LDH was investigated in the groundwater, henceforward. The molar ratios of manganese and iron ions were 0.5 and 1.0 during the preparations of LDHs. The different manganese containing dried powder sample was dosed to the fresh groundwater (> 1 day) and the 5 days old groundwater.

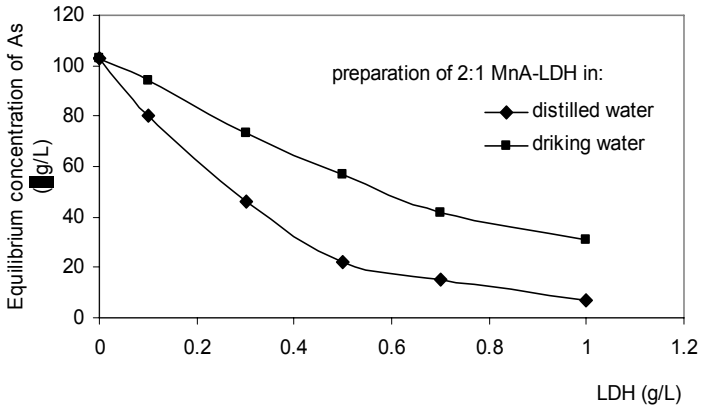



Figure 5. Arsenic conc. in the groundwater after arsenic removal of 2:1 MnAl-LDHs

The **Fig. 6** and **7** show that the arsenic content was reduced in the treated water by increasing the manganese content in the calcinated adsorbent. The MnFe-LDHs adsorbed less arsenic species in the fresh groundwater through both the arsenite ($As^{3+}$) arsenate ($As^{5+}$) content. The arsenite can be removed more efficiently with MnFe oxides than the arsenate. It is noted that the calcinated samples remove less arsenate than the LDHs. There is not such a clear relationship between manganese content of adsorbent and arsenic removal efficiency of the unheated samples. Redissolution of manganese was calculated by the (3) equation where c is the manganese concentrations in the groundwater after the treatment and $c_{max}$ is the maximum manganese concentration of samples.

$$Mn\ redissolution\ (\%) = (c / c_{max})\ 100 \qquad (3)$$

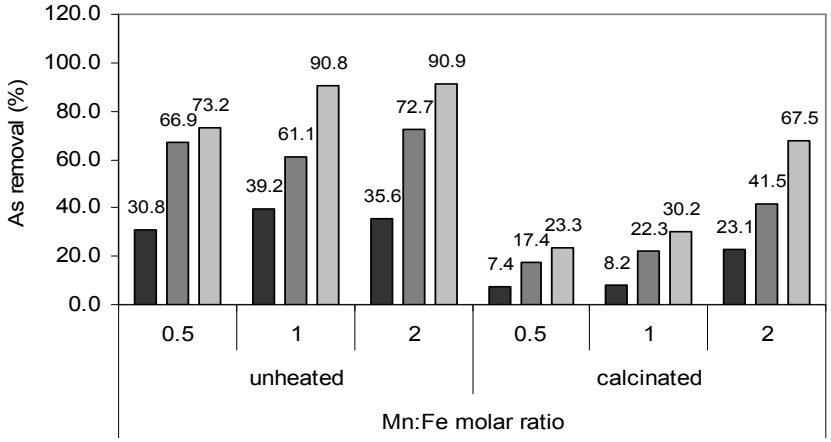



Figure 6. Arsenic removal efficiency of several molar ratio of MnFe LDHs and oxides in the groundwater (0.10 ■, 0.25 ■, 0.50 ■, g LDH /L)

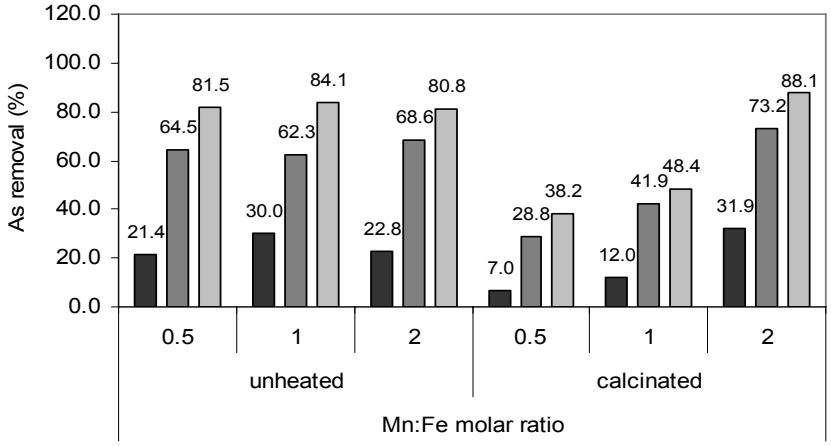



Figure 7. Arsenic removal efficiency of several molar ratio of MnFe LDHs and oxides in the fresh groundwater (0.10 ■, 0.25 ■, 0.50 ■, g LDH /L)

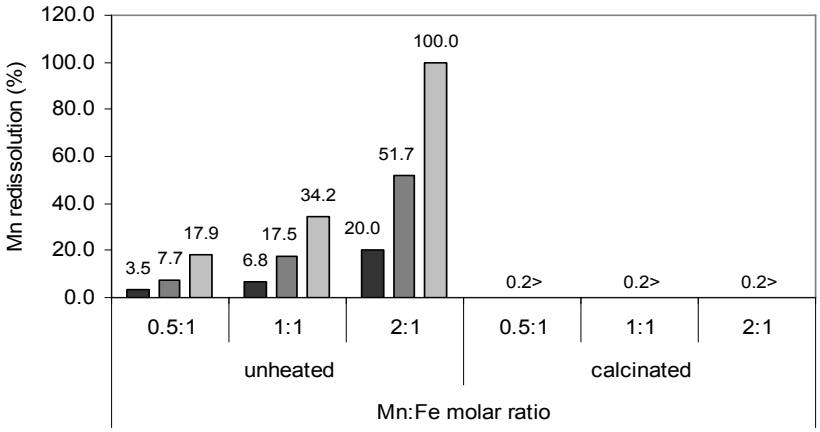



Figure 8. Redissolution of manganese from several molar ratio of MnFe LDHs and oxides after arsenic removal (0.10 ■, 0.25 ■, 0.50 ■, g LDH /L)

Redissolution of manganese from the unheated LDHs was increased in proportion to the increase of the solid at the same manganese-iron ratio (**Fig. 8**). The molar ratio of the manganese-iron was resulted in a greater degree of redissolution of manganese in the treated water at a given amount of investigated adsorbent. Manganese migration is negligible in the arsenic content calcined samples. Therefore, the health-damage of manganese migration could be abolished by the calcination.

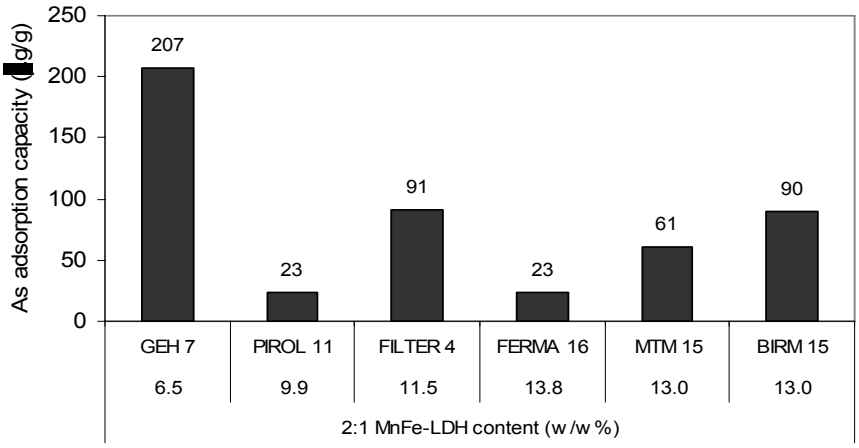



Figure 9. Arsenic adsorption capacity of several bearers at similar 2:1 MnFe-LDH content

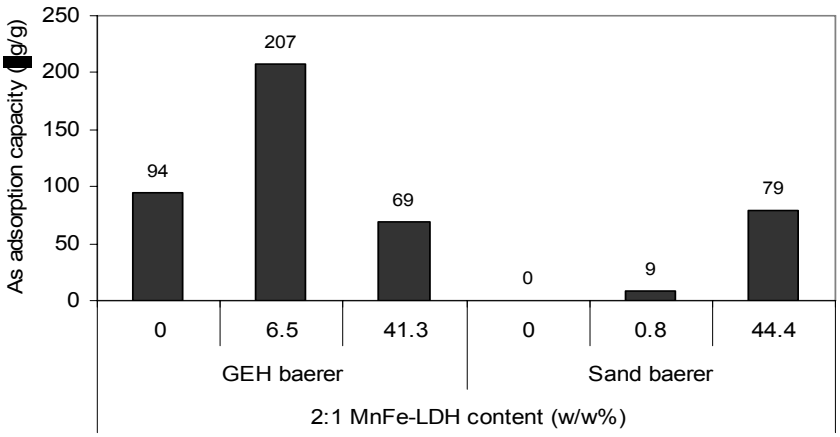



Figure 10. Arsenic adsorption capacity of GEH and sand bearers at different 2:1 MnFe-LDH content

The 2:1 MnFe-LDH precipitated onto the surface of different solid bearer. We investigated the effect of seven different bearers on the arsenic removal of LDH. The MnFe-LDH content bearers were loaded in the glass column. The groundwater was circulated, thus the measured arsenic concentration of the treated water increased below the health limit. In the similar LDH content bearer the GEH

adsorbed the most amount arsenate (207 mg/g) and half of this amount was adsorbed by FILTER 4 and BIRM 15 bearer (**Fig. 9**). The MTM 15 bearer adsorbed 61 mg arsenic/g from the groundwater. The PIROL 11 and FERMA 16 are the least arsenic removal columns. The GEH without LDH adsorbed 94 mg/g and 41.3 w/w% LDH 69 mg arsenic/g, respectively (**Fig. 10**). Larger amount of surface LDH inhibited the efficiency, because the LDH particles entirely cover the surface of larger size GEH particles and fill the pores of the bearer. The arsenic removal of indifferent sand bearer was also investigated. The adsorption of arsenate enhanced with increasing MnFe-LDH on the indifferent sand bearer. The 0.8 w/w% LDH content sand bearer column was regenerated with 100 mL of 5 mol/L concentration calcium chloride solution. The 0.2 w/w% of adsorbed arsenic content left for the column after six hours circulation. The arsenic saturated FERMA bearer was tried to regenerate with 1 mol/L concentration sodium chloride solution. The removal of arsenic from the column didn't exceed the 1.0 w/w% in this case. The 6.5 w/w% LDH content GEH was regenerated by 1.0 L of 1.0 mol/L sodium hydroxide. Half of arsenic content of column can be removed after one hour of treatment and further 5-10 % in the next hour.

## Conclusion

Our aims were efficient arsenate removal and production of a cheap adsorbent for industrial application as the syntheses of LDHs were carried out in air atmosphere. When the LDH is synthesized at low pH (pH ~9) value in air atmosphere that little carbonate content and better arsenic adsorber the product will be. The MnFe-LDH at different metal content LDHs adsorbs the most arsenate from the groundwater at same metal molar ratio in the layers. The calcination of MnFe-LDHs decreases the arsenate removal but the binding of arsenite enhance and it dissolves the resolution of manganese from the solid phase. The type of bearer influences the arsenic removal at the column experiments. The best arsenate adsorbent GEH has optimal LDH content by the arsenic release. Sodium hydroxide can be used to regenerate of the LDH content columns.

**Acknowledgment**
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# OXIDATIVE TREATMENT OF PHENOLIC WASTEWATERS: DETEMINATION OF THE EFFICIENCY OF FE-CONTAINING CATALYST

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**ABSTRACT**

Phenol and substituted phenols are toxic organic pollutants commonly present in industrial water streams, especially in wastewater of chemical and pharmaceutical industries. However, the phenolic compounds in water can be natural origin, especially some Hungarian thermal water contains these materials. The effective removal of these toxic pollutants from wastewater is an important task of the environmental technology.

The treatment of phenol in aqueous solutions has been generally carried out by oxidation of molecular oxygen from the air, at elevated pressure in the presence of catalysts (CWAO: catalytic wet air oxidation). However, the development of CWAO technique is a continuous work to find the proper reaction conditions (oxidant, catalyst, etc.). Our task has been to study the applicability of iron containing materials with different structure in the oxidative treatment of phenolic wastewaters.

The catalyst samples (Fe-ZSM5 zeolite, Fe-MCM41 mesoporous silicate, Fe,Mg,Al-mixed oxide and supported $Fe_2O_3$) either were synthesized in our laboratory, or natural materials were used after thermal pretreatment (bauxite ore and red mud). XRD and BET adsorption methods were used for characterization of the catalysts. A recirculating bubble reactor was utilized to perform the oxidation of phenol in different origin waters. The reaction was followed by the determination of chemical oxygen demand (COD).

All the catalyst samples tested have reasonable activity in the air oxidation at ambient temperature, however, the efficiency can be improved by using of ozone. The obtained results proved the enforceability of the cheap mineral catalysts besides the expensive synthetic ones.

**Keywords:**

phenol, catalytic wet air oxidation, Fe-MCM-41, Fe-hydrotalcite, red mud

## 1. INTRODUCTION

Increasing interest for the environment is making it necessary to develop effective techniques to treat industrial waste waters containing compounds that are toxic to aquatic life. Phenol and substituted phenols are of particular interest because these toxic organic pollutants commonly present in industrial water streams, especially in wastewater of chemical and pharmaceutical industries. Moreover, phenol and its derivatives are powerful bactericide which prevents them from being treated in classical sewage processing plants even at concentrations as low as 50 mg/l [1]. Thus, phenolic aqueous effluents must be specially decontaminated before being biologically treatment. The effective removal of these pollutants from wastewater is a problem with great practical importance and interest.

In the present years, the treatment of phenol in aqueous solutions has been generally carried out by oxidation of molecular oxygen from the air at elevated pressure [2]. These are the so called “wet air oxidation: WAO" processes. The rate and efficiency of oxidation can be enhanced by the increasing of temperature and by the optimization of pH, however, the solubility of oxygen decreases at higher temperatures. The prosperous solution is decreasing of temperature, however, it could be achieved by application of catalyst. Nowadays, the investigation and development of catalysts, which would have high activity for oxidation of phenols and related compounds in aqueous solutions under mild conditions, are the objective of many studies in the wastewater treatment [3,4].

One of the most promising catalyst family for phenol oxidation is the transition metal containing micro and mesoporous materials [5-7].

The hydrotalcite type materials are layered double hydroxides (LDH) and their structures is very similar to that of the brucite [$Mg(OH)_2$]. For LDH-s an isomorphous substitution of $Mg^{2+}$ by a trivalent element (generally aluminum) occurs in the brucite-like network and this replacing generates a positive charge in the brucite layer. The positively charged Mg-Al double hydroxide sheets are charge balanced by anions residing in the interlayer sections. During the synthesis of LDH both of magnesium and aluminum can be changed many bivalent or trivalent cations respectively resulted in materials with different character. LDH and LDH originated materials have many practical applications such as catalysts, adsorbents, anion-exchangers, stabilizers, etc. because of their relatively high surface area, basic properties, high metal dispersion and stability [8].

The MCM-41 material is a well-known member of the recently discovered mesoporous molecular sieves M41S family which possesses a regular hexagonal array of uniform pore openings with a broad spectrum of pore diameters between 1.5 and 10 nm [9].

As oxidation catalyst the $Fe^{2+} \leftrightarrow Fe^{3+}$ system is well-known in the Fenton type reactions in which $H_2O_2$ is the oxidation agent [10].

Recently, development of catalysts based on waste materials is an issue of great interest, because of two environmental objectives could be achieved simultaneously: (i) reuse the waste materials and (ii) the saving of raw materials, such as catalyst precursors [11]. After a proper pretreatment as possible waste material the „*red mud*" can be considered as hydrodechlorination catalyst. The red mud is a by-product in the manufacture of alumina using Bayer-process that contains mainly oxides of iron, aluminum, titanium, silicon, calcium and sodium. In Hungary the annual red mud production is over one million tons in the last decades. The environmental danger of red mud originates from the high alkalinity, and from the very fine-graining. The mixed oxide from red mud could be possible alternative of commercial scale catalysts implied for hydrodechlorination reactions [12].

In this paper we present the study on the preparation and application in air and ozone oxidation of phenol over Fe-containing synthesized (hydrotalcite, MCM-41) or natural origin catalysts (red mud and bauxite after heat treatment) at ambient temperature working on atmospheric pressure.

## 2. EXPERIMENTAL SECTION

### Catalysts

The Al/Fe-mixed oxide was synthesized by coprecipitation from aluminum nitrate and iron nitrate solutions followed by calcination at 500 °C for four hours, and the alumina supported iron oxide was prepared by impregnating γ-$Al_2O_3$ with iron nitrate solution followed by heat treatment at 500 °C.

The Fe/Al/Mg-hydrotalcite ($M^{II}/M^{III}$ = 2, and $M^{III}$: 0.9 Al and 0.1 Fe) was prepared by coprecipitation at constant pH = 10 ± 0.2 of an aqueous solution of $Mg(NO_3)_2$, $Al(NO_3)_3$ and $Fe(NO_3)_3$ with a solution of NaOH and $Na_2CO_3$.

The Fe-ZSM-5 zeolite catalyst was prepared by solid state ion-exchange starting from the synthesized H-ZSM-5 and $FeCl_3 \cdot 5\ H_2O$.

The Fe-MCM-41 specimen was prepared from sodium silicate, CTMA-Br and $Fe(NO_3)$ solution at pH 12. The crystallization was carried out at 373 K for 2 days followed by calcination at 823 K for six hours.

The *red mud* utilized for catalyst preparation was the original waste from the Ajka Aluminum Industry of Hungary. The wet *red mud* was filtered, dried at 100 °C followed by calcination at 500 °C for four hours. The average composition of the Hungarian *red mud* is displayed in Table 1.

Table 1: The average composition of Hungarian *red mud*

| | | | |
|---|---|---|---|
| $Al_2O_3$ | 16-18 wt% | CaO | 0,5-3,5 wt% |
| $Fe_2O_3$ | 33-48 wt% | $V_2O_5$ | 0,2-0,3 wt% |
| $SiO_2$ | 9-15 wt% | $P_2O_5$ | 0,5-1 wt% |
| $TiO_2$ | 4-6 wt% | $CO_2$ | 2-3 wt% |
| $Na_2O$ | 8-12 wt% | S | 0.15-0.30 wt% |
| MgO | 0.3-1 wt% | F | 0.10-0.15 wt% |

All the catalyst samples were heat treated at 400 °C for two hours before the use in the oxidation reaction. The catalyst samples were characterized by XRD, $N_2$ adsorption IR-spectroscopy and TEM.

### Methods

The oxidation of phenol was carried out in a recirculating laboratory bubble column reactor (Fig. 1).

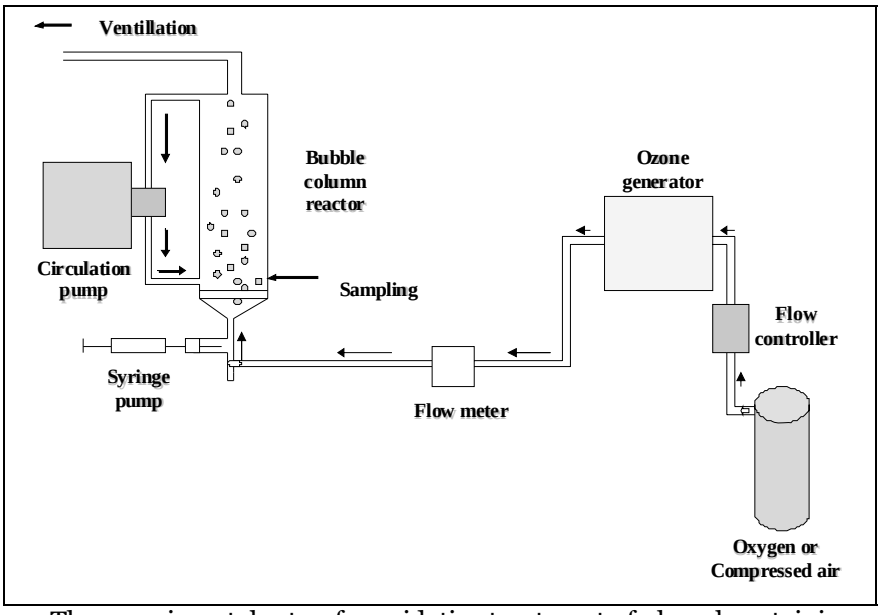



Figure 1: The experimental setup for oxidative treatment of phenol containing waters

In the bubble column reactor air at atmospheric pressure or ozone containing air (also at the same pressure) was used as flowing gas phase. The rate of the gas flow was constant: 50 $dm^3/h$, and the reaction was carried out at ambient temperature.

The reaction was followed by the determination of Chemical Oxygen Demand (COD) using the operative Hungarian Standard, No: MSZ 448-20.

## 3. RESULTS AND DISCUSSIONS

### Characterization of the catalysts

The X-ray diffractograms of the hydrotalcite and the hydrotalcite origin Fe-Mg-Al mixed oxide, Fe-ZSM-5 and Fe-MCM-41 samples prove the expected crystallinity, while the XRD data of bauxite and red mud are very complicated correspond to the complex structure of these materials.

The BET surface areas and pore diameters could be calculated by the evaluation of $N_2$ adsorption isotherms, the date are presented in Table 2. The Fe content of the catalysts were determined by X-ray fluorescence method.

Table 2: **:** Characteristics of the catalysts

| Catalyst sample | Average pore diameter (Å) | Character of the pore | BET surface area ($m^2/g$) | Fe content (w/w%) |
|---|---|---|---|---|
| Fe/Al/Mg-mixed oxide | 180 | wide | 135 | 1.0 |
| FeZSM-5 | 5.5 | narrow | 335 | 4.13 |
| Fe-MCM-41 | 36 | wide | 964 | 1.5 |
| $Fe_2O_3/Al_2O_3$ | - | wide | 103 | 2.5 |
| Bauxite, calcined | - | none | 2.5 | 14.0 |
| red mud, calcined | - | none | 37 | 35.0 |

### Oxidation measurements

In the first stage the catalysts were tested in a well determined reaction, namely in the oxidation of phenol solution in distilled water (concentration: 2000 mg/L), at ambient temperature, where the pH of the solution was 4.6. The reactions were run for four hours, with sampling and COD determination hourly. As oxidant air or ozone was applied, the latter was produced using an *OZOMATIC Modular* type ozone equipment. The data can be seen on Figure 1, lines A and B.

Considering the data it could be established, that using air the oxidation efficieny is low (under 5 %), and by charge of ozone the activity could be increased significantly, but the extent is also low.

To regard the catalyst it could be appointed that the efficiency of the cheap, iron oxide base materials near to activity of the synthetic samples, nevertheless their surface area is significantly less.

In the next measurements the solutions were stabilized using a phosphate-borax buffer solution of pH 6.8, and the reactions were run similarly as earlier. The results obtained can be seen in Figure 1, lines C and D.

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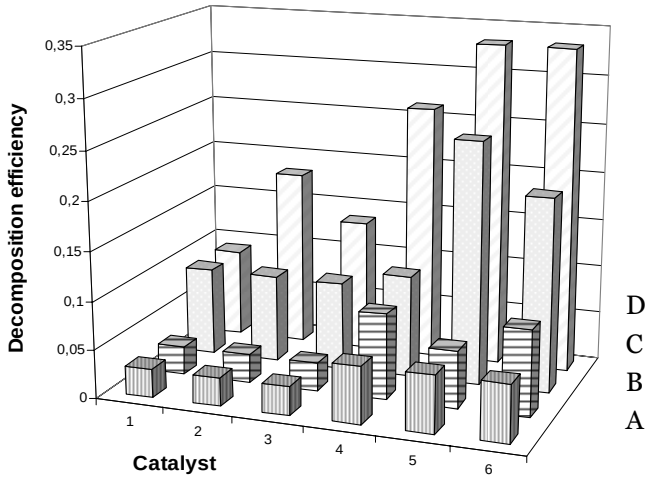



Figure 2: Catalytic oxidation of phenol in water with: a) air, B) ozone, C) air by buffering, d) ozone by buffering; Catalysts: 1.red mud, 2. $Fe_2O_3/Al_2O_3$, 3. bauxite, 4. Fe-ZSM-5, 5. Fe-hydrotalcite, 6. Fe-MCM-41

To summarize the results obtained for synthetic waste water: the demolition of phenol could be achieved with relatively high efficiency. Choosing the optimal pH, the oxidation by ozone is proper, first of all in the presence of the synthetic, porous catalysts. Nevertheless, the activity of the natural origin catalysts with iron oxide content are less, these achievements are enough high to the demolition of the organic pollutants.

In the initial stage the oxidation was fast, however, after four hours a saturation could be observed. This behavior can be explained by the formation of stable intermediates which oxidation is hindered. The identification of these compounds, as well as the determination of the mechanism of the oxidation is an another task.

### 4. CWAO treatment of phenolic thermal water

Additional studies were carried out with used (cooled) thermal water from Szentes (souteast Hungary). The pH of this water 8.6 and its COD is 90 mg/dm$^3$. The investigations were emphasized to utilize the natural origin catalysts, while for treatment of large amount of water – considering the economical conditions – the application of these materials posesses fundamental importancy.

The results obtained can be seen on Fig. 3 and 4. In the reaction by air (Fig. 3) the tendency of efficiency curves is close to saturation for two hours, which indicate the formation of stable intermediates. These compounds could react with the radicals or could inhibit the active centers of the catalyst. To determine of these intermediates or steps is important for the clarifying the mechanism of the reaction, moreover for thr optimization of the reaction conditions as well.

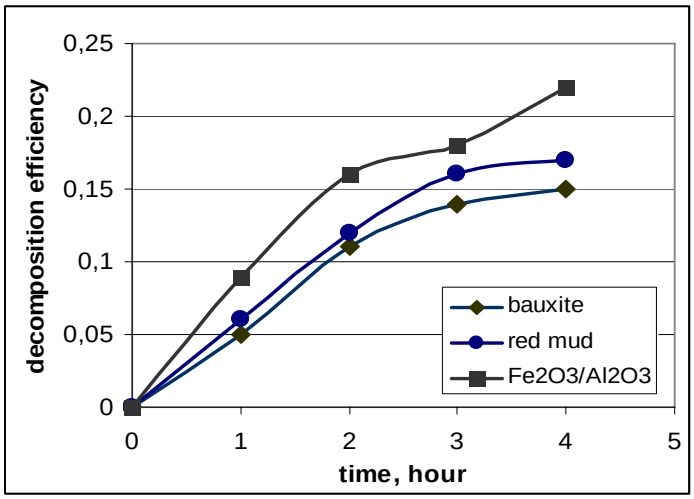



Figure 3: Oxidative treatment of used thermal water (COD: 90 mg/dm$^3$) in the presence of iron oxide base catalysts, oxidative agent: air

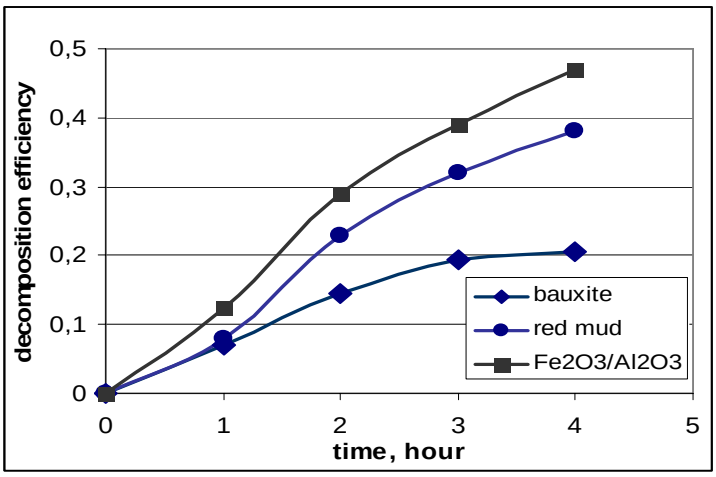



Figure 4: Oxidative treatment of used thermal water (COD: 90 mg/dm3) in the presence of iron oxide base catalysts, oxidative agent: ozone

Using ozone as oxidative agent, the decomposition efficiency increased in a large extent, and the saturation character could be observed only in the case of bauxite. Theoretically, this method is proper for removing of organic pollution in industrial scale. Considering the economical aspects, however, the utilization of ozone is too expensive for the treatment of the high amount of thermal water. Therefore, the development of catalytic air oxidation is the important task.

## 5. CONCLUSIONS

The mesoporous Fe-MCM-41, Fe/Al/Mg-mixed oxide and the microporous Fe-ZSM-5 zeolite are promising catalysts for the treatment of toxic wastewater containing phenol or other poisonous organic materials. Highest activity could be produced in the presence of Fe-MCM-41.

Considering the technological aspects the application of Fe-MCM41 would be prosperous because of the higher specific activity, however, from the economic point of view the application of the much less expensive natural catalysts (red mud or bauxite) could be suggested.

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# THERMODYNAMIC STUDY OF A SYMMETRICAL DISAZO DIRECT DYE DERIVED FROM 4,4'-DIAMINO-BENZANILIDE ON MERCERIZED COTTON

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**ABSTRACT:**
The sorption isotherms of a symmetrical disazo direct dye with symmetrical structure on a mercerized cotton were determined at 60°, 86° and 96°C. In order to find out the best sorption model of the considered dyes, a theoretical study was also performed. The experimental data obtained from the dyeing process was fitted by non-linear and linear regression analysis to the classical Freundlich, Langmuir and Nernst isotherms. Better statistical results were obtained in the case of the Freundlich sorption model.

**KEY WORDS:**
Direct dyes, dyeing theory, adsorption isotherms, Nernst model, Freundlich model, Langmuir model

## 1. INTRODUCTION

The textile dyeing equilibrium of the direct dyes on cellulose fibres presents a great interest, but a general model which could offer complete explanations of the dye–cellulose fibre sorption was not reported yet [1-4].

The dye adsorption at equilibrium represents the maximum possible sorption from the dyebath, under certain conditions. From the final dye equilibrium concentrations, sorption isotherms are obtained, most of them corresponding to the Freundlich and Langmuir equations [1].

In the Freundlich model (equation 1) the dye is considered as being contained in an internal phase of volume V of the fibre [1].

$$[C]_f = K_F \cdot [C]_S^x \quad (1)$$

where:
$[C]_f$ represents the dye concentration in the fibre at equilibrium, in mol/kg dry fibre, and
$[C]_s$ represents the dye concentration in solution at equilibrium, in mol/L;
$K_F$ is the equilibrium constant, and x is a sub-unitary power.

The Nernst adsorption isotherms (equation 2) are considered as a limit case of Freundlich and Langmuir adsorption isotherms [5].

$$[C]_f = K_P \cdot [C]_S \quad (2)$$

The Langmuir isotherm (equation 3) has been obtained from kinetics considerations [4]. The basic assumption is related to the idea that the dye adsorption takes place on independent fixed sites, in monomolecular layer and all the adsorption positions are equivalent energetically.

$$\frac{1}{[C]_f} = \frac{1}{S_f \cdot [C]_S} \cdot K_L + \frac{1}{S_f} \quad (3)$$

where $S_f$ is the saturation value in mols/kg fibre and $K_L$ is the equilibrium constant.

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Some authors reported that the Langmuir model offers a better interpretation of the direct dye cellulose sorption than the Freundlich one [2-3, 6-9].

In this present work, an experimental and theoretical study of the sorption of one disazo direct dye with symmetrical structure on a cellulosic substrate was performed. The aim of this study was to establish the best sorption model of the considered dye. For this purpose, the equilibrium sorption data of the studied dye were fitted by non-linear regression analysis to the Nernst, Freundlich and Langmuir sorption models.

## 2. THE STUDY

### General

All the chemicals were purchased from Merck Co, Aldrich Chemical Co and Reactivul Bucureşti.

The dye used in this study was a disazo direct dye derived from 4,4'-diaminobenzanilide. The coupling component was resorcinol. The dye was synthesized, purified by several recrystallizations from distilled water and characterized by means of electronic spectra (VIS) and mass spectroscopy (MS-FAB) and its homogeneity was determined by thin layer chromatography (TLC).

Electronic spectra were recorded on a Cecil CE 7200 spectrophotometer. Mass spectra were recorded on a Nermag R 10-10 spectrometer, from nitrobenzylalcool and glycerol as matrix. The TLC data were taken from silica gel plates (Merck 60F-25) and *i*-propanol/methylethylketone/$NH_4OH$ 25%=4:3:3 (v:v:v) as eluting system.

In the experimental study of the dye sorption on a cellulosic substrate, samples of mercerized cotton (100 %) were used. The samples were soaked in a bath with a liquor ratio of 20:1 at 80°C for 60 minutes, rinsed with distilled water and air - dried.

### Procedures

#### Synthesis of resorcinol ←4, 4'-diaminobenzanilide→ resorcinol

A suspension of 11.5 g 4,4'-diaminobenzanilide (0.05 mol), 70 ml water, 26 ml (0.27 mol) 35% HCl and 50 g ice was bis-diazotised by the direct method [10].

11.4 g (0.1 mol) of resorcinol were dissolved in a solution containing 0.5 g sodium acetate in 90 mL water. The solution was cooled to 5°C and was added dropwise to the solution of bis-diazonium salt obtained above, in a 45 minutes period. The temperature of the reaction mixture was kept around 5°C and the pH of the reaction was maintained around 8.5 by addition of 0.5 mol/L $Na_2CO_3$ aqueous solution. The mixture was stirred for three hours at 5-10°C. The dye was precipitated by salting out with natrium chloride and was separated by vacuum filtration. The yellow disazo dye was obtained in 88% yield.

Samples of the synthesized dye, free of sodium chloride were obtained by dyeing cotton fabric in boiling solutions containing 5 g of dye in 250 mL water. After rinsing the dyed fabrics, the dye was extracted using solutions of 50-60% aqueous pyridine. The extracts were then evaporated, giving a dye free of salts.

### Dyeing system and measurements

The dyeing processes were carried out in round flasks, equipped with a stirrer, a condenser and a thermometer. The dyeings were made at three temperatures, namely 60°, 86° and 96°C (± 1°C). The cotton samples weight in every case was near 70 mg (±0.1 mg). The liquor ratio was 150:1. The initial dyebath concentrations of the studied dye varied from 0.15 g/L to 5 g/L. Sodium chloride concentrations in the dyebath were in every case $6.84.10^{-2}$ mol/L.

The time necessary for reaching equilibrium for each dye and each dyeing temperature was evaluated in a series of preliminary experiments.

The dyed cotton samples were removed from the hot dyebath and rinsed for about 30 seconds in ice water to remove the adhering dye liquor. The dye was extracted from the dyed samples with 25% aqueous pyridine at 80°C. The molar extinction coefficients were determined at one wavelength from the Lambert-Beer law.

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The dye concentrations in the dyebath as well as the extracted dye from the substrate were recorded spectrophotometrically, using a Specord M40 UV-VIS spectrophotometer. Other details on the dyeing system can be found in references [6-9].

In order to find out the model which describes best the sorption of the studied dyes on mercerized cotton, the experimental data thus obtained were fitted to the classical Nernst, Freundlich and Langmuir sorption models by nonlinear regression analysis. For this purpose, the STATISTICA software [11] was used.

The standard deviation (expressed in [%]) of the experimental values obtained for the concentration of the dye on the substrate ($C_f$) from the calculated ones) was calculated according to equation (4).

$$SS = \left[ \frac{1}{N} \sum_{i=1}^{N} \left( \frac{C_{fi\,exp} - C_{ficalc}}{C_{ficalc}} \times 100 \right)^2 \right]^{\frac{1}{2}} \qquad (4)$$

where the suffixes "exp" and "calc" refer to experimental and calculated values, respectively; suffix "i" refers to the number of sorption data.

Figure 1 presents the Freundlich dye adsorption isotherm at 60°, 86° and 96°.

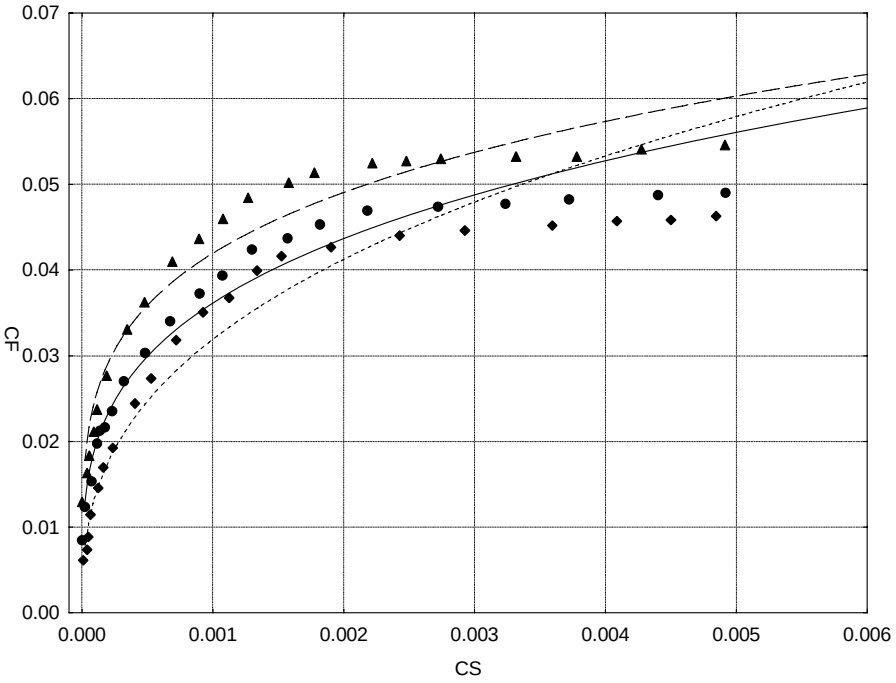
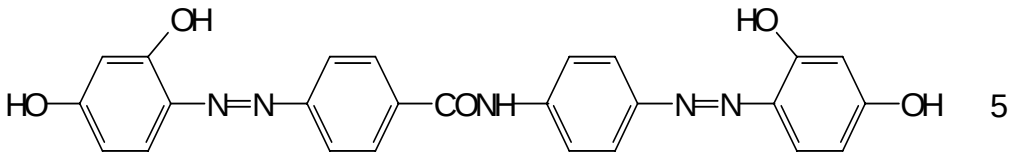



Figure 1. Freundlich adsorption isotherm at 60° ( ▲points and large interrupted fitting line), 86° ( ● points and continuous fitting line) and 96° ( ◆ points and small interrupted fitting line)

## 3. DISCUSSIONS

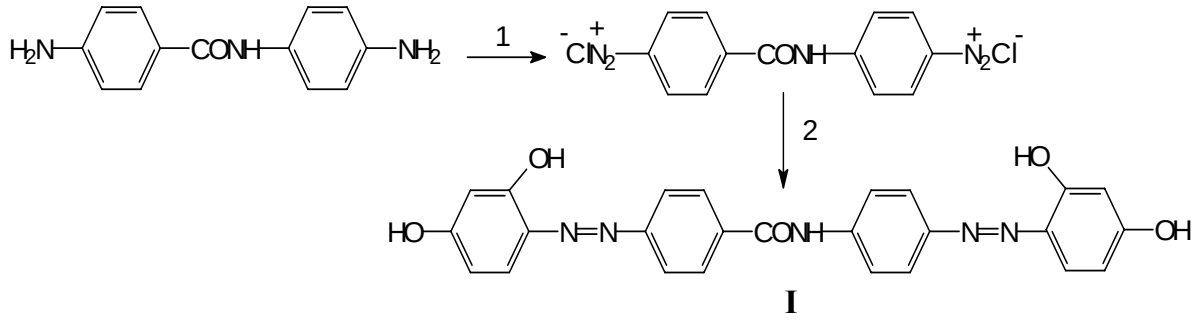
In the present study, the sorption isotherms of a symmetrical disazo direct dye on mercerized cotton were determined at 60°, 86° and 96°C. The studied dye (I) contains 4,4'-diaminobenzanilide as diazo component and resorcinol as coupling component.




5

Dye **I**

The dye was prepared in a two steps procedure, as shown in Scheme 1.




**I**

Scheme 1

1. $NaNO_2$, HCl, 0°C, 1 hour, 2. Resorcinol, 1:2 molar ratio, pH = 8.5-9, 5-12°C, 3 hours.

The bis-diazotization of 4, 4'-diaminobenzanilide was carried out by the direct method, in aqueous HCl solutions.

The coupling step was conducted at a pH value of 8.5-9, and with a 2-3% excess of coupling component. The progress of the coupling reaction was monitored by the usual way (drop reaction) and by thin layer chromatography (TLC), when the formation of dye **I** was examined. Dye **I** was obtained with overall high yields and was characterized by means of VIS spectra and negative (-) FAB – MS spectroscopy. Dye homogeneity was examined by TLC. The chromatographic mobility ($R_f$) of dye I was found equal to 0.76. The VIS spectrum was examined in the region of 350 to 800 nm. The spectra contain one maxim of absorption at about $\lambda_{max}$= 435 nm ($\varepsilon_{1cm}^{1g/L}$ = 52) in 0.1 mol/L aqueous NaOH solution. The molecular peak [MS(FAB-1)] was found at 468.45 m/z.

The disazo dye **I** was further used in the experimental study of the dye sorption on mercerized cotton, as shown in Experimental section. Dyeings were carried out until equilibrium was reached, at three different temperatures and in presence of sodium chloride. The experimental equilibrium dye concentrations in fibre $[C]_f$ and in solution $[C]_s$ were fitted to equations (1) and (2) by nonlinear regression analysis and to equation (3) by linear regression analysis, in order to provide the best model of sorption of the studied dye on cotton.

The values of the thermodynamic parameters $K_F$, $K_L$ respectively $S_f$ have been evaluated by means of nonlinear least squares fit of experimental sorption data to respective equations (1, 2), respectively by linear regression fit of experimental sorption data to equation (3) for $K_P$. The multiple regression coefficient (R) and the standard deviation (SS) calculated by equation (4) were used as statistical criterions in the regression analysis.

The thermodynamic data and the statistical results obtained for the studied dyes are presented in tables 1, 2 and 3.

TABLE 1

Thermodynamic data and statistical results of the sorption on mercerized cotton of dye I according to equation $[C]_f = K_F \cdot [C]_S^x$ (Freundlich model)*

| T [°C] | $K_F$ [L/lg] | x | R | SS [%] |
|---|---|---|---|---|
| 96 | 0.411 | 0.37 | 0.949 | 11.59 |
| 86 | 0.238 | 0.27 | 0.979 | 6.6 |
| 60 | 0.199 | 0.23 | 0.977 | 9.3 |

*$K_F$ represents the Freundlich partition constant; x- the subunitary power;
R- the multiple regression coefficient and SS-the standard deviation.

TABLE 2
Thermodynamic data and statistical results of the sorption on mercerized cotton of dye I according to equation $\frac{1}{[C]_f} = \frac{1}{S_f \cdot [C]_S} \cdot K_L + \frac{1}{S_f}$ (Langmuir model)*

| T [°C] | $S_1$ [mol/kg] | $K_L$ [L/mol] | R | SS |
|---|---|---|---|---|
| 96 | 0.041 | 10050.96 | 0.920 | 24.63 |
| 86 | 0.041 | 50252.52 | 0.703 | 27.62 |
| 60 | 0.046 | 125002.3 | 0.579 | 27.39 |

*$S_1$ represents the saturation value; $K_L$ - Langmuir partition constant;
R –the multiple regression coefficient and SS-the standard deviation

TABLE 3
Thermodynamic data and statistical results of the sorption on mercerized cotton of dye I according to equation $[C]_f = K_P \cdot [C]_S$ (Nernst sorption model)*

| T [°C] | $K_P x 10^{-2}$ [L/mol] | R | SS |
|---|---|---|---|
| 96 | 13.63 | 0.883 | 10.49 |
| 86 | 15.09 | 0.864 | 32.09 |
| 60 | 17.19 | 0.866 | 62.84 |

* $K_P$ - Nernst partition constant;
R- the multiple regression coefficient and SS-the standard deviation.

Comparing the obtained data presented in Tables 1, 2 and 3 it could be seen that for the studied dye, overall high values of R respectively low standard deviation (SS) values were obtained for the Freundlich sorption model as compared to the classical Nernst and Langmuir models.

## 4. CONCLUSIONS

The equilibrium sorption isotherms of a symmetrical disazo direct dye on cotton were determined at three temperatures and one sodium chloride concentration.

Experimental data were fitted to the standard known adsorption isotherms of Nernst, Freundlich, and Langmuir by nonlinear regression. The results indicated best statistical values in the case of the Freundlich sorption model.

## AKNOWLEDGEMENTS

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# INCLUSION COMPLEXES WITH A SYMMETRICAL DISAZO DYE WITH α- AND β-CYCLODEXTRINS

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**ABSTRACT:**

The results for the synthesis of a disazo dye with symmetrical structure derived from 4, 4'-diaminobenzanilide and its inclusion complexes (IC) with α- and β-cyclodextrins is reported. The free azo dye was prepared by the bis-diazotisation of 4,4'-diaminobenzanilide and the coupling reaction of the obtained bis-diazonium salt with alkaline solutions of the salicylic acid. The free azo dye and its inclusion complexes with α- and β- cyclodextrins were purified by gravity and flash column chromatography. Further, UV-VIS, FTIR and thin-layer chromatography (TLC) studies of the synthesized compounds were performed.

**KEYWORDS:**

Azo dye, Cyclodextrins, Inclusion complexes

## 1. INTRODUCTION

Cyclodextrins (CD) are macrocyclic compounds built from glucopyranose units linked by α-(1,4)-glycosidic bonds. CD can be obtained by enzymatic degradation of starch; in this process compounds with 6-12 glucopyranose units per ring are produced. Depending on the enzyme and the way in which the reaction is controlled, the main product is α, β or γ-cyclodextrin (6, 7 and 8 glucopyranose units, respectively).

Cyclodextrins can form inclusion complexes with a large number of organic molecules, a property that enables them to be used in a variety of different textile applications [1]. Through the incorporation, the physical and chemical proprieties of the "guest" compounds are changing. Their toxicity is lower, and they became biodegradable [2].

Azo dyes represent a major group of all the synthetic dyes and have extensive applications in textile industry, paper industry, additives, food, cosmetics and pharmaceutic industry [3]. The encapsulation of the disazo dye with cyclodextrins is a procedure that has been investigated as a method of controlling their stability, solubility and aggregation. It was found that rotaxane structure offers the protection of the dye which is encapsulated inside the cavity of the cyclodextrin, without forming covalent bonds [4].

In this work, the synthesis of a disazo dye and its inclusion complexes in α- and β-cyclodextrins is presented.

## 2. THE STUDY

The chemicals used in this study were of analytical grade and were obtained from Merck Co., Aldrich and Chimopar Bucharest. 4,4'-diaminobenzanilide was synthesized according to reference [5].

The thin layer chromatographic (TLC) data were taken from silica gel plates (Merck 60F-254) using isopropanol: methyl-ethyl-ketone: ammonia 25% = 4:3:3 as eluting system for the free azo dyes, respectively buthanol-ethanol-water = 4:3:5 as eluting system for their inclusion complexes.

For the gravity and flash column chromatography we used silica gel (Merck) as stationary phase and buthanol-piridine-water = 3:3:3 and buthanol-ethanol-water = 4:3:5 as eluting systems.

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The FTIR spectroscopy was recorded on JASCO FT/IR -4200 from KBr pellets.

The UV-VIS spectra were recorded on a Cecil CE-7200 spectrophotometer from 1 mol/L NaOH aqueous solutions for the free disazo dyes, and from aqueous solutions in the case of the inclusion complexes.

**General mode of synthesis of the azo dye AS**

0.06 g 4,4'-diaminobenzanilide (0.26 mmol) was bis-diazotised using the direct method of diazotization, in mineral acid solution, with natrium nitrite. The reaction was maintained at 0÷5 °C for 1 hours and the pH in the range of 0.5÷1 [8]. The bis-diazonium salt thus obtained was coupled in a 1:2 molar ration with alkaline solutions of the salicylic acid (dye AS). The pH of the reaction mixtures was maintained in the range of 8.5÷9 by periodic addition of $Na_2CO_3$. The obtained dye was separated by filtration and was purified by gravity and flash column chromatography.

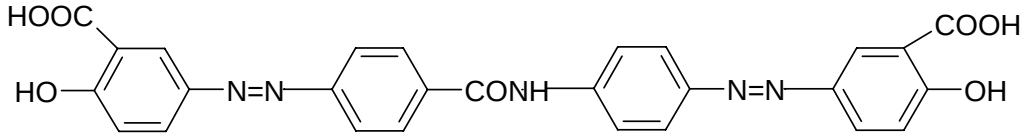
**General mode of synthesis of the azo dyes/cyclodextrins complexes**

0.06 g 4,4'-diaminobenzanilide (0.26 mmol) was bis-diazotised by the direct method. To the bis-diazonium salt thus obtained, aqueous solutions of the corresponding cyclodextrins (α, and respectively β) were added dropwise. The reaction mixture was maintained under vigorous stirring at 0÷5 °C for 30 minutes. The encapsulated bis-diazonium salt was subjected to the coupling reaction with alkaline solutions of salicylic acid in the case of the β-cyclodextrin. In the case of the synthesis of the α-cyclodextrin complexe, the alkaline solution of salicylic acid was added to the encapsulated bis-diazonium salt. The coupling reaction was monitored by the conventional method and by TLC. The reaction mixture was maintained under stirring at 7.5÷8 pH, at 20 °C for 2 hours. The final products were separated by centrifugation and the rotaxane complexes were isolated by evaporation from the supernatant.

The synthesized dyes and their inclusion complexes were purified by gravity and flash column chromatography and were characterized by thin-layer chromatography (TLC), FTIR and UV-VIS spectroscopy.

## 3. DISCUSSIONS

The first step of this work was to prepare the disazo dye with structure (I), and further its complexes with α- and β-cyclodextrins.




**I**

From previous work [6], it was noticed that the bis-diazotization of 4,4'-diaminobenzanilide occurred with better yields when the direct method of bis-diazotisation is used. The temperature was maintained in the range of 0÷5°C and the pH of the mixture around 1. In the coupling step, 3 % excess of coupling component was used. In order to avoid the formation of undesirable by-products, the bis-diazonium salt was quickly added to the alkaline solution of the coupling components and the pH was maintained and adjusted in the range of 8÷9 by periodic addition of $Na_2CO_3$.

For the preparation of the inclusion complexes of the model dye (I) with α- and β-cyclodextrins, a simple procedure using the hydrophobic effect to direct rotaxane formation was developed. According to this procedure, 4, 4'-diaminobenzanilide was bis-diazotizated by the direct method, and to the bis-diazonium salt thus obtained, an aqueous solution of α- and then β-cyclodextrin was added. The symmetric coupling reaction of the encapsulated bis-diazonium salt with alkaline solution of the coupling component (salicylic acid), in the case of the α-cyclodextrin, was obtained by 2 methods: firstly, the encapsulated bis-diazonium salt was added to the alkaline solution of the coupling component (SA) as described in reference [7]. Secondly, the alkaline solution of the coupling component is added to the encapsulated bis-diazonium salt. In the case of the β-cyclodextrin the encapsulated bis-diazonium salt was

subjected to the coupling reaction with alkaline solutions of salicylic acid. Further, the coupling reaction of the encapsulated bis-diazonium salt with salicylic acid was carried-out.

It was noticed that when the bis-diazonium salt is added to the alkaline solution in the presence of α-, respectively β-cyclodextrin, the solution immediately turns yellow. Thin layer chromatography reveals the formation of the rotaxane, respectively the non-rotaxanated dye, which is rather insoluble in water and can be separated from the rotaxane by centrifugation.

The progress of the coupling reaction was monitored by the usual way (drop reaction with an alkaline solution of 1-amino-8-hydroxy-3,5-naphthalene disulphonic acid and with the diazonium salt of p-nitroaniline) and by TLC.

The synthesized dyes and their inclusion complexes were purified by gravity and flash column chromatography, and were characterized by thin-layer chromatography (TLC), FTIR and UV-VIS spectroscopy. The results are shown in Table 1 and Figure 1.

Table 1.
Yields of reaction, chromatographic mobilities $R_f$, and spectrophotometric properties of the disazo dye I, non-encapsulated dye and rotaxane complexes.

| Dye and dye_CD | η [%] | Rf* | $\lambda_{max}$ ** [nm] | lgε |
|---|---|---|---|---|
| AS | 82 | 0.88 | 441 | 1.8 |
| AS_α-CD | 13 | 0.65 | 269 | 2.3 |
| AS_β-CD | 23 | 0.68 | 355 | 1.9 |

*Silicagel plates, iso-propanol:methy-ethyl-ketone:ammonia 25% = 4:3:3 as eluent of the synthesized dyes, respectively eluent: buthanol: ethanol: $H_2O$ = 4: 3: 5 of the rotaxane complexes.
**$\lambda_{max}$ – wavelenght of maxim absorbance, from dye solution in 1 mol/L NaOH, respectively aqueous solutions in the case of the inclusion complexes, CECIL 7200 spectrophotometer.

The FTIR study: KBr pellets, for the disazo dye and inclusion complexes are showed a difference among the initial α- and β-cyclodextrins, free disazo dye and its complexes. IR: for α-CD was found: OH, 3403 $cm^{-1}$; $CH_2$, 2925 $cm^{-1}$; CH, 1337 $cm^{-1}$; COC, 1079 $cm^{-1}$; for β-CD: OH, 3383 $cm^{-1}$; $CH_2$, 2927 $cm^{-1}$; CH, 1337 $cm^{-1}$; COC, 1079 $cm^{-1}$; for dye SA: OH, 3377 $cm^{-1}$; CH, 1590 $cm^{-1}$; CO, 1635 $cm^{-1}$; for SA/α-CD complex: OH, NH, 3438 $cm^{-1}$; CONH, 2241 $cm^{-1}$; N=N, 1414 $cm^{-1}$; CO, 1641 $cm^{-1}$; CH, 1561 $cm^{-1}$; COC, 1021 $cm^{-1}$; and for SA/β-CD complex: OH, NH, 3425 $cm^{-1}$; CONH, 2241 $cm^{-1}$; N=N, 1415 $cm^{-1}$; CO, 1638 $cm^{-1}$; CH, 1576 $cm^{-1}$; COC, 1030 $cm^{-1}$.

In Figure 1 the UV-VIS spectra for the disazo dye, cyclodextrins and inclusion complexes are shown. The absorption spectra in the 200÷700 nm region of the disazo dye and cyclodextrins were comparated with inclusion complexes, and differences in the spectra were observed. It was noticed that both obtained inclusion complexes show a hipsochromic shift of their absorptions maxima in comparison to the free azo dye (SA).

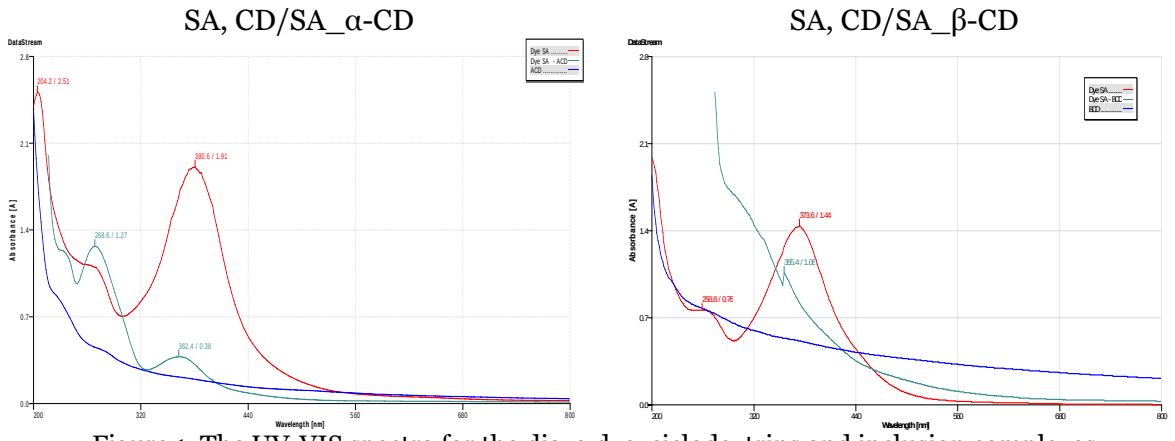


Figure 1. The UV-VIS spectra for the diazo dye, ciclodextrins and inclusion complexes

## 4. CONCLUSIONS

Two inclusion complexes of a symmetrical disazodye with α- and β-cyclodextrin have been obtained and characterized by UV-Vis spectra, FTIR and Thin Layer Chromatography.

The direct route to a rotaxane encapsulated azo dye will facilitate investigations into consequences of chromophore encapsulation.

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# OPTICAL STUDY OF STEEL SURFACES AFTER THERMOCHEMICAL TREATMENT

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**Abstract:**
In this paper we introduced the ellipsometrical measurements of steel OLC-45 after thermochemical treatment. We obtained the optical constants and the film thickness of nitrated case formed on the steel surface after thermochemical treatment. This nitrated case and the metallic substrate have different mechanical properties because of the metallic nitride formed.
The correlation between the optical properties and the mechanical properties of metallic surfaces allow to correctly decide upon the optimal thermochemical treatment settings for a certain type of steel.

**Keywords:**
ellipsometry, optical constants, thermochemical treatment, nitriding steel

## 1. INTRODUCTION

The thermochemical treatment of the metallic surface forms films with special properties, which differ from those of the metal.

Ellipsometry is an optical study of metal surfaces of a special smoothness. It allows us to obtain the optical properties of the solid surfaces and of the surface films formed on the solid surfaces from a change in the state of light polarization that is reflected on the surface [1,3,6].

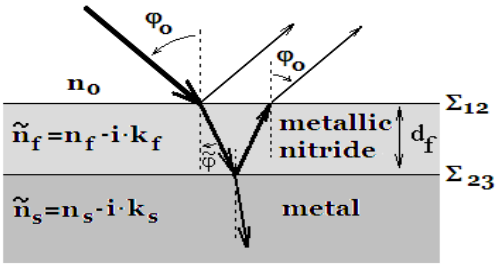



Figure 1. Light reflection on a metal covered by an optically absorbent film

Figure 1 presents the model of the metal surface coated with a film formed by the superficial thermochemical treatment, which reflects a monochromatic radiation.

The fundamental ellipsometry equation links the measurable angles Δ and Ψ to the optical constants of the substrate $\overline{n}_s, \overline{k}_s$, the superficial film thickness $d_f$ and the optical constants of the superficial film $\overline{n}_f, \overline{k}_f$:

$$tg\Psi e^{i\Delta} = f\left(n_o, \varphi_o, \lambda, \overline{n}_f, \overline{k}_f, d_f, \overline{n}_s, \overline{k}_s\right) \quad (1)$$

In order to know the optical properties of the film formed on the surface after thermochemical treatment it is necessary to know the optical constants $\overline{n}_s$ and $\overline{k}_s$ of the substrate [1,6].

They are determined by a measurement of the angles $\overline{\Delta}_o$ and $\overline{\Psi}_o$, for the metal, before the thermochemical treatment. The optical constants of the substrate are obtained by solving the equation:

$$tg\overline{\Psi}_o e^{i\overline{\Delta}_o} = f\left(n_o, \varphi_o, \lambda, \overline{n}_s, \overline{k}_s\right) \quad (2)$$

The films formed on the surface of steel are optically absorbent so that both the thickness $d_f$ and the optical constants $\overline{n}_f$ and $\overline{k}_f$ must be determined.

If the superficial film with complex refractive index $\tilde{n}_f = \overline{n}_f - i \cdot \overline{k}_f$ is optically absorbent, the relationship described by (1) does not allow the determination of three

unknown: $d_f$, $\overline{n}_f$ and $\overline{k}_f$ by a single pair of $\Delta$ and $\Psi$ parameters, measured at a single angle of incidence.

The graphical methods are commonly used to determine the three sizes $d_f$, $\overline{n}_f$ and $\overline{k}_f$ by means of the ellipsometric measurements:

- at two or more different incidence angles;
- at two or more wavelengths;
- for two or more incidence media with different refractive indices [1,2,6].

Reference literature presents in detail the technique for processing the data resulting from experimental measurements [1,4,6].

If the optically absorbent superficial film thickness is greater than a minimum value $d_m$, then radiation is absorbed in the superficial film and does not reach the $\Sigma_{23}$ interface. In this case angles $\Delta$ and $\Psi$ do not depend on the film thickness. They remain constant as can be observed in Figure 2. From $\Delta_f$ and $\Psi_f$ we obtained the optical constants of the superficial film as bulk material. The minimum film thickness from which $\Psi$ and $\Delta$ remain constant depends on the optical constants of the superficial film.

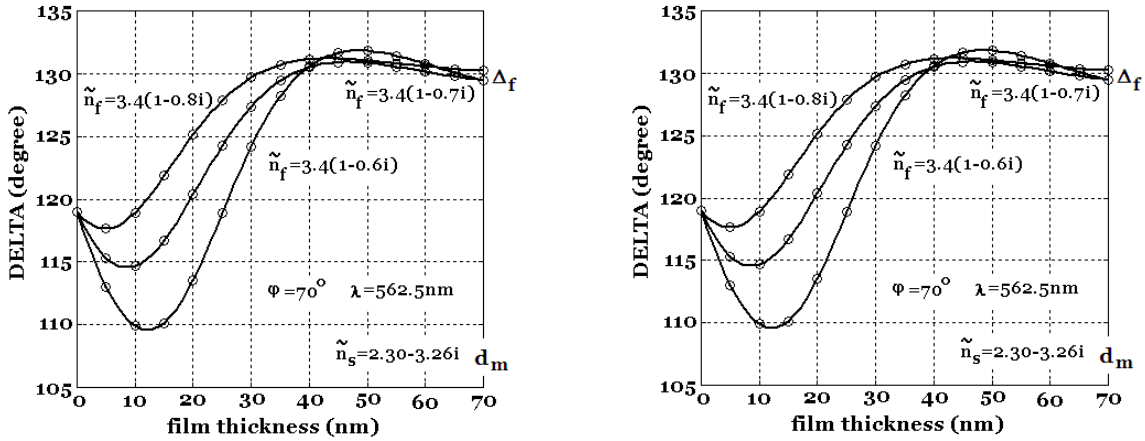



Figure 2 $\Delta$ and $\Psi$ angles versus the thickness of an optically absorbent film formed on the metallic surface.

The ellipsometry relationship expressed by (1) no longer allows the determination of the thickness $d_f$ of the superficial film. From the relationship:

$$tg\overline{\Psi}_f e^{i\overline{\Delta}_f} = f\left(n_o, \varphi_o, \lambda, \overline{n}_f, \overline{k}_f\right) \qquad (3)$$

we can only determine the optical constants $\overline{n}_f$ and $\overline{k}_f$ based on the ellipsometrical angles at one angle of incidence.

In relation (1) it is assumed that the superficial film has an arbitrarily chosen value, but greater than $d_m$.

## 2. EXPERIMENTS

The surface of steel samples OLC-45, was polished and then burnish extra-brightly with aluminum oxide burnishing powder. Before the ellipsometrical measurements for the determination of the optical constants, the metal surface of the freshly polished samples was washed in a jet of distilled water to remove impurities and then it was washed with absolute ethanol.

The thermochemical treatment of steel samples was performed in an ion-nitriding furnace for 8 hours. The samples were then washed by the method described above, before the ellipsometrical measurements of the film that was formed.

The ellipsometrical angles $\Delta$ and $\Psi$ through which we determined the optical constants of the surfaces were measured by means of a photoelectric ellipsometer in PCSA assembly (polarized, compensatory, surface, analyzer) with an accuracy of 0.1°.

The calculations were made with the help of our own computer program based on the calculation developed by McCrackin [6].

## 3. RESULTS AND DISCUSSION

There were two methods used for determining the thickness and the optical constants of the surface films.

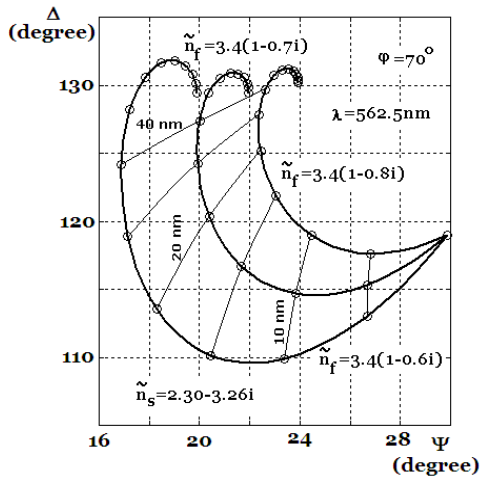



Fig. 2 The theoretical curves Δ=f(Ψ) for superficial optical absorbent film.

In one of the methods, we used the optical constants of the substrate with which it can draw the theoretical curves Δ= f (Ψ) for various possible values of the optical constants of the film formed by thermo chemical treatment [2].

Figure 2 shows the appearance of these curves.

The optical constants have values between $\overline{n}_f$ =1.5 ÷ 3.0 respectively $\overline{k}_f$ = 0.75 ÷ 1.5.

Thus, we determined the approximate values of the optical constants of the superficial film. The error of this determination depends on the accuracy of the graphical representation and of the reading of the graph.

Another method for determining the thickness and the optical constants of superficial films uses a set of two ellipsometrical measurements for metal covered with the surface film, at two different incidence angles: 60 ° and 70 ° [5].

$$tg\Psi_1 e^{i\Delta_1} = f\left(n_0, \varphi_{01}, \lambda, \overline{n}_f, \overline{k}_f, d_f, \overline{n}_s, \overline{k}_s\right) \quad (4)$$

$$tg\Psi_2 e^{i\Delta_2} = f\left(n_0, \varphi_{02}, \lambda, \overline{n}_f, \overline{k}_f, d_f, \overline{n}_s, \overline{k}_s\right) \quad (5)$$

The results of the measurements, the optical constants and the superficial film thickness are shown in Table 1.

For nitride layers whose thickness is larger than 100 nm the ellipsometrical measurement determines only the optical constants of the layer, by means of equation (3).

Table 1. The ellipsometrical angles measured and the optical characteristics of the metal and of the superficial film obtained by ion-nitriding of OLC-45 steel

| Sample | Metallic substrate | | | | | Nitriding steel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\varphi_0$ | Δ | Ψ | $\overline{n}_s$ | $\overline{k}_s$ | $\varphi_0$ | Δ | Ψ | $\overline{n}_f$ | $\overline{k}_f$ | $d_f$ |
| - | deg. | deg. | deg. | - | - | deg. | deg. | deg. | - | - | nm |
| 1 | 70 | 118,45 | 29,35 | 2,32 | 3,18 | 60 | 152,07 | 28,72 | 3,46 | 2,46 | 22 |
| | | | | | | 70 | 124,92 | 20,35 | | | |
| 2 | 70 | 119,01 | 29,85 | 2,30 | 3,26 | 60 | 147,39 | 28,72 | 3,4 | 2,48 | 15 |
| | | | | | | 70 | 118,42 | 22,06 | | | |

## 4. CONCLUSIONS

The determination of the optical constants and the surface film thickness require at least two ellipsometrical measurements at different incidence angles or wavelength or by using different incidence media with different refractive indices.

The optical characteristics of optical absorbent films can be obtained by rather laborious graphical methods.

If the superficial films have the thicknesses greater than 0.1 μm, it is not possible to determine the thickness by the ellipsometrical method. The optical constants determined from the Δ and Ψ ellipsometrical angles correspond to the bulk metallic nitride.

The correlation between the optical properties of films formed after thermo chemical treatment and the mechanical properties of the metals allow an optimal treatment to be applied to particular steel.

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# DETERMINATION OF THE ROUGHNESS LEVELLING DEPTH FOR METALLIC SURFACES BY OPTICAL MEASUREMENTS BASED ON THE LIGHT REFLEXION

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**Abstract:**

The used optical method is based on the roughness metallic surface model, which supposed one superficial inhomogeneous film. This is considered a mixture of the basic metal and the air.
For this film, the thickness, the amount of the metal per unit area of the surface and the weight fraction of the metal in the film are determined by the ellipsometric method. These values for Cu, Ni and steel allow the determination of the roughness leveling depth.

**Key words:**

ellipsometry, roughness, superficial film

## 1. INTRODUCTION

As a result of mechanical processing of metallic surface arise rupture of the crystal lattice and the formation of a transitional layer composed of amorphous crystalline areas of metal and impurities from the processing method [1,3].

Impurities existing on the rough surface can be removed by washing the area with various solvents, and transition layer will have properties intermediate two adjacent medium.

As well it should polish, metal surface has a roughness that can be characterized by mean deviation of the roughness to the median line:

$$R_a = \frac{1}{\ell}\int_0^{\ell} |y - m| \cdot dx \qquad (1)$$

Median line taken as a reference is characterized by roughness leveling depth $R_p$ taken to the outside line of profile or to the inside line of it:

$$R_p = \frac{1}{\ell}\int_0^{\ell} y \cdot dx \qquad (2)$$

y is coordinate of a point of the profile diagram to the inside line, m=$R_p$ coordinate of the average line to the inside line and $\ell$ is the measured length [4].

In the case of the minute surface, use of mechanical feeler is limited by the size of pick-up.

Ellipsometric method, based on variation of the polarization of light when reflected on the surface between two media, can be used to characterize roughness of metal surfaces [2]. By this method can determine the thickness and optical properties of superficial films on metal surfaces with an accuracy of the order hundredth of nanometer.

The method used is based on a model of the rough metallic surface as in Figure 1. Rough surface may be resembled with a superficial film made from a mixture of metal (with the index of refraction ñ and density ρ) and the immersion medium (with the index of refraction $n_o$ and density $\rho_o$), as in Figure 1.

Refraction index $n_f$ and thickness $d_f$ of the film can be determined by ellipsometric readings based on the optical model of the superficial intermediate film, shown in Figure 1,

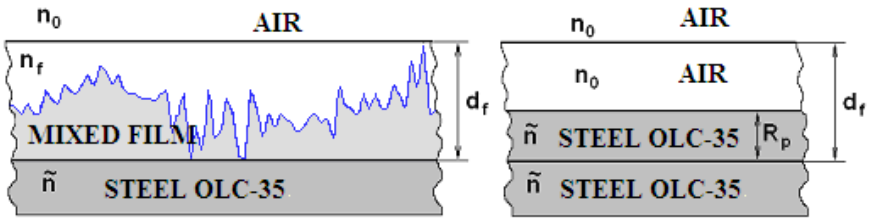



Figure 1. Model of rough surface resembled with a transition layer

The weight fraction of the metal in the film:

$$f = \frac{r_f - r_0}{\tilde{r} - r_0} \tag{3}$$

and the amount of the metal per unit area of the surface:

$$m_f = \rho_f \cdot d_f \cdot f \tag{4}$$

on determine from these optical values.

In this relationship $\rho_f$ represents film density calculated with the phrase:

$$\rho_f = \frac{1}{\frac{f}{\rho} + \frac{1-f}{\rho_0}} \tag{5}$$

$r_o$, $\tilde{r}$ and $r_f$ are the specific refractions of immersion environment (air), metal, and the superficial film:

$$r_0 = \frac{n_0^2 - 1}{n_0^2 + 2} \cdot \frac{1}{\rho_0} \quad ; \quad \tilde{r} = \frac{\tilde{n}^2 - 1}{\tilde{n}^2 + 2} \cdot \frac{1}{\rho} \quad ; \quad r_f = \frac{n_f^2 - 1}{n_f^2 + 2} \cdot \frac{1}{\rho_f} \tag{6}$$

Model shown in Figure 1 shows that the product between density of metal ρ and roughness leveling depth $R_p$ is equal to the amount of metal per unit area of the film:

$$m_f = \rho \cdot R_p \tag{7}$$

## 2. EXPERIMENTAL PART

Measurements of the roughness of metal surfaces of copper, nickel and steel OLC-35 were carried out.

Samples of metallic copper, nickel and steel OLC-35 were cut to size 45x22x5 (mm), then were polished with glass paper grain size 12. Samples were burnish extra-bright before measurements with abrasive metallographic paper to grain M14, then with the burnishing powder of aluminum oxide "Presi 2" Italy. The samples were washed with absolute ethanol.

Metallic surface roughness was measured with a profilograph "Profilograf-201". For accounting of roughness we used the M system, which uses the median line of profile for the baseline [6]. Calculated physical and statistical parameters for the effective profiles were: the roughness leveling depth $R_p$ and average deviation of roughness $R_a$ reported to the median line.

Ellipsometric measurements were made with a photoelectric ellipsometer IFTAR (PCSA assembly) using monochromatic light with wavelength λ = 546.1 nm, at the angle of incidence $\varphi_o = 70^o$.

## 3. Results and Discussion

In Figure 2 shows, for example, profile diagram recorded for the surface of a sample of nickel.

Table 1 are given values of $R_p$ and $R_a$ for metal surfaces studied, calculated from profile diagram recorded. The calculations were made using a computer one's own program in Matlab language.

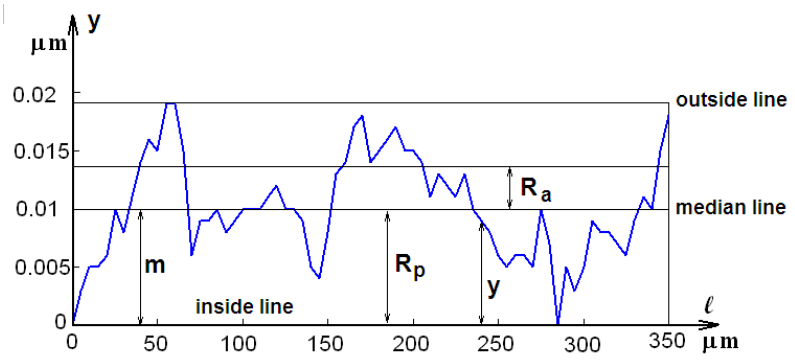



Figure 2. Profile diagram for nickel

Table 1

| Metal | $\ell$ | $R_p$ | $R_a$ |
|---|---|---|---|
| - | µm | µm | µm |
| Copper | 60 | 0.026 | 0.022 |
| Nickel | 350 | 0.010 | 0.004 |
| Steel OLC-35 | 60 | 0.010 | 0.004 |

Ellipsometric measurements and optical values calculated for rough superficial film, based on optical model shown in Figure 1, are presented in Table 2. To calculate optical values for superficial film were used optical constants of metal, and ellipsometric quantities measured at incidence angle $\varphi_0 = 70°$ and wavelength $\lambda = 546.1$ nm.

All calculations were performed using a software own, based on the McCrackin program for processing ellipsometric measurements [5].

Table 2

| Metal | optical constants of metal | | ρ | Δ | Ψ | $d_f$ | $n_f$ |
|---|---|---|---|---|---|---|---|
| | n | k | | | | | |
| | - | - | g/cm³ | grd. | grd. | nm | - |
| Copper | 0.82 | 2.21 | 8.93 | 74.47 | 35.51 | 345,6 | 0.98 |
| Nickel | 1.79 | 3.30 | 8.90 | 97.56 | 35.37 | 23.4 | 1.25 |
| Steel OLC-35 | 2.54 | 3.42 | 7.86 | 98.44 | 32.03 | 11.5 | 2.12 |

Were calculated the weight fraction of the metal in the film f and the amount of the metal per unit area of the surface $m_f$ , according to the relations (3) and (4), using the optical values $n_f$ and $d_f$ calculated for rough superficial film.

Levelling depth of roughness $R_p$ , shown in Table 3, was calculated according to the relationship (7).

Table 3

| Metal | $d_f$ | f | $m_f$ | ρ | $R_p^{optic}$ | $R_p^{mechanic}$ |
|---|---|---|---|---|---|---|
| | nm | - | mg/cm² | g/cm³ | µm | µm |
| Copper | 34,6 | 0.50 | 0.0031 | 8.93 | 0.035 | 0.026 |
| Nickel | 23.4 | 0.84 | 0.0077 | 8.90 | 0.009 | 0.010 |
| Steel OLC-35 | 11.5 | 0.97 | 0.0076 | 7.86 | 0.010 | 0.010 |

It notes that in general there is a pretty good correlation between the leveling depths of roughness, optically determined (by ellipsometric measuring) $R_p^{optic}$ and the same, mechanically determined (with profilograph) $R_p^{mechanic}$. Differences that may arise due to the fact that the base length of profil graph is of the order tenth of a millimeter while the optical surface of the metallic sample examined has an area with radius of about 2mm. Differences may occur because of errors due to limitations imposed by the size of profilograph pick-up.

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## 4. CONCLUSIONS

For characterization of micro-roughness of metal surfaces ellipsometric method, based on modifying of the polarization of light reflected from the solid surfaces, is used. This method has an accuracy of the order tenth of a nanometer can provide information about the structures of various films on solid or liquid surfaces. The method does not require direct contact with the measured area and requires approximately 20 minutes measuring time.

Although a simple ellipsometric measurement not allow determination of roughness (expressed by the mean deviation of the roughness $R_a$ to the median line taken as reference), it provides very valuable information about areas in terms of roughness. Levelling depth of roughness $R_p$ determined by the optical measurement can be used later as middle reference line for calculating the roughness.

Ellipsometric measurements at several angles of incidence, or to different states of polarization of radiation, may provide additional information that can be used to characterize the roughness of surfaces.

Ellipsometric method can be used only for highly polished solid surfaces, reflecting specular light.

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# DETERMINATION OF OPTICAL CONSTANTS OF POLYMER FILMS THROUGH REFLECTION

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**Abstract:**

The transmittance values measured in IR specular external reflection (RS) or internal reflection (ATR) spectra can be used to determine the optical constants of solid surfaces or dielectric films laid on solid substrates.

To obtain the optical constants of polystyrene films laid on steel we used Kramers-Kronig analysis. In this case, the optical constants are obtained from IR external reflection spectrum recorded at a single incidence angle. The transmittance measured and the phase shift angle obtained by Kramers-Kronig integral, are used in this case.

Using Kramers-Kronig analysis offers the advantage of processing a large volume of data.

**Keywords:**

Reflection-absorption, optical constants, IR spectra, Kramers-Kronig analysis, dispersion analysis

## 1. INTRODUCTION

The study of reflectance spectra of films deposited on solid surfaces allows the determination of thickness and optical constants of these: refractive index n and absorption index k.

In order to determine the optical constants of polymer films one can use the specular external reflectance spectra or the internal reflectance spectra. If the polymer film deposited on the metal is thick, it can be treated as a bulk material. The reflectance spectrum recorded is not influenced by the substrate.

The reflection and transmission of radiation on solid surfaces are expressed by the complex reflection coefficient $\tilde{r} = |\tilde{r}|\exp(i\theta)$ and the complex transmission coefficient $\tilde{t} = |\tilde{t}|\exp(i\theta)$. They depend on the complex refractive index of the film $\tilde{n} = n - ik$ and on the angle of incidence.

Reflectance, denoted by R represents the ratio of the reflected radiation intensity $I_r$ and the incident radiation intensity $I_o$ and it is equal to the square complex reflection coefficient: $R=r^2=|\tilde{r}|^2$.

Transmittance, denoted by T represents the ratio of the transmitted radiation intensity $I_t$ and the incident radiation intensity $I_o$ and is equal to the square complex transmission coefficient: $T= t^2=|\tilde{t}|^2$.

For thick films (with thickness higher than 50 μm), the optical constants are determined from the specular reflectance spectra (RS) or from the attenuated total reflectance spectra (ATR). You can use the reflectances R1 and R2 measured at two angles of incidence or the reflectance R at one angle of incidence and θ angle measured across the whole spectral domain [4,8,14]. This is possible by Kramers-Kronig analysis, using integral:

$$\theta(\nu_i) = \frac{\nu_i}{\pi}\int_0^{\infty}\frac{\ln R(\nu)}{\nu^2 - \nu_i^2}d\nu \qquad (1)$$

From reflectance R and angle θ, the complex refractive index is determined, for normal incidence:

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$$\tilde{n} = n - ik = \frac{(1-R) - i \cdot 2\sqrt{R}\sin\theta}{1 + R - 2\sqrt{R}\cos\theta} \tag{2}$$

In case of specular reflection from the polymer thin films deposited on metals (with thickness less than 10 μm), the reflected radiation contains two components: one reflected from the air-film interface ($I_r$ intensity) and one reflected by the film-metal interface ($I_t$ intensity), after having crossed twice the polymer film, as shown in Figure 1.

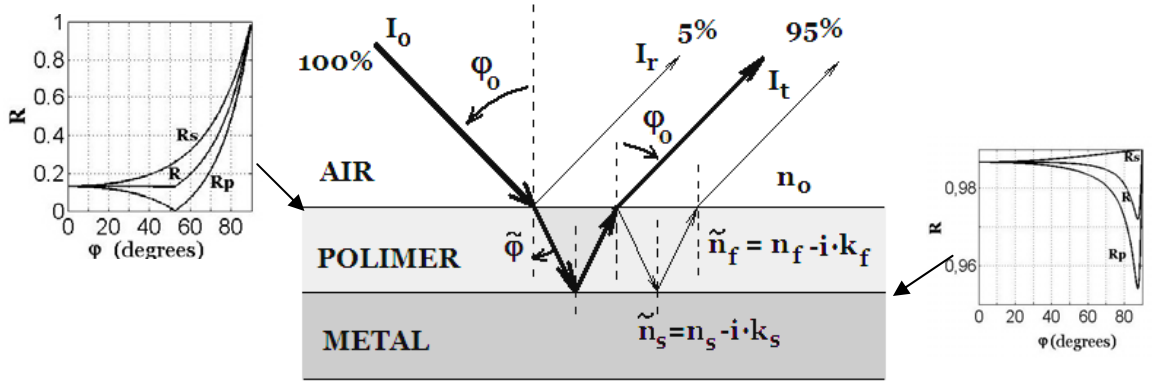



Figure 1. The specular reflection of radiation for thin films deposited on metals

The reflectance due to reflection at the air/film interface is about 5% since the refractive indices of polymers is less than 1.5 in the middle-IR spectral domain. The reflection at the polymer/metal interface is much higher and the reflectance is about 99%. The radiation reflected from the polymer/metal interface and crossing twice the polymer film is thus about 95% of the incident radiation intensity. It is almost 20 times more intense than the reflected beam to the air/polymer interface. For this reason, this spectrum is a reflection-absorption spectrum (or a transflectance spectrum). It is similar in terms of quality to the transmission spectrum of the polymer film.

This spectrum can be processed to obtain optical constants n and k [9].

It is necessary to know the transmittance $T(\nu)$ along the whole spectral domain and by means of the Kramers-Kronig relationship the θ angle is determined [12.13].

$$\theta(\nu) + 2m\pi = -\frac{\nu}{\pi} P \int_0^{\infty} \frac{\ln T(\nu')}{\nu'^2 - \nu^2} d\nu' + 2\pi\nu d \tag{3}$$

Transmittance T and θ angle are related to the complex refractive index by the relationship:

$$\sqrt{T} e^{i\theta} = \frac{4\tilde{n}}{(\tilde{n}+1)^2 e^{-i\delta} - (\tilde{n}-1)^2 e^{i\delta}} \tag{4}$$

where: $\delta = 2\pi\nu\tilde{n}d_f / c$ depends on the thickness $d_f$ of the film [3].

Dispersion analysis is another way of obtaining the optical constants of thin films deposited on metal surfaces. This method can be more flexible than the Kramers-Kronig relations as it can be applied to a more complicated geometry.

Dispersion analysis is based on building an appropriate model for calculating the dielectric and optical properties of this model. The best known is the Drude-Lorentz damped harmonic oscillator model [11] for the complex dielectric function:

$$\varepsilon(\nu) = \varepsilon_\infty + \sum_j \frac{\nu_{pj}^2}{\nu_{oj}^2 - \nu^2 - i\gamma_j \nu} \tag{5}$$

It describes the optical response of a set of harmonic (damped) oscillators. Here $\varepsilon_\infty$ is the so-called "high-frequency dielectric constant", which represents the contribution of all oscillators at very high frequencies. Parameters $\nu_{pj}$, $\nu_{oj}$ and $\gamma_j$ are the "plasma" frequency, the transverse frequency (eigenfrequency) and the linewidth (scattering rate) respectively of

the j -th Lorentz oscillator. Reflectance R or transmittance T can be obtained from the theoretical model of the complex dielectric function. The spectra of these optical magnitudes are compared to those experimentally determined. The model parameters are continuously adjusted to fit the theoretical values with the experimental data measured. For the reflection-absorption spectra, the theoretical transmittance and the experimental transmittance are compared. When the differences between the theoretical and experimental spectra are minimal, the parameters fitting process is stopped.

Suppose, we have a set of N experimental data points $\{x_j, y_j, \sigma_j\}$ (j = 1,...., N), that we want to fit. Here, $x_j$ is the data coordinate, $y_j$ is the data value and $\sigma_j$ is the data error bar. Next, we take a model, which calculates the model value y = f (x, p1,...., $p_M$) for a set of M internal parameters.

So-called Levenberg-Marquardt algorithm is used to minimize the amount

$$\chi^2 = \sum_j^N \left( \frac{y_j - f(x_j, p_j \ldots p_M)}{\sigma_j} \right)^2 = \chi^2(p_1, \ldots p_M) \qquad (5)$$

is used.

The fitting process stops when the stopping criterion is fulfilled [10].

In the case of the internal reflection at angles of incidence greater than the critical angle, the radiation is totally reflected on the surface film. The evanescent-wave penetrates into the superficial thin film. The depth of radiation penetration into the superficial film is given by the relationship:

$$d_p = \frac{\lambda}{2\pi\sqrt{n_o^2 \sin^2 \varphi_o - n_f^2}} \qquad (5)$$

The depth of penetration is a measure of how far radiation penetrates into the sample in an ATR experiment, calculated as the depth at which the electric field of the evanescent wave has decreased to 37% of its original value.

Figure 2 presents the model of the internal reflection on thin films (with thickness $d_f$ less than the depth of penetration $d_p$) deposited on metal mirrors.

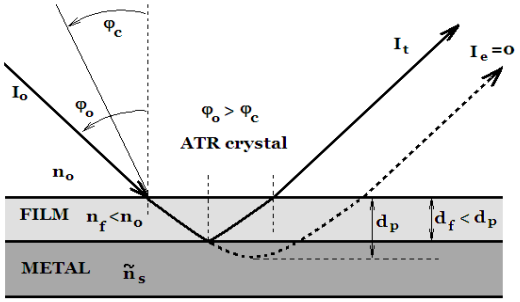



Figure 2. The attenuated total reflection from thin film deposited on metal surface

The radiation that penetrates through the polymer film as well as an evanescent wave, is reflected on the polymer/metal interface and it crosses the polymer film again. In this case, the internal reflectance spectra of thin films resemble more the transmission spectra and have a much different aspect, as compared to those recorded for thick films [4,6]. In the case of thin film, absorption bands are not displaced or distorted, if the incidence angle is close to the limit. The spectrum recorded is influenced by the nature of the substrate.

In order to determine the thickness of the surface films, one may use only the external reflectance spectra. For this, it is necessary that the film should have even thickness and that it should have values comparable to the wavelength of the radiation. Interference fringes may occur between the radiation reflected from the interface air/film and one that reflects the film/metal interface and crossing the film 2 times. The interference fringes are missing in case of internal reflection [4].

## 2. EXPERIMENTS

Thin films of polystyrene (PS) were obtained by depositing a solution of polymer dissolved in toluene on the surface of OLC-35 steel. Reducing the solvent evaporation rate allows us to obtain a film with an even thickness. The low concentration of polymer in the solvent allowed us to obtain thin films with thickness less than 1μm. Then, the metal sample coated with polymer was heated to 500°C, in order to evaporate all traces of solvent. The metallic surfaces used as substrates were obtained by grinding and polishing.

IR reflectance spectra were recorded using the specular reflection device of the UR-20 spectrograph.

In order to obtain the optical constants of the polymer film, the reflection-absorption spectra were processed using the RefFIT software [10].

## 3. RESULTS AND DISCUSSION

The IR reflection-absorption spectra recorded at incidence angles of 20 and 55 degrees are shown in Figure 3. The diagram shows the spectral ranges 500-850 $cm^{-1}$ and 2400-3360 $cm^{-1}$, which contain absorption bands corresponding to the C-H stretching vibrations of aromatic nucleus [2].

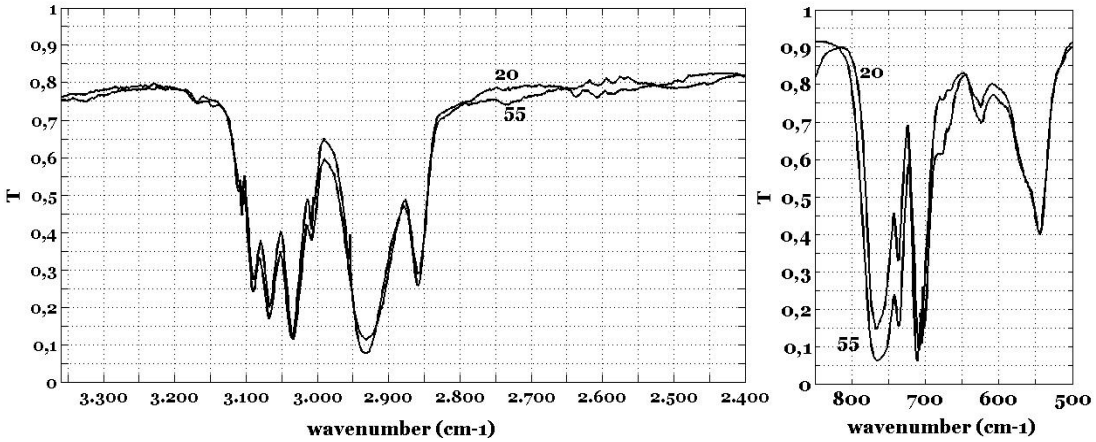



Figure 3. The reflection-absorption spectrum of polystyrene deposited on steel, recorded for 20 and 55 degrees angles of incidence

It is noted that changing the angle of incidence does not alter significantly the transmission spectrum of polystyrene. Reflectance R and transmittance T depend very little on the incidence angle, as can be observed in Figure 1.

Because the thickness of the superficial film is less than 1μm, the interference fringes are not present in the recorded spectra. For the same reason the recorded spectrum is a reflection-absorption (transflection) one.

The spectrum obtained can be processed to obtain the optical constants n (refractive index) and k (absorption index).

In order to improve the accuracy of the dielectric function, both R-A spectra recorded at incidence angles of 20 and 55 degrees were simultaneously fit. We also used the refractive index of polystyrene $n_f = 1.57$ ellipsometrically determined for $\lambda = 562.5$ nm [7] and the value $n_f = 1.5842$ for $\lambda = 633$ nm [1].

The refractive index spectrum obtained by dispersion analysis of reflection-absorption spectrum for polystyrene deposited on steel is shown in Figure 4.

Absorption index k has a spectrum very similar to the absorption spectrum. The values of the absorption coefficient are low so that it can be concluded that polystyrene is almost transparent and in the IR range. In this spectrum the positions of the absorption bands do not show deviations from the positions of the absorption bands in the reflection-absorption spectrum. It can also be noticed that the intensity of absorption bands decreases at higher frequencies. The wavenumbers corresponding to the model used are about 5 $cm^{-1}$ higher than those of literature [2].

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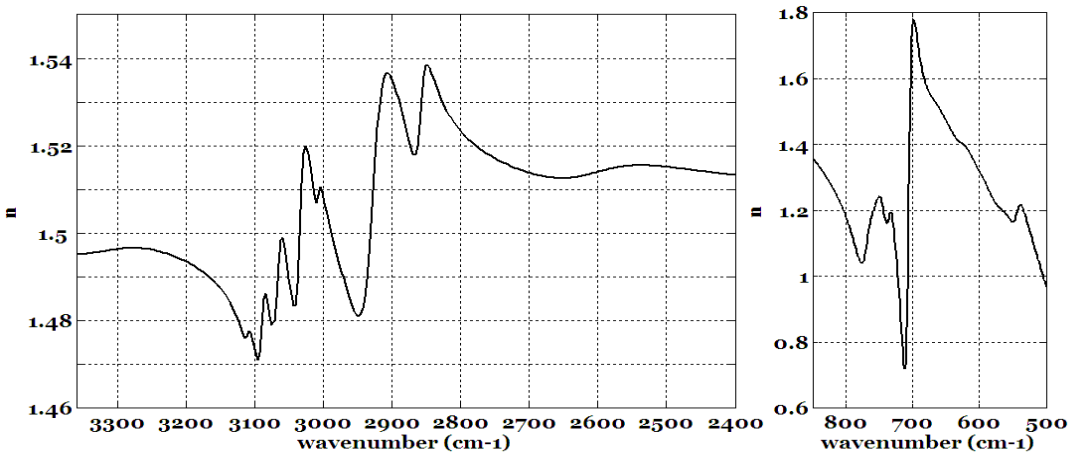



Figure 4. The refractive index spectrum for polystyrene deposited on steel

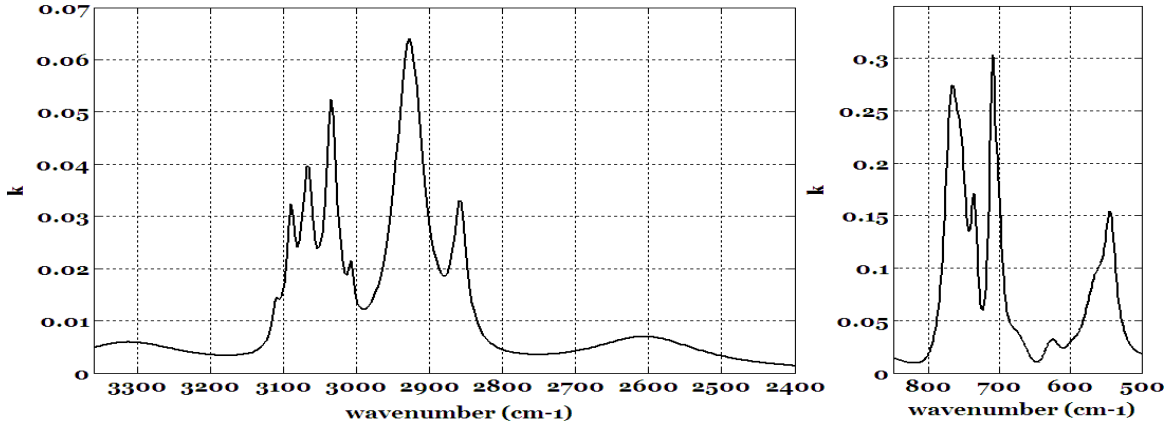



Figure 5. The absorption index (extinction coefficient k) spectrum for polystyrene deposited on steel

## 4. CONCLUSIONS

The IR reflectance spectra for thin films (with thickness less than 1μm) are reflection-absorption spectra in which transmittance T is recorded. The reflection-absorption spectrum for polymer films is very similar in terms of quality to the transmission spectrum.

The dispersion analysis of the reflection-absorption spectra is more accurate and easier than the Kramers-Kronig analysis. Kramers-Kronig analysis is used mainly for superficial thick films or for bulk material.

Simultaneous fitting of several datasets of different types related to the superficial film leads to obtaining correct values for optical constants **n** and **k**.

The internal reflectance spectra for thin films, deposited on metals, with thickness less than the depth of penetration at angles of incidence greater than the critical angle are the reflection-absorption spectra and not the attenuated total reflectance spectra. They have the same look as the transmission spectra and can be used to determine the optical constants of the superficial film.

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# MATHEMATICAL MODEL FOR THE BLOOD FLOW IN CAPILLARY VESSELS

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**Abstract:**
In this paper we develop an original model for the blood flow in capillaries. In the first approach the Stokes system is accepted for the blood flow in capillaries and the fluid is considered to be incompressible. The vessels' walls have a linear elastic and permeable behavior. For the second model a non-Newtonian, rheological model for the blood flow, with a non-constant viscosity coefficient, is used, the walls of the capillaries being linearly elastic, permeable and porous.

**Key words:**
blood flow in capillary vessels, Newtonian-model, rheological model, elastic permeable porous walls.

## 1. INTRODUCTION

The most important aspect of the blood flow in capillaries is to supply "with food" the living cells of the organs and to remove the byproducts from every cell. The capillary vessels are built so that molecules with different dimensions can penetrate through the tissues in the surroundings of the capillaries in both ways. Generally capillaries are considered as tubes with very thin and porous walls, through which the transport of certain substances are realized. The presence of these pores and the small diameter of the capillaries distinguish these types of vessels from the others. Due to this reduced diameter and the slow character of the flow we can neglect the non-stationary (pulsating) aspect connected to the rhythmical pumping of the blood by the heart. Furthermore we can neglect the inertial (convective) aspects connected to the viscosity of the blood. Moreover the permeable (porous) character of the capillaries is dominating the elasticity of the vessels' walls.

## 2. NEWTONIAN MODEL FOR THE BLOOD FLOW IN CAPILLARIES

The first model we propose accepts for the blood flow in thin vessels the Stokes system for incompressible fluids, taking into consideration that the Reynolds number is small. Implicitly it is accepted that the blood is homogenous, the viscosity is constant, the flow has a laminar character and there are no exterior field forces.

The vessels' walls have a linear elastic and permeable behavior and the fluid (substance) change through these walls, very small in volume, respects the Starling hypothesis [7]. This classical hypothesis, which was checked experimentally later by many researchers (Mauro [3], Meschia [4], etc.), maintains the fact that the mass debit through this kind of capillary wall is proportional with the pressure difference between the exterior and the interior of the capillary tube. Moreover, using the results of Beavers and Joseph [1], it is accepted the existence of a slip condition, along the permeable surface, which is "covered" by a porous media, an essential condition confirmed also experimentally.

For simplification we accept the axi-symmetric character of the flow, the axis of symmetry being $Oz$. Using the cylindrical coordinates $(r,\theta,z)$, the motion domain will be, at every time $t$:

$$\Omega(t) \equiv \{(r,\theta,z) / r < R + \eta(z,t),\ \ \theta \in [0,2\pi),\ z \in (0,L)\}, \tag{1}$$

where $R$ and $L$ are the (initial) radius and the length of the tube respectively, $\eta$ is the elastic displacement of the wall $\Sigma(t) \equiv \{r = R + \eta(z,t), z \in (0,L)\}$ at the considered moment.

Noting by $(u,v)$ the velocity components of the blood in the directions $z$ and $r$ respectively, by $p$ the pressure while by $\mu$ the dynamic viscosity coefficient, the motion equations (Stokes) and the continuity equation becomes

$$\frac{\partial p}{\partial r} = \mu\left(\frac{\partial^2 v}{\partial r^2} + \frac{1}{r}\frac{\partial v}{\partial r} - \frac{v}{r^2} + \frac{\partial^2 v}{\partial z^2}\right) \tag{2}$$

$$\frac{\partial p}{\partial z} = \mu\left(\frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r} + \frac{\partial^2 u}{\partial z^2}\right) \tag{3}$$

and

$$\frac{1}{r}\frac{\partial}{\partial r}(rv) + \frac{\partial u}{\partial z} = 0 \tag{4}$$

For the boundary conditions, noting by $\bar{p}$ the average of the pressure values given in the respective section, we get:

$$\frac{\partial u}{\partial r} = 0 \text{ and } v = 0, \text{ for } r = 0 \tag{5}$$

$$\frac{\partial u}{\partial r} = -\frac{\beta}{\sqrt{k}}u \text{ and } v = K(p - \nu), \text{ for } r = R + \eta \tag{6}$$

$$\bar{p}(r,z) = p_a, \text{ for } z = 0 \tag{7}$$

$$\bar{p}(r,z) = p_v, \text{ for } z = L. \tag{8}$$

Here $\frac{\partial u}{\partial r} = -\frac{\beta}{\sqrt{k}}u$ is the Beavers-Joseph slip condition, where $\beta$ is the slip parameter, while $k$ is the specific permeability of the porous media, $v = K(p - \nu)$ is the consequence of the Starling law, where $K$ is the constant permeability of the wall, while $\nu$ (built by the interstitial and osmotic pressure) is a given constant. Concerning to $p_a$ and $p_v$ they are the arterial and venous pressure, both supposed constants.

Reffering to the elasticity of the capillary wall, accepting the linear elastic membrane model, the radial component of the stress can be expressed by the radial displacement $\eta$, such that:

$$T_r = \rho_m h\frac{\partial^2 \eta}{\partial t^2} + \frac{hE}{1-\sigma^2}\frac{1}{R^2}\eta + p_{ref}\frac{\eta}{R}, \tag{9}$$

where $h$ is the thickness of the membrane, $E$ the Young modulus, $\sigma$ the Poisson coefficient, $\rho_m$ is the density of the capillary wall, while $p_{ref}$ is the reference pressure in the "unperturbed" state, supposed to be constant (the above mentioned $p$ is in fact $p - p_{ref}$).

It is obvious that on a this kind of elastic wall the kinematic condition for the continuity of the pressure, evaluated on the deformed interface $\Sigma(t)$, must be satisfied, namely

$$\frac{\partial \eta(z,t)}{\partial t} = v(R + \eta(z,t), z) \text{ and } u(R + \eta(z,t), z) = 0. \tag{10}$$

These conditions together with the previous Beavers-Joseph and Starling conditions lead to $\frac{\partial \eta}{\partial t} = K(p - \gamma)$ and $\frac{\partial u}{\partial r} = 0$ for $r = R + \eta$ respectively.

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Concerning the dynamic condition, it implies the continuity of the stress along the deformable interface (wall). As the constitutive law accepted in this case is that of the Newtonian fluid, we must have along $\Sigma(t)$

$$[(p-p_{ref})[\mathbf{T}]-2\mu[\mathbf{D}]]\mathbf{n}\cdot\mathbf{e}_r = T_{r,} \tag{11}$$

which leads to

$$[(p-p_{ref})[\mathbf{T}]-2\mu[\mathbf{D}]]\mathbf{n}\cdot\mathbf{e}_r(1+\frac{\eta}{R})\sqrt{1+(\frac{\partial\eta}{\partial t})^2} = T_{r,} \tag{12}$$

on $\Sigma(t)$, at any time $t$.

## 3. RHEOLOGICAL NON-NEWTONIAN MODEL

In the previous model the blood was investigated as a Newtonian fluid and the system of equations was the Stokes system. Now we accept for the blood a rheological non-Newtonian representation with a non-constant viscosity coefficient. All the other assumptions (non-stationary character, incompressibility, homogeneity, linear elasticity, porosity of the wall) are the same, like in the previous model. The Starling hypothesis and the Beavers-Joseph slip condition are also fulfilled.

We accept again the axi-symmetric character of the blood flow in the capillary tube, the axis of symmetry being $Oz$. Using the cylindrical coordinates $(r,\theta,z)$, the motion domain will be, at every time $t$, $\Omega(t)\equiv\{(r,\theta,z)/r<R+\eta(z,t),\ \theta\in[0,2\pi),z\in(0,L)\}$, where $R$, $L$, $\eta(z,t)$ and $\Sigma(t)$ have the same meaning as in the previous model.

In the meridian plane $\theta=const$ if $u_z$ and $u_r$ are the components of the velocity in $z$ and $r$ directions, if $p$ is the pressure (evaluated to a reference pressure $p_{ref}$), then in the absence of the exterior forces, the mass conservation principle (continuity equation) can be written as

$$\frac{1}{r}\frac{\partial}{\partial r}(ru_r)+\frac{\partial u_z}{\partial z}=0. \tag{13}$$

Concerning the flow equations they are obtained from the general Cauchy motion equations, where for the stress tensor we accept the following representation (rheological model for blood)

$$\mathbf{T}=-[p+\lambda(\frac{\partial K}{\partial\dot\gamma}\ddot\gamma+\frac{\alpha}{\eta_p}\mathrm{K}^2)]\mathbf{I}+2(\eta_s+\eta_{RBC})\mathbf{D}, \tag{14}$$

where $\mathbf{D}$ is the rate of strain tensor while $\mathbf{I}$ the unity tensor, $p$ the physical pressure, while $\eta_{RBC}$ is given by (the Cross model):

$$\eta_{RBC}=\frac{\eta_0^*}{1+(k\dot\gamma)^{1-n}}\equiv\eta_p+\lambda\mathrm{K}(\dot\gamma). \tag{15}$$

with $\dot\gamma=\left|4I_2\right|^{1/2}$, $I_2$ being the second invariant of the rate of strain tensor $\mathbf{D}$, $\eta_s$ the plasma viscosity, $\eta_p$ and $\eta_0^*$ the viscosity coefficients of the blood, $\alpha$ the "relaxation time", $k$ is a time constant for the shear thining behavior, $n$ the shear thining index, $\alpha$ the mobility parameter, while the function

$$K(\dot\gamma)=\frac{1}{\lambda}(\frac{\eta_0^*}{1+(k\dot\gamma)^{1-n}}-\eta_p),\ \text{for}\ \lambda>0 \tag{16}$$

is the so called normal function in the variable $\dot\gamma$, which measures the variation of deformation.

For sake of simplicity we denote

$$\eta(\dot\gamma)=\lambda K(\dot\gamma)+\eta_s+\eta_p\equiv\eta_s+\eta_{RBC},$$

$$L=-\frac{2\alpha\lambda}{\eta_p}\frac{\partial \mathrm{K}}{\partial\dot\gamma}-\lambda\frac{\partial^2\mathrm{K}}{\partial\dot\gamma^2}\ddot\gamma \text{ and}$$

$M=-\frac{k\eta_0^*(1-n)(k\dot\gamma)^{-n}}{[1+(k\dot\gamma)^{1-n}]^2}$, so that, expressing the tensor **D** and the other operators ($\frac{\partial}{\partial x_i}=\ldots$ etc.) in cylindrical coordinates, we arrive to the following two equations of flow (in $u_z$ and $u_r$, $u_\theta=0$)

$$\rho\left(\frac{\partial u_r}{\partial t}+u_r\frac{\partial u_r}{\partial r}+u_z\frac{\partial u_r}{\partial z}\right)=-\frac{\partial p}{\partial r}+\eta(\dot\gamma)\left(\frac{\partial^2 u_r}{\partial r^2}+\frac{1}{r}\frac{\partial u_r}{\partial r}+\frac{\partial^2 u_r}{\partial z^2}\right)+ +L\frac{\partial\dot\gamma}{\partial r}+M\left[-\frac{\partial\ddot\gamma}{\partial r}+2\frac{\partial\dot\gamma}{\partial r}\frac{\partial u_r}{\partial r}+\frac{\partial\dot\gamma}{\partial z}\left(\frac{\partial u_r}{\partial z}+\frac{\partial u_z}{\partial r}\right)\right], \tag{17}$$

$$\rho\left(\frac{\partial u_z}{\partial t}+u_r\frac{\partial u_z}{\partial r}+u_z\frac{\partial u_z}{\partial z}\right)=-\frac{\partial p}{\partial z}+\eta(\dot\gamma)\left(\frac{\partial^2 u_z}{\partial r^2}+\frac{1}{r}\frac{\partial u_z}{\partial r}+\frac{\partial^2 u_z}{\partial z^2}\right)+ +L\frac{\partial\dot\gamma}{\partial z}+M\left[-\frac{\partial\ddot\gamma}{\partial z}+2\frac{\partial\dot\gamma}{\partial z}\frac{\partial u_z}{\partial r}+\frac{\partial\dot\gamma}{\partial r}\left(\frac{\partial u_r}{\partial z}+\frac{\partial u_z}{\partial r}\right)\right]. \tag{18}$$

These evolution systems are completed by the boundary conditions which express both the presence of a pressure gradient along the *Oz* axis (in accord with the rhythmical pumping of the blood in vessels) and the elastic character of the permeable, porous wall, more precisely

$$\frac{\partial u_z}{\partial r}=0 \text{ and } u_r=0 \text{ for } r=0, \tag{19}$$

$$\frac{\partial u_z}{\partial r}=-\frac{\beta}{\sqrt{\mathrm{K}}}u_z \text{ and } u_r=\mathrm{K}(p-\nu) \text{ for } r=R+\eta(z,t), \tag{20}$$

(the first relation in (20) expresses the Beavers-Joseph slip condition with the slip parameter $\beta$ while $K$ is the specific permeability of the porous media, meantime $u_r=\mathrm{K}(p-\nu)$ is the consequence of the Starling law, with K the constant permeability of the wall, $\nu$, built by the interstitial and osmotic pressure, supposed to be fixed and $a$ a given constant), while for the pressure we have

$$p=\frac{\cos(\omega t)}{a}+p_m \text{ for } z=0, \text{ where } a>0, \tag{21}$$

$$p=\frac{\cos(\omega t)}{a+L}+p_m \text{ for } z=L, \text{ where } a>0, \tag{22}$$

where $p_m=\frac{\int_0^R f(r)dr}{R}\equiv f(\xi)$, $f$ is a primitivable and derivable function according to *r*, with a maximum for $r=0$ and a minimum for $r=R+\eta$. It can be remarked that $p\big|_{z=0}>p\big|_{z=L}$ at any time of the motion $(0,\ T)$.

Observations: These boundary conditions on the "edges" $z=0$ and $z=L$ of the capillary are in accord with the acceptance of a representation for the pressure of the type $p=\frac{\cos(\omega t)}{a+z}+f(r)$, namely of a pressure gradient (in the cylindrical reference $\vec e_z,\vec e_r$) under the form $\mathrm{grad}p=-\frac{\cos(\omega t)}{(a+z)^2}\vec e_z+f'(r)\vec e_r$. If $f'(0)=0$ and $f'(R+\eta(z,t))=0$ we have

$\text{grad}p\big|_{Oz} = -\dfrac{\cos(\omega t)}{(a+z)^2} = \text{grad}p\big|_{r=R+\eta(z,t)}$, in accord with the motion of the pressure in the interior of the capillary.

On the other hand accepting for the capillary wall the linear elastic membrane model, the radial component of the membrane's stress is expressed by the radial displacement $\eta$ as follows

$$T_r = \rho_m h\frac{\partial^2\eta}{\partial t^2} + \frac{hE}{1-\sigma^2}\frac{1}{R^2}\eta + p_{ref}\frac{\eta}{R}, \tag{23}$$

where $h$ is the thickness of the membrane, $E$ the Young modulus, $\sigma$ the Poisson coefficient, $\rho_m$ is the density of the capillary wall while $p_{ref}$ is the reference pressure in the "unperturbed" state. It is evident that this stress must coincide with the stress generated by the blood on the same radial direction, namely $\vec{T} = \mathbf{T}\vec{n}\cdot\vec{e}_r = T_r$, which represents the relation for determining $f$ (the pressure) or $\eta(z,t)$.

At the same time the kinetic condition must be satisfied on the elastic wall, $\dfrac{\partial\eta}{\partial t} = u_r(R+\eta(z,t),z)$ but also $u_z(R+\eta(z,t),z) = 0$, what leads to $\dfrac{\partial\eta}{\partial t} = \mathrm{K}(p(z,r,t)-\nu)$ and $\dfrac{\partial u_z}{\partial r} = 0$ for $r = R+\eta$ respectively.

It can be remarked that the last relation, together with $u_z(R+\eta(z,t),z) = 0$, implies $u_z = 0$ in the whole a surrounding of the elastic wall while the conditions $\dfrac{\partial u_z}{\partial r} = 0$ and $u_r = 0$ for the axis $r = 0$ show that $\vec{u} = u_z\vec{e}_z$ depends only on $z$ and $t$ so that we have a pulsating flow along the axis $Oz$, which "calms down" on the elastic wall ($u_z = 0$) where the exterior imposed pressure will have a minimum. At the same time from $\dfrac{\partial\eta}{\partial t} = \mathrm{K}(p(z,r,t)-\nu)\Big|_{r=R+\eta(z,t)}$ we obtain $\dfrac{\partial^2\eta}{\partial t^2} = \mathrm{K}\left(\dfrac{-\omega\sin(\omega t)}{a+z}\right)\Big|_{r=R+\eta(z,t)}$. This last evaluation for $\dfrac{\partial^2\eta}{\partial t^2}$ permits us to make precise the condition on the capillary wall (linear elastic membrane), namely the expression of the "equilibrium" condition $\mathbf{T}\vec{n}\cdot\vec{e}_r = T_r$ in cylindrical coordinates. More precisely if we note by

$$P = [p + \lambda(\frac{\partial\mathsf{K}}{\partial\dot{\gamma}}\ddot{\gamma} + \frac{\alpha}{\eta_p}\mathsf{K}^2)] \tag{24}$$

the equilibrium condition becomes

$$-\frac{P}{\sqrt{1+(\frac{\partial\eta}{\partial z})^2}} + \frac{2\eta(\dot{\gamma})}{\sqrt{1+(\frac{\partial\eta}{\partial z})^2}}\frac{\partial u_r}{\partial r} - \frac{\frac{\partial\eta}{\partial z}}{\sqrt{1+(\frac{\partial\eta}{\partial z})^2}}(\frac{\partial u_r}{\partial z} + \frac{\partial u_z}{\partial r}) = \rho_m h(-\frac{\mathrm{K}\omega\sin(\omega t)}{a+z}) + \frac{hE}{1-\sigma^2}\frac{1}{R^2}\eta + p_{ref}\frac{\eta}{R}, \tag{25}$$

what provides an equation to determine the deformation of the capillary wall, namely $\eta(z,t)$, so that the whole set of unknowns of our problem can be determined.

## 4. CONCLUSIONS

In this paper we elaborated an original mathematical model for the blood flow in capillary vessels. First we presented a model where the blood was accepted as a Newtonian

fluid. In the second approach we extended the model to a more general rheological (non-Newtonian) blood behavior which stands closer to the realistic phenomena.

The previous model will be approached numerically in another paper where we will also consider a more general behavior for the blood.

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# A THREE DIMENSIONAL AXI-SYMMETRIC MODEL FOR THE BLOOD FLOW IN THIN VESSELS

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**Abstract:**
In this paper, taking into consideration the rheological Cross model, we elaborate a three dimensional axi-symmetric numerical model for the blood flow in thin vessels with adequate algorithms. First we consider the vessel wall to be rigid than we take into account the elastic and porous behavior of this wall what leads to a more realistic approach of the problem.

**Key words:**
rheological Cross model, blood flow in thin vessels, elastic porous walls.

## 1. INTRODUCTION

In the proposed model, set up in this work, we accept for the blood flow a rheological non-Newtonian representation with a non-constant viscosity coefficient. The blood is considered to be a homogenous fluid, the flow has a laminar character and there are no exterior field forces. The walls of the vessels have a linear elastic, permeable and porous behavior. For the blood flow in the vessel we also accept an axial symmetry (*Oz* being the axis of symmetry). Using the cylindrical coordinates $(r,\theta,z)$, the motion domain will be, at every time $t$, $\Omega(t) \equiv \{(r,\theta,z)/r < R + \mu(z,t),\ \ \theta \in [0,2\pi),\ z \in (0,L)\}$, where $R$ and $L$ are the (initial) radius and the length of the tube(vessel) respectively, $\mu$ is the elastic displacement of the wall $\Sigma(t) \equiv \{r = R + \mu(z,t), z \in (0,L)\}$ at the considered moment.

## 2. NUMERICAL MODEL FOR THE BLOOD FLOW IN THIN VESSELS

This model is based on the rheological Cross model, where the viscosity coefficient for the blood is not constant and can be written as follows

$$\eta(\dot{\gamma}) = \eta_s + \frac{\eta_0^*}{1 + k\dot{\gamma}^{1-n}}, \qquad (1)$$

where $\eta_s$ is the plasma viscosity, $\dot{\gamma} = \left|4I_2\right|^{1/2}$, $I_2$ being the second invariant of the rate of strain tensor $\mathbf{D}$ ($\mathbf{D}$ is the rate of strain tensor), $\eta_0^*$ the viscosity coefficient of the blood and $k$ is a time constant for the shear thining behavior.

In the absence of the exterior forces we can write for the continuity equation

$$\frac{1}{r}\frac{\partial}{\partial r}(ru_r) + \frac{\partial u_z}{\partial z} = 0, \qquad (2)$$

where $u_z$ and $u_r$ are the components of the velocity in $z$ and $r$ directions respectively. For the flow equations we use the general Cauchy motion equations, where we accept for the stress tensor the following representation

$$\mathbf{T} = -[p + \lambda(\frac{\partial K}{\partial \dot{\gamma}}\ddot{\gamma} + \frac{\alpha}{\eta_p}\mathrm{K}^2)]\mathbf{I} + 2(\eta_s + \eta_{RBC})\mathbf{D}, . \qquad (3)$$

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where where **D** is the rate of strain tensor while **I** is the unity tensor, $p$ the physical pressure and $\eta_{RBC}$ is given by the Cross model

$$\eta_{RBC} = \frac{\eta_0^*}{1+(k\dot{\gamma})^{1-n}}, \tag{4}$$

$with\ n$ the shear thining index, $\alpha$ the mobility parameter, while the function

$$K(\dot{\gamma}) = \frac{1}{\lambda}\left(\frac{\eta_0^*}{1+(k\dot{\gamma})^{1-n}} - \eta_p\right),\ \text{for}\ \lambda > 0, \tag{5}$$

is the so called normal function of the variable $\dot{\gamma}$, which measures the variation of deformation.

Using the above mentioned Cross model, the continuity equation and the Cauchy motion equations, expressing the tensor **D** and the other involved operators in cylindrical coordinates, we arrive to the following three dimensional axi-symmetric system

$$\frac{1}{r}\frac{\partial(ru)}{\partial r} + \frac{\partial v}{\partial z} = 0 \tag{6}$$

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial r} + v\frac{\partial u}{\partial z}\right) + \frac{\partial p}{\partial r} = \eta(\dot{\gamma})\Delta' u + L\frac{\partial \dot{\gamma}}{\partial r} + M\left[-\frac{\partial \ddot{\gamma}}{\partial r} + 2\frac{\partial \dot{\gamma}}{\partial r}\frac{\partial u}{\partial r} + \frac{\partial \dot{\gamma}}{\partial z}\left(\frac{\partial u}{\partial z} + \frac{\partial v}{\partial r}\right)\right] \tag{7}$$

$$\rho\left(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial r} + v\frac{\partial v}{\partial z}\right) + \frac{\partial p}{\partial z} = \eta(\dot{\gamma})\Delta' v + L\frac{\partial \dot{\gamma}}{\partial z} + M\left[-\frac{\partial \ddot{\gamma}}{\partial z} + 2\frac{\partial \dot{\gamma}}{\partial z}\frac{\partial v}{\partial z} + \frac{\partial \dot{\gamma}}{\partial r}\left(\frac{\partial u}{\partial z} + \frac{\partial v}{\partial r}\right)\right]. \tag{8}$$

where $u$ is the radial velocity (in direction $r$), $v$ the axial velocity (in direction $z$) and $p$ is the pressure, while

$$\dot{\gamma} = \sqrt{2\left(\frac{\partial u}{\partial r}\right)^2 + 2\left(\frac{\partial v}{\partial z}\right)^2 + \left(\frac{\partial u}{\partial z} + \frac{\partial v}{\partial r}\right)^2 + 2\left(\frac{u}{r}\right)^2}$$

$$L = -\frac{2\lambda\alpha}{\eta_p}\mathrm{K}\frac{\partial \mathrm{K}}{\partial \dot{\gamma}} - \lambda\frac{\partial^2 \mathrm{K}}{\partial \dot{\gamma}^2}\ddot{\gamma} \tag{9}$$

$$M = \lambda\frac{\partial \mathrm{K}}{\partial \dot{\gamma}},\ \mathrm{K}(\dot{\gamma}) = \frac{1}{\lambda}\left(\frac{\eta_0^*}{1+k\dot{\gamma}^{1-n}} - \eta_p\right)$$

These evolution systems are completed by the boundary conditions which express both the presence of a pressure gradient along the *Oz* axis (in accord with the rhythmical pumping of the blood in vessels) and the elastic character of the permeable, porous wall

$$\frac{\partial u_z}{\partial r} = 0\ \text{and}\ u_r = 0\ \text{for}\ r = 0, \tag{10}$$

$$\frac{\partial u_z}{\partial r} = -\frac{\beta}{\sqrt{\mathrm{K}}}u_z\ \text{and}\ u_r = \mathrm{K}(p - v)\ \text{for}\ r = R + \mu(z,t), \tag{11}$$

In the first relation of (11) the Beavers-Joseph slip condition is expressed with the slip parameter $\beta$ while $K$ is the specific permeability of the porous media, meantime $u_r = \mathrm{K}(p - v)$ is the consequence of the Starling law, with K the constant permeability of the wall, $v$ is built by the interstitial and osmotic pressure, supposed to be fixed, and $a$ is a given constant.

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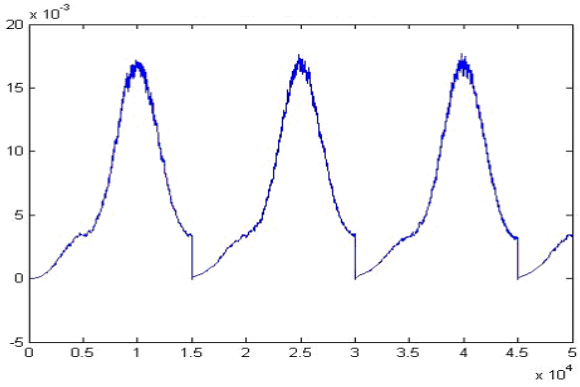



Figure 1. Evolution of the central axial velocity

We have calculated the case of the rigid wall and numerical tests have been effectuated for a vessel with radius 100μm. It was used the finite difference method (to simplify the program on a right angle domain), with separate nodes for $u$, $v$, $p$.

The evolution in time was made with the Adams-Basforth-Crank-Nicholson method with implicit part for the Laplacian and explicit part for the non-linear components. Thus, at every time step a huge linear system is to be solved but with a sparse matrix. It is necessary to work with small time step ($dt$=0.0001) for assuring the numerical stability. The algorithm presents some oscillations of the calculated solution but these don't disturb the stability. The work efficiency is acceptable (15000 time steps in about 2 hours). The attached figure 1 presents the evolution of the longitudinal velocity in the centre of the vessel for oscillating input and output pressure.

$$pin = 10100\ Pa * fact$$
$$pout = 10000\ Pa * fact$$
$$fact = \begin{cases} \sin \pi t, 0 < t < \frac{1}{2} \\ \frac{3}{2} - \frac{1}{2}\cos(2\pi(t - \frac{1}{2})), \frac{1}{2} < t < \frac{3}{2} \end{cases} \quad (12)$$

## 3. NUMERICAL MODEL FOR THE ELASTIC WALLS

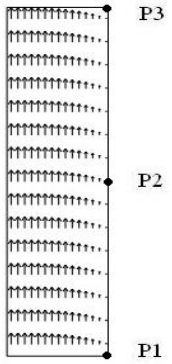



Figure 2. The velocity field at time t=1

One step further we use the presented mathematical model in the case when the elasticity and the porosity of the vessel wall are also considered. The data used for the numerical algorithms were achieved experimentally by C. Balan [1].

We have worked with a small vessel segment of radius $10^{-4} m$ and length of $4*10^{-4} m$. The blood parameters of the proposed model are: $\eta_S = 10^{-3} Pas$, $\eta_0^* = 1Pas$, $k = 100$, $n = 0.2$, $\lambda = 100$, $\alpha = 50$, the mass density is $1060 kg/m^3$. We considered an oscillatory pressure $pin = 10100 + 150\cos(2\pi t) Pas$ on the input boundary ($z = 0$) and a constant pressure on the output boundary $pout = 10000 Pa$. The permeability constant is $K = 5*10^{-5}$ and the osmotic pressure is $\nu = 9900$. On the axis of symmetry we imposed the axial symmetry requirements and on the tube walls the Beavers-Joseph condition [2] and the permeability condition (Starling law [5]) $u_r = \mathrm{K}(p - \nu)$.

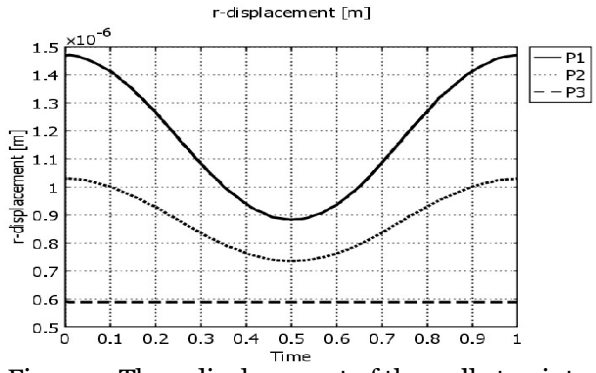



Figure 3. The r-displacement of the wall at points P1, P2 and P3

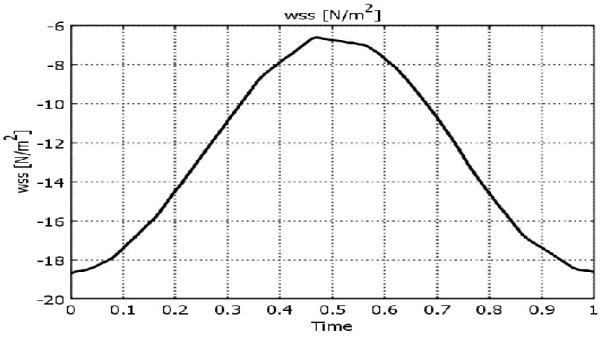



Figure 4. The WSS at point P2

On the attached figures some results of the numerical experiments are presented: on figure 2 the velocity field at the moment $t = 1$, on figure 3 the r-displacement (in the direction of the radius) of the wall at points P1, P2 and P3, on figure 4 the wall shear stress ($WSS = \eta(\frac{\partial u_r}{\partial z} + \frac{\partial u_z}{\partial r})$ evaluated at P2 is shown.

## 4. CONCLUSIONS

In this paper by considering a more general rheological model for the blood flow in thin vessels, with adequate numerical algorithms and solvers, we got some results for the longitudinal velocity in the case of the rigid vessel wall. Considering the elastic, porous behavior of the wall we obtained other results for the velocity field, for the r-displacement of the wall and for the wall shear stress (WSS).

In the future we will try to elaborate other numerical algorithms for reducing the calculation time and to eliminate completely the oscillating behavior. We also mention that this implemented rheological model can be easily set up, adjusting the parameters to obtain a better correspondence with the physical measurements.

The completed model can be applied for stenotic arteries, even in the 3-D case (axi-symmetric).

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# CONSIDERATIONS UPON THE $C_R^2$ TRUNCATED EXPONENTIAL DISTRIBUTION

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**Abstract**

In this paper we generalize the one-dimensional exponential distribution, considering a continuous and twice differentiable extension of the truncated discontinuous probability density of exponential distribution.
Theoretical statements are in agreement with numerical analysis of data sets, calculations being performed in MathCAD package.

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# ON H-TRICHOTOMY IN BANACH SPACES

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**Abstract**

In this paper we emphasize the notion of skew-evolution semiflows, considered a generalization of semigroups, evolution operators and skew-product semiflows, which arise in the stability theory. We define and characterize a particular case of trichotomy, called the *H*-trichotomy, which is useful in describing the behaviors of the solution of evolution equations. We emphasize the fact that the trichtomy, introduced in finite dimensions in [1] and [5], is a natural generalization of dichotomy. A similar concept for stability was studied for evolution operators in [2]. This paper considers also other asymptotic properties, as exponential growth and decay, stability and instability.

*Mathematics Subject Classification*: 34D09

**Keywords:**

evolution equation, skew-evolution semiflow, *H*-trichotomy

## 1. INTRODUCTION

The concept of skew-evolution semiflows arises in the theory of evolution equations, which, as well as the theory of optimal control, is an important tool in describing processes derived from engineering or economics. The dynamical systems that study the real life phenomena are complex and the identification of appropriated mathematical models is difficult because in the case of systems described by partial differential equations the state space is often of infinite dimension. It is interesting to reconsider the definitions of asymptotic properties for differential equations by means of skew-evolution semiflows. In what follows, we will consider a more general case for asymptotic behaviors that not involves necessarily exponentials, but, instead, properly defined functions. Let us define the set $\Gamma$ of all continuous functions $H:\mathbb{R}_+ \to \mathbb{R}_+^*$. We will denote by $\Theta$ the set of all functions $f:\mathbb{R}_+ \to \mathbb{R}_+$ with the property that there exists a constant $\mu \in \mathbb{R}$ *such that* $f(t)=e^{\mu t}$, $\forall t \geq 0$, with the subsets $\Theta_+$ and $\Theta_-$, for positive, respectively negative values of $\mu$. By $\Psi$ is denoted the set of continuous functions $h:\mathbb{R}_+ \to [1,\infty)$ defined such that, for all $H \in \Gamma$, there exist a function $f \in \Theta$ and a constant $k > 0$ with the properties

$$h(s) \leq k f(t-s) H(t), \ \forall t,s \geq 0 \text{ and } h(2t)h(2s) \leq H(t+s), \ \forall t,s \geq 0.$$

**Remark 1.1.** The set $\Psi$ is not empty, as we can consider

$$h(t)=f(t)=e^{\nu t} \text{ and } H(t)=e^{2\nu t}, \ \nu > 0, \ t \geq 0.$$

We will emphasize the notion of skew-evolution semiflows by means of evolution semiflows and evolution cocycles, as introduced by us in [4]. They naturally generalize notions as operators semigroups, evolution operators or skew-product semiflows. A skew-evolution semiflow depends on three variabiles, contrary to a skew-product semiflow, which depends only on two, and, hence, the study of asymptotic behaviors for skew-evolution semiflows in the nonuniform setting arises as natural, relative to the third variabile. In this paper we will also consider the definitions and characterizations of some asymptotic properties, by means of the set of functions $\Theta$, $\Gamma$ and $\Psi$.

## 2. SKEW-EVOLUTION SEMIFLOWS

Let us consider *(X, d)* a metric space, *V* a real or complex Banach space , $V^*$ its topological dual and *B(V)* the family of linear *V*-valued bounded operators defined on *V*. The norm of vectors and operators is $\|\cdot\|$.

In what follows, we will denote $Y = X \times V$ and we will consider the set $T = \{(t,t_0) \in R \mid t \geq t_0 \geq 0\}$. By $I$ is designed the identity operator on $V$.

**Definition 2.1.** A mapping $\varphi : T \times X \to X$ with the properties:

$(s_1)$ $\varphi(t,t,x) = x$, $\forall (t,x) \in R_+ \times X$;

$(s_2)$ $\varphi(t,s,\varphi(s,t_0,x)) = \varphi(t,t_0,x)$, $\forall (t,s),(s,t_0) \in T$, $\forall x \in X$

is called *evolution semiflow* on $X$.

**Definition 2.2.** A mapping $\Phi : T \times X \to B(V)$ with the properties:

$(c_1)$ $\Phi(t,t,x) = I$, $\forall (t,x) \in R_+ \times X$;

$(c_2)$ $\Phi(t,s,\varphi(s,t_0,x))\Phi(s,t_0,x) = \Phi(t,t_0,x)$, $\forall (t,s),(s,t_0) \in T$, $\forall x \in X$

is called *evolution cocycle* over the evolution semiflow $\varphi$.

**Definition 2.3.** The mapping

$$C : T \times Y \to Y,\ C(t,s,x,v) = (\varphi(t,s,x), \Phi(t,s,x)v),$$

where $\varphi$ is an evolution semiflow on $X$ and the mapping $\Phi$ is an evolution cocycle over $\varphi$, is called *skew-evolution semiflow* on $Y$.

The next example emphasizes a skew-evolution semiflow generated by a system of differential equations.

**Example 2.1.** Let us consider the system of differential equations

$$\begin{cases} \dot{u} = (2t\sin t - 3)u \\ \dot{w} = (t\cos t + 2)w \\ \dot{z} = (2 - \cos t)z. \end{cases}$$

Let us define the spaces $X = \boldsymbol{R}_+$ and $V = \boldsymbol{R}^3$, which is endowed with the norm $\|v\| = |v_1| + |v_2| + |v_3|$, where $v = (v_1, v_2, v_3) \in V$.

The mapping

$$\varphi : T \times R_+ \to R_+,\ \varphi(t,s,x) = t - s + x$$

is an evolution semiflow on $\boldsymbol{R}_+$.

The mapping

$$\Phi : T \times X \to B(V),\ \Phi(t,s,x)(v_1,v_2,v_3) = (U(t,s)v_1, W(t,s)v_2, Z(t,s)v_3),$$

where $U(t,s) = u(t)u^{-1}(s)$, $W(t,s) = w(t)w^{-1}(s)$, $Z(t,s) = z(t)z^{-1}(s)$, $\forall (t,s) \in T$ and $u(t)$, $w(t)$ and $z(t)$, where $t \in \boldsymbol{R}_+$, are the solutions of the given system of differential equations, is an evolution cocycle over the evolution semiflow $\varphi$ on the metric space $\boldsymbol{R}_+$. We obtain that $C = (\varphi, \Phi)$ is a skew-evolution.

The following asymptotic behaviors of skew-evolution semiflow are useful in characterizing the property of $H$-trichotomy, as well as their characterizations.

**Definition 2.2.** A skew-evolution semiflow $C = (\varphi, \Phi)$ is said to have *exponential growth* if there exists a nondecreasing function $g : R_+ \to [1,\infty)$ with the property $\lim_{t\to\infty} g(t) = \infty$ such that:

$$\|\Phi(t,t_0,x)v\| \leq g(t-s)\|\Phi(s,t_0,x)v\|,\ \forall\ (t,s),(s,t_0) \in T,\ \forall\ (x,v) \in Y.$$

**Proposition 2.1.** *A skew-evolution semiflow $C = (\varphi, \Phi)$ has exponential growth if and only if there exist some constants $M \geq 1$ and $\omega > 0$ such that:*

$$\|\Phi(t,t_0,x)v\| \leq Me^{\omega(t-s)}\|\Phi(s,t_0,x)v\|,\ \forall\ (t,s),(s,t_0) \in T,\ \forall\ (x,v) \in Y.$$

**Proof.** *Necessity*. Let $t \geq s \geq t_0 \geq 0$ and $n$ be the integer part of the real number $t - s$. We obtain successively

$$\|\Phi(t,t_0,x)v\| \leq g(1)\|\Phi(t-1,t_0,x)v\| \leq \ldots \leq [g(1)]^n\|\Phi(t-n,t_0,x)v\| \leq$$
$$\leq Me^{n\omega}\|\Phi(s,t_0,x)v\| \leq Me^{\omega(t-s)}\|\Phi(s,t_0,x)v\|,$$

for all $(t,s),(s,t_0) \in T$ and all $(x,v) \in Y$, where we have denoted $M = g(1) > 1$ and $\omega = \ln M > 0$.

*Sufficiency*. It is obtained immediately if we consider $g(u) = Me^{\omega u}$, $u \geq 0$. □

**Definition 2.3.** A skew-evolution semiflow $C = (\varphi, \Phi)$ is said to be with *exponential decay* if there exists a nondecreasing function $g : R_+ \to [1,\infty)$ with the property $\lim_{t\to\infty} g(t) = \infty$ such that:

$$\left\|\Phi(s,t_0,x)v\right\| \le g(t-s)\left\|\Phi(t,t_0,x)v\right\|,\ \forall\ (t,s),(s,t_0)\in T,\ \forall\ (x,v)\in Y.$$

**Proposition 2.2.** *A skew-evolution semiflow* $C=(\varphi,\Phi)$ *has exponential decay if and only if there exist some constants* $M\ge 1$ *and* $\omega>0$ *such that:*

$$\left\|\Phi(s,t_0,x)v\right\| \le Me^{\omega(t-s)}\left\|\Phi(t,t_0,x)v\right\|,\ \forall\ (t,s),(s,t_0)\in T,\ \forall\ (x,v)\in Y.$$

**Proof.** *Necessity*. Let $t\ge s\ge t_0\ge 0$. There exists a natural number *n* such that. We have following relations

$$\left\|\Phi(s,t_0,x)v\right\| \le g(1)\left\|\Phi(s+1,t_0,x)v\right\| \le \ldots \le [g(1)]^n\left\|\Phi(s+n,t_0,x)v\right\| \le$$
$$\le Me^{n\omega}\left\|\Phi(t,t_0,x)v\right\| \le Me^{\omega(t-s)}\left\|\Phi(t,t_0,x)v\right\|,$$

for all $(t,s),(s,t_0)\in T$ and all $(x,v)\in Y$, where we have considered the constants $M = g(1) > 1$ and $\omega=\ln M>0$.

*Sufficiency*. It follows immediately for $g(u)=Me^{\omega u}$, $u\ge 0$.

## 3. ON THE PROPERTY OF *H*-TRICHOTOMY

A general concept of exponential trichotomy is emphasized in this section.

**Definition 3.1.** A mapping $P:Y\to Y$ given by $P(x,v)=(x,P(x)v)$, where $P(x)$ is a projection on $Y_x=\{x\}\times V$ and $x\in X$, is called *projector* on *Y*.

**Definition 3.2.** A skew-evolution semiflow $C=(\varphi,\Phi)$ is said to be *H-trichotomic* if there exist some mappings $N_1, N_2, N_3$: $\boldsymbol{R}_+\to\boldsymbol{R}_+^*$ and three projectors families $\{P_k\}_{k\in\{1,2,3\}}$ such that following conditions hold:

*($t_1$)* for each projector $P_k$, $k\in\{1,2,3\}$, the relation

$$P(\varphi(t,s,x))\Phi(t,s,x)=\Phi(t,s,x)P(x)$$

holds for all $(t,s)\in T$ and all $x\in X$;

*($t_2$)* for all $x\in X$, the projections $P_1(x)$, $P_2(x)$ and $P_3(x)$ satisfy the conditions

$$P_1(x)+P_2(x)+P_3(x)=I \text{ and } P_i(x)P_j(x)=0, \text{ for all } i,j\in\{1,2,3\},\ i\ne j;$$

*($t_3$)* following inequalities

$$(t_3^1)\ H(t)\left\|\Phi(t,t_0,x)P_1(x)v\right\| \le N_1(s)\left\|\Phi(s,t_0,x)P_1(x)v\right\|;$$
$$(t_3^2)\ H(s)\left\|\Phi(s,t_0,x)P_2(x)v\right\| \le N_2(t)\left\|\Phi(t,t_0,x)P_2(x)v\right\|;$$
$$(t_3^3)\ \left\|\Phi(t,t_0,x)P_3(x)v\right\| \le N_3(s)H(t)\left\|\Phi(s,t_0,x)P_3(x)v\right\| \text{ and}$$
$$\left\|\Phi(s,t_0,x)P_3(x)v\right\| \le N_3(t)H(s)\left\|\Phi(t,t_0,x)P_3(x)v\right\|,$$

hold for all $(t,s),(s,t_0)\in T$, for all $(x,v)\in Y$ and all $H\in\Gamma$.

**Remark 3.1.** In the particular case $H(t)=e^{\nu t}$, $t\ge 0$, $\nu>0$, the exponential trichotomy for skew-evolution semiflows, defined and characterized by us in [3] for evolution operators, is obtained in a nonuniform setting.

**Remark 3.2.** *(i)* A projector *P* on *Y* with property ($t_1$) is also called invariant relative to the skew-evolution semiflow $C=(\varphi,\Phi)$;

*(ii)* If three projectors families $\{P_k\}_{k\in\{1,2,3\}}$ satisfy relations ($t_1$) and ($t_2$) of Definition 3.2, they are usually said to be compatible with the skew-evolution semiflow *C*.

In what follows, we will denote a skew-evolution semiflow $C_k=(\varphi,\Phi_k)$, $k\in\{1,2,3\}$, where $\Phi_k(t,s,x)v=\Phi(t,s,x)P_k(x)v$, $(t,s)\in T$, $(x,v)\in Y$.

**Example 3.1.** Let us consider the skew-evolution semiflow given in Example 2.1.

We obtain for the evolution cocycle $\Phi:T\times X\to B(V)$ following relations

$$\Phi(t,s,x)(v_1,v_2,v_3)=$$
$$=\left(e^{2t\cos t-2s\cos s-2\sin t+2\sin s-3t+3s}v_1,\ e^{t\sin t-s\sin t+\cos t-\cos s+2t-2s}v_2,\ e^{-\sin t+\sin s+2t-2s}v_3\right)$$

Let us define the projectors $P_1(x,v)=(v_1,0,0)$, $P_2(x,v)=(0,v_2,0)$ and $P_3(x,v)=(0,0,v_3)$. As following relation holds

$$2t\cos t-2s\cos s-2\sin t+2\sin s-3t+3s\le -t+5s+4,\ \forall (t,s)\in T,$$

we have that

$$H_1(t)\left\|\Phi(t,s,x)P_1(x)v\right\| \le N_1(s)\left|v_1\right|,\ \forall (t,s,x,v)\in T\times Y,$$

where we have denoted $H_1(t) = e^t$ and $N_1(s) = e^{5s+4}$.

According to the inequality

$$t \sin t - s \sin s + \cos t - \cos s + 2t - 2s \geq t - 3s - 2, \ \forall (t, s) \in T,$$

it follows that

$$N_2(t)\left\|\Phi(t,s,x)P_2(x)v\right\| \geq H_2(s)\left|v_2\right|, \ \forall (t, s, x, v) \in T \times Y,$$

where we have considered $H_2(s) = e^{-3s}$ and $N_2(t) = e^{-t+2}$.

Also, as

$$-\sin t + \sin s + 2t - 2s \leq 2t - s + 1, \ \forall (t, s) \in T,$$

we have

$$\left\|\Phi(t,s,x)P_3(x)v\right\| \leq N_3(s)H_3(t)\left|v_3\right|, \ \forall (t, s, x, v) \in T \times Y$$

and, as

$$-\sin t + \sin s + 2t - 2s \geq t - 2s - 1, \ \forall (t, s) \in T,$$

we obtain

$$N_3(t)H_3(s)\left\|\Phi(t,s,x)P_3(x)v\right\| \geq \left|v_3\right|, \ \forall (t, s, x, v) \in T \times Y,$$

where, in both cases, we have denoted $H_3(u) = e^{2u}$ and $N_3(u) = e^{-u+1}$.

As a remark, we can consider, without any loss of generality, the function denoted $H(t) = \min\{H_1(t), H_2(t), H_3(t)\}$, $t \geq 0$.

It follows that the skew-evolution semiflow $C = (\varphi, \Phi)$ is $H$-trichotomic.

The next main result of this paper can be considered as an integral characterization for the concept of $H$-trichotomy.

**Theorem 3.1.** *Let $H \in \Gamma$ and $h \in \Psi$. A skew-evolution semiflow $C = (\varphi, \Phi)$ is $H$-trichotomic if and only if there exist some mappings $M_1, M_2, M_3: \mathbb{R}_+ \to \mathbb{R}_+^*$, some functions $f_1, f_2 \in \Theta$ and three projectors families $\{P_k\}_{k \in \{1,2,3\}}$ compatible with $C$ such that the skew-evolution semiflow $C_1$ has exponential growth and the skew-evolution semiflow $C_2$ has exponential decay and such that following conditions hold:*

$$(i) \ \frac{1}{H(t)}\int_{t_0}^{t} h(\tau)\left\|\Phi_1(t,\tau,x)^* v^*\right\| d\tau \leq M_1(t_0)\left\|P_1(x)v^*\right\|;$$

$$(ii) \ h(t_0)\int_{t_0}^{t} \frac{1}{H(\tau)}\left\|\Phi_2(\tau,t_0,x)v\right\| d\tau \leq M_2(t)\left\|\Phi_2(t,t_0,x)v\right\|;$$

$$(iii) \ \int_{s}^{t} f_1(\tau - s)\left\|\Phi_3(\tau,t_0,x)v\right\| d\tau \leq M_3(t_0)\left\|\Phi_3(s,t_0,x)v\right\|;$$

$$(iv) \ \int_{s}^{t} f_2(t - \tau)\left\|\Phi_3(\tau,t_0,x)v\right\| d\tau \leq M_3(t_0)\left\|\Phi_3(t,t_0,x)v\right\|,$$

*for all $(t,s), (s,t_0) \in T$ and all $(x,v) \in Y$, $v^* \in V^*$ with $\left\|v^*\right\| \leq 1$.*

**Proof.** *Necessity*. As the skew-evolution semiflow C is $H$-trichotomic, it implies that the relations $(t_3)$ of Definition 3.2 hold.

*(i)* There exist a function $f \in \Theta_-$ and a constant $k > 0$ with the property

$h(s) \leq kf(t-s)H(t)$, $\forall t \geq s \geq 0$. Let us denote $f(t) = e^{-\nu t}$, $\nu > 0$. We obtain

$$\left\|\Phi_1(t,t_0,x)v\right\| \leq \frac{N_1(s)}{H(t)}\left\|\Phi_1(s,t_0,x)v\right\| \leq \overline{M}_1(s)e^{-\nu(t-s)}\left\|\Phi_1(s,t_0,x)v\right\|,$$

for all $(t,s),(s,t_0) \in T$ and for all $(x,v) \in Y$, where we have considered the function $\overline{M}_1 : \mathbb{R}_+ \to \mathbb{R}_+$, $\overline{M}_1(u) = k\frac{N_1(u)}{h(u)}$.

We obtain further

$$\frac{1}{H(t)}\int_{t_0}^{t} h(\tau)\left\|\Phi_1(t,\tau,x)^* v^*\right\| d\tau \leq k\int_{t_0}^{t} e^{-\nu(t-\tau)}\left\|\Phi_1(t,\tau,x)^* v^*\right\| d\tau \leq M_1(t_0)\left\|P_1(x)v^*\right\|,$$

where we have denoted $M_1(u) = k\nu^{-1}\overline{M}_1(u)$, $u \geq 0$.

*(ii)* There exist a function $f \in \Theta_-$ and a constant $k > 0$ with the property $h(t_0) \leq kf(s-t_0)H(s)$, $\forall s \geq t_0 \geq 0$. Let us consider $f(t) = e^{-\nu t}$, $\nu > 0$. We have

$$\left\|\Phi_2(s,t_0,x)v\right\| \leq \frac{N_2(t)}{H(s)}\left\|\Phi_2(t,t_0,x)v\right\| \leq k\frac{N_2(t)}{h(t_0)}e^{-\nu(s-t_0)}\left\|\Phi_2(t,t_0,x)v\right\| \leq$$

$$\leq k\frac{N_2(t)}{h(t_0)}e^{\nu t}e^{-\nu(t-s)}e^{-\nu(2s-t_0)}\left\|\Phi_2(t,t_0,x)v\right\| \leq \overline{M}_2(t)e^{-\nu(t-s)}\left\|\Phi_2(t,t_0,x)v\right\|,$$

for all $(t,s),(s,t_0) \in T$ and for all $(x,v) \in Y$, where we have denoted the function $\overline{M}_2 : \boldsymbol{R}_+ \to \boldsymbol{R}_+$, $\overline{M}_2(u) = kN_2(u)e^{\nu u}$.

*(iii)* and *(iv)* are obtained by a similar argumentation, according to Proposition 2.1 and Proposition 2.2.

*Sufficiency*. *(i)* Let $t \geq t_0 + 1$ and $s \in [t_0, t_0+1]$. As $H \in \Gamma$ and $h \in \Psi$, there exists a constant $\alpha > 0$ such that $h(s) \leq e^{-\alpha(t-s)}H(t)$, for all $(t,s) \in T$. Then, as the skew-evolution semiflow $C_1$ has exponential growth, according to Proposition 2.1, there exist some constants $M \geq 1$ and $\omega > 0$ such that following relations hold

$$e^{-(\alpha+\omega)}\left|\left\langle v^*, e^{\alpha(t-t_0)}\Phi_1(t,t_0,x)v\right\rangle\right| = e^{-(\alpha+\omega)}\int_{t_0}^{t_0+1}\left|\left\langle \Phi_1(t,\tau,x)^*v^*, e^{\alpha(t-t_0)}\Phi_1(\tau,t_0,x)v\right\rangle\right|d\tau \leq$$

$$\leq \int_{t_0}^{t_0+1} e^{\alpha(t-\tau)}\left\|\Phi_1(t,\tau,\varphi(\tau,t_0,x))^*v^*\right\|e^{-\omega(\tau-t_0)}\left\|\Phi_1(\tau,t_0,x)v\right\|d\tau \leq$$

$$\leq M\|v\|\int_{t_0}^{t} e^{\alpha(t-\tau)}\left\|\Phi_1(t,\tau,\varphi(\tau,t_0,x))^*v^*\right\|d\tau \leq MN_1(t_0)\left\|P_1(x)v\right\|\left\|P_1(x)v^*\right\|.$$

By taking supremum relative to $\left\|v^*\right\| \leq 1$, we have

$$\left\|\Phi_1(t,t_0,x)v\right\| \leq M_1(t_0)e^{-\alpha(t-t_0)}\left\|P_1(x)v\right\|,$$

for all $t \geq t_0 + 1$ and all $(x,v) \in Y$, where $M_1(u) = MN(u)e^{\alpha+\omega}$, $u \geq 0$.

On the other hand, for $t \in [t_0, t_0+1]$ and $(x,v) \in Y$, we obtain

$$\left\|\Phi_1(t,t_0,x)v\right\| \leq Me^{\omega(t-t_0)}\|v\| \leq \hat{M}e^{-\alpha(t-t_0)}\|v\|,$$

where we have denoted $\hat{M} = Me^{\alpha+\omega}$. Hence, it follows that

$$\left\|\Phi_1(t,t_0,x)v\right\| \leq [M_1(t_0) + \hat{M}]e^{-\alpha(t-t_0)}\|v\|,$$

for all $(t,t_0) \in T$ and for all $(x,v) \in Y$.

Further, if we consider

$$H(u) = f(u) \text{ and } N_1(u) = [M_1(u) + \hat{M}]f(u),$$

where $f(u) = e^{\nu u} \in \Theta_+$ and $u \geq 0$, we obtain relation ($t_3^1$).

*(ii)* We have considered $H \in \Gamma$ and $h \in \Psi$, hence there exists a constant $\beta > 0$ such that $h(s) \leq e^{-\beta(t-s)}H(t)$, for all $(t,s) \in T$. As the skew-evolution semiflow $C_2$ has exponential growth, according to Definition 2.3, there exists a nondecreasing function $g : \boldsymbol{R}_+ \to [1,\infty)$ with the property $\lim_{t\to\infty} g(t) = \infty$ such that

$$\left\|\Phi_2(s,t_0,x)v\right\| \leq g(t-s)\left\|\Phi_2(t,t_0,x)v\right\|, \ \forall\ (t,s),(s,t_0) \in T, \ \forall\ (x,v) \in Y.$$

We will denote

$$K = \int_0^1 e^{-\beta\tau}g(\tau)d\tau.$$

We obtain successively following relations

$$K\|P_2(x)v\| = \int_{t_0}^{t_0+1} e^{-\beta(\tau-t_0)} g(\tau - t_0)\|\Phi_2(t_0, t_0, x)v\|d\tau \leq$$

$$\leq \int_{t_0}^{t_0+1} e^{-\beta(\tau-t_0)}\|\Phi_2(\tau, t_0, x)v\|d\tau \leq M_2(t)e^{\beta(t-t_0)}\|\Phi_2(t, t_0, x)v\|,$$

for all $(t, t_0) \in T$ and for all $(x, v) \in Y$. According to Definition 2.2, this relation is equivalent with

$$\|\Phi_2(s, t_0 x)v\| \leq \frac{1}{K} M_2(t)e^{\beta(t-s)}\|\Phi_2(t, t_0, x)v\|,$$

for all $(t,s),(s,t_0) \in T$ and for all $(x, v) \in Y$.

If we take

$$H(u) = f(u) \text{ and } N_2(u) = M_2(u)f(u),$$

for $f(u) = e^{-vu} \in \Theta_-$ and $u \geq 0$, relation ($t_3^2$) is obtained.

*(iii)* and *(iv)* can simmilarly be proved.

## 4. CONCLUSIONS

In the last decades, a great progress concerning the study of asymptotic behaviors for evolution equations can be observed. The possibility of reducing the nonautonomous case in the study of evolutionary families or skew-product flows to the autonomous case of evolution semigroups on Banach spaces is considered an important way toward interesting applications. The study of the asymptotic behavior of linear skew-product semiflows has been used in the theory of evolution equations in infinite dimensional spaces. The approach from the point of view of asymptotic properties for the evolution semigroup associated to the linear skew-product semiflows was essential. Instead, in our study we have considered more general characterizations for the asymptotic properties of the solutions of evolution equations, described by means of skew-evolution semiflows, which generalize the above notions. Also, the approach was not restrained by considering in the definitions exponentials. As a remark, in Definition 3.2 we have the definitions for *H*-stability, *H*-instability, *H*-growth and *H*-decay, characterized, respectively, by Theorem 3.1, which extends toward applications in engineering and economics the study of evolution equations.

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# ASYMPTOTIC BEHAVIORS OF STOCHASTIC EVOLUTION COCYCLE

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**Abstract:**
The paper presents the properties of exponential stability for stochastic evolution semiflow and stochastic evolution cocycles. Some characterizations which generalize classics results are also provided.

**Keywords**:
Stochastic evolution semiflow, stochastic evolution cocycles, exponential stability

## 1. INTRODUCTION

The problem of existence of stochastic semiflows for semilinear stochastic evolution equation is a non-trivial one, mainly due to the well-established fact that finite-dimensional methods for constructing (even continuous) stochastic flow break down in the infinite dimensional setting of semilinear stochastic evolution equations (cf. [3], [7], [8]). For linear stochastic evolution equation with finite-dimensional noise, a stochastic semiflow (i.e. random evolution operator) was obtained in [1].

In [5], is prove the existence of perfect differentiable cocycles generated by mild solutions of a large class of semilinear stochastic evolution equations (sees) and stochastic partial differential equations (spdes).

In this article we consider the stochastic evolution cocycle over a stochastic evolution semiflow, and present the proprieties of exponential stability.

We considered (X, d) metric space and denote V and U real Hilbert spaces. Let B(V ) be a Banach space of all linear and bounded maps $A: V \to V$. We denote the sets $T = \{(t, t_0) \in R^2, t \geq t_0 \geq 0\}$ and $Y = X \times V$. The mapping $P: Y \to Y$ given by P(x,v)=(x, P(x)v), $\forall (x, v) \in Y$ is an projector on Y, where P(x) is a projection on $Y_x = \{x\} \times V$, $x \in X$. Let B(X) denote its Borel $\sigma$-algebra.

Assume $(\Omega, F, \mathbf{P})$ is a complete probability space with a normal filter $\{F_t\}_{t \geq 0}$, i.e. $F_0$ contains the null sets in F and $F_t = \cap_{s>t} F_s$, for all $t \geq 0$, and let us consider a real valued $\{F_t\}$ - Wiener process $\{W(t)\}, t \geq 0$.

**Definition 1.** A stochastic process $W(t): (\Omega, F, P) \to U$ is a Wiener process if and only if $W(t) = \sum_{i=1}^{\infty} \beta_i(t) e_i$ where $\beta_i(t)$ are real Wiener process, independents, which are the mean $E(\beta_i(t)^2) = \lambda_i t$, where $\sum_{i=1}^{\infty} \lambda_i < \infty$, $\{e_i\}, i = 1,2,\cdots$ is an orthonormal system of vectors from U.

**Definition 2.** Let be X a Banach space. A stochastic evolution semiflow on X is a random field $\varphi: T \times X \times \Omega \to X$ satisfying the following proprieties:

(1) $\varphi(t, t, x, \omega) = x$, for all (t, x) from T×X and $\omega \in \Omega$;

(2) $\varphi(t, s, \varphi(s, t_0, x, \omega), \omega) = \varphi(t, t_0, x, \omega)$, $\forall (t, s), (s, t_0) \in T$, $\forall x \in X$, and $\omega \in \Omega$.

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**Definition 3.** A stochastic evolution cocycles on V, over an stochastic evolution semiflow $\varphi : T \times X \times \Omega \to X$, is a random field $\Phi : T \times X \times \Omega \to B(V)$, with the following proprieties:

(1) $\Phi(t,t,x,\omega) = I,\ \forall (t,x) \in R_+ \times X$, and $\omega \in \Omega$,

(2) $\Phi(t,s,\varphi(s,t_0,x,\omega),\omega)\Phi(s,t_0,x,\omega) = \Phi(t,t_0,x,\omega),\ \forall (t,s),(s,t_0) \in T,\ \forall x \in X$, and $\omega \in \Omega$.

**Definition 4.** An stochastic evolution cocycles $\Phi$ has uniformly exponential growth if exist the constants $M \geq 1,\ \lambda > 0$ such that

$$E \| \Phi(t,s,x,\omega) \|^2 \leq Me^{\lambda(t-s)},\ \forall (t,s) \in T, \forall x \in X \text{ and } \omega \in \Omega. \quad (1)$$

**Definition 5.** The stochastic evolution cocycles $\Phi$ is called strongly measurable if for every $(s,x,\omega,v) \in T \times X \times \Omega \times V$ the mapping $t \to \| \Phi(t,s,x,\omega)v \|$ is measurable on $[s,\infty)$.

**Definition 6.** The mapping, $C : T \times X \times V \times \Omega \to X \times V$, definite by

$$C(t,s,x,v,\omega) = \left(\varphi(t,s,x,\omega), \Phi(t,s,x,\omega)v\right), \quad (2)$$

where $\Phi$ is a stochastic evolution cocycles over an stochastic evolution semiflow $\varphi$, is called stochastic skew-evolution semiflow on Y.

## 2. UNIFORMLY EXPONENTIALLY STABILITY

Let be $F : [0,T] \times \Omega \to H$ an stochastic process, then $E(F) = \int_\Omega F(\Omega)\, dP(\omega)$ represent the mean of stochastic process F, where P is the probability measure. If $F \in C\left([0,T], L^2(\Omega, H)\right)$ then

$$\int_0^T E \| F(t) \|^2 \, dt = E \int_0^T \| F(t) \|^2 \, dt. \quad (3)$$

For an process Wiener W(t) in rapport with the filter $\{F_t\}$ we have

$$E \left\| \int_0^T F(t)\, dw(t) \right\|^2 = E \int_0^T \| F(t) \|^2 \, dt. \quad (4)$$

**Definition 7.** The stochastic evolution cocycles $\Phi$ is said to be uniformly exponentially stable if for some positive constants $N \geq 1, \nu > 0$ one has

$$E \| \Phi(t,t_0,x,\omega)v \|^2 \leq Ne^{-\nu(t-s)} E \| \Phi(s,t_0,x,\omega)v \|^2, \quad (5)$$

for all $(t,s),(s,t_0) \in T,\ (x,v) \in X \times V,$ and $\omega \in \Omega$.

**Lemma 8.** The stochastic skew-evolution semiflow C=($\varphi, \Phi$), is uniformly exponentially stable if and only if a no decreasing function $f : [0,\infty) \to [1,\infty)$, with property $\lim_{t \to \infty} f(t) = \infty$, such that we have the relation:

$$f(t-s) E \| \Phi(t,t_0,x,\omega)v \|^2 \leq E \| \Phi(s,t_0,x,\omega)v \|^2, \quad (6)$$

for all $(t,s),(s,t_0) \in T,\ (x,v) \in X \times V$, and for all $\omega \in \Omega$.

**Proof.** *Necessity*. If C=($\varphi, \Phi$), is uniformly exponentially stable, result from Definition 7 that for $f(t) = N^{-1}e^{\nu t}$.

*Sufficiency*. Let be $t \geq s \geq t_0 \geq 0$ and we denote t - s = [n]. Let N= f(1) > 1 and $\nu = \ln N$. That result:

$$E \| \Phi(s,t_0,x,\omega)v \|^2 \geq f(1) E \| \Phi(s+1,t_0,x,\omega)v \|^2 \geq \cdots \geq N^n E \| \Phi(s+n,t_0,x,\omega)v \|^2 \geq$$

$$\geq N^{n+1} E \| \Phi(t,t_0,x,\omega)v \|^2 \geq Ne^{n\nu} E \| \Phi(t,t_0,x,\omega)v \|^2 \geq Ne^{\nu(t-s)} E \| \Phi(t,t_0,x,\omega)v \|^2$$

and so

$$E \| \Phi(s,t_0,x,\omega)v \|^2 \geq Ne^{\nu(t-s)} E \| \Phi(t,t_0,x,\omega)v \|^2,$$

for all $(t,s),(s,t_0) \in T,\ (x,v) \in X \times V$, and for all $\omega \in \Omega$.

Thus the stochastic skew-evolution semiflow $C=(\varphi,\Phi)$, is uniformly exponentially stable.

**Theorem 9.** Let be $C=(\varphi,\Phi)$, an skew-product semiflow with uniformly exponential growth, and is strong measurable. Then C is uniformly exponentially stable if and only if $\exists\, M \geq 0$ a constant, such that:

$$\int_t^{\infty} E \| \Phi(s,t_0,x,\omega)v \|^2 \, ds \leq M E \| \Phi(t,t_0,x,\omega)v \|^2, \qquad (7)$$

for all $(t,t_0) \in T,\ (x,v) \in X \times V$, and for all $\omega \in \Omega$.

**Proof.** *Necessity*. Let be an stochastic skew-evolution semiflow $C=(\varphi,\Phi)$, uniformly exponentially stable. Then, for $N \geq 1, \nu > 0$ we have from Definition 7, that

$$E \| \Phi(s,t_0,x,\omega)v \|^2 \leq N e^{-\nu(s-t)} E \| \Phi(t,t_0,x,\omega)v \|^2, \qquad (8)$$

for all $(s,t),(t,t_0) \in T,\ (x,v) \in X \times V$, and for all $\omega \in \Omega$. Then from integration of this inequality result:

$$\int_t^{\infty} E \| \Phi(s,t_0,x,\omega)v \|^2 \, ds \leq NE \| \Phi(t,t_0,x,\omega)v \|^2 \int_t^{\infty} e^{\nu(t-s)} ds \leq ME \| \Phi(t,t_0,x,\omega)v \|^2,$$

for all $(t,t_0) \in T,\ (x,v) \in X \times V$, and $\omega \in \Omega$, where $M = N\nu^{-1}$.

*Sufficiency*. For $t \geq t_0 + 1$, and $\omega$ from Definition 4 we have

$$\frac{1-e^{-\omega}}{\omega} E \| \Phi(t,t_0,x,\omega)v \|^2 \leq \int_{t_0}^{t} e^{-\omega(t-s)} E \left| \left\langle v^*, \Phi(t,s,\varphi(s,t_0,x,\omega))\Phi(s,t_0,x,\omega)v \right\rangle \right|^2 ds \leq$$

$$\leq M' \| v^{\bullet} \| \int_{t_0}^{t} E \| \Phi(s,t_0,x,\omega)v \|^2 \, ds \leq M'M \| v \| \| v^{\bullet} \|,$$

for all $(t,t_0) \in T,\ (x,v) \in X \times V$, and $\omega \in \Omega$. So we have the relation

$$E \| \Phi(t,t_0,x,\omega)v \| \leq K \| v \|, \quad \forall (t,t,x,v,\omega) \in T \times Y \times \Omega,$$

where $K = M'\left(e^{\omega} + M/c\right),\ c = (1-e^{-\omega})/\omega$.

Thus result that

$$(t-t_0) E \| \Phi(t,t_0,x,\omega)v \|^2 = \int_{t_0}^{t} E \| \Phi(t,t_0,x,\omega)v \|^2 \, ds =$$

$$= \int_{t_0}^{t} E \| \Phi(t,s,\varphi(s,t_0,x,\omega),\omega)\Phi(s,t_0,x,\omega)v \|^2 \, ds \leq$$

$$\leq K \int_{t_0}^{t} E \| \Phi(s,t_0,x,\omega)v \|^2 \, ds \leq KM \| v \|.$$

In conclusion we obtain the relation

$$(t-t_0+1) E \| \Phi(t,t_0,x,\omega)v \|^2 \leq K(M+1) \| v \|,$$

for all $(t,t_0) \in T,\ (x,v) \in X \times V$, and $\omega \in \Omega$.

Thus for function $f : [0,\infty) \to [1,\infty)$, with property $\lim_{t \to \infty} f(t) = \infty$, definite by

$$f(t) = \frac{t+1}{K(M+1)},$$

Result from Lemma 8, that C is uniformly exponentially stable.

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# SOME DISADVANTAGES OF STANDARD BUCKLING ANALYSIS COMPARING TO INCREMENTAL GEOMETRIC NONLINEAR ANALYSIS

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**Abstract:**
Modeling of real behavior of structural systems requires complex assumptions, which have, as consequences, nonlinear stress-strain state. One of the causes of nonlinear behavior is geometric nonlinearity.
Determining of critical load parameter by standard bifurcation buckling solution is appropriate for solving stability problems if the longitudinal and lateral load ratio is small. In case that structure has large displacements, it is necessary to use incremental-iterative solution. The main advantage of this concept is possibility to verify changes in: loads, mechanical-reological properties of material, geometry of structural system, and modeling effect of those changes on structural behavior.
**Keywords:**
finite element method, geometric nonlinearity, buckling analysis

## 1. INTRODUCTION

A FEM linear model in some cases of numerical analysis of structural systems is not appropriate. Assumptions in linear analysis are simple and results may vary of close solution. Using simple FEM models, it is possible to achieve efficiency of analyses and calculations, but without adequate accuracy. Also, bearing capacity, adaptability and durability of structural system can be endangering.

For modelling of real behaviour of structural system nonlinear stress-strain relation should be taken into consideration. The nonlinear analysis is more complex than linear analysis because:

- during the load process deformations are not proportional,
- after the effect of load, model does not have original form,
- for finite values of displacements, deformations and stresses principle of superposition can not be applied and
- the stiffness matrix and load vector of loading can not be fully formed due to the fact that they depending on the final solution.

One of the causes of nonlinear behaviour is geometric nonlinearity, where relation between strains and displacement is nonlinear, but material has linear elastic properties.

Geometric nonlinearity arises when deformations and/or displacements are large enough to significantly change geometry and position of the system. As a consequence of large deformation and/or displacement, relation deformation-displacement and equilibrium are nonlinear. Reaching the limit state in the geometric nonlinearity is loss of stability of structural system.

Problems of geometric nonlinearity can be classified as continual nonlinearity (smooth nonlinearities). The characteristic examples of smooth nonlinearity are nonlinear behavior due to large displacements and/or deformations, elasto-plastic material properties, reological

properties of material, etc. Continual "smooth" functions are used for approximation of continual nonlinearity.

Figure 1 show examples of large deformations and large displacements. For large deformations, changes in shape are significant and for large displacements, changes in translational and/or rotational position are significant. Procedures for solving such problems are numerous and implemented in the general computer FEM software.

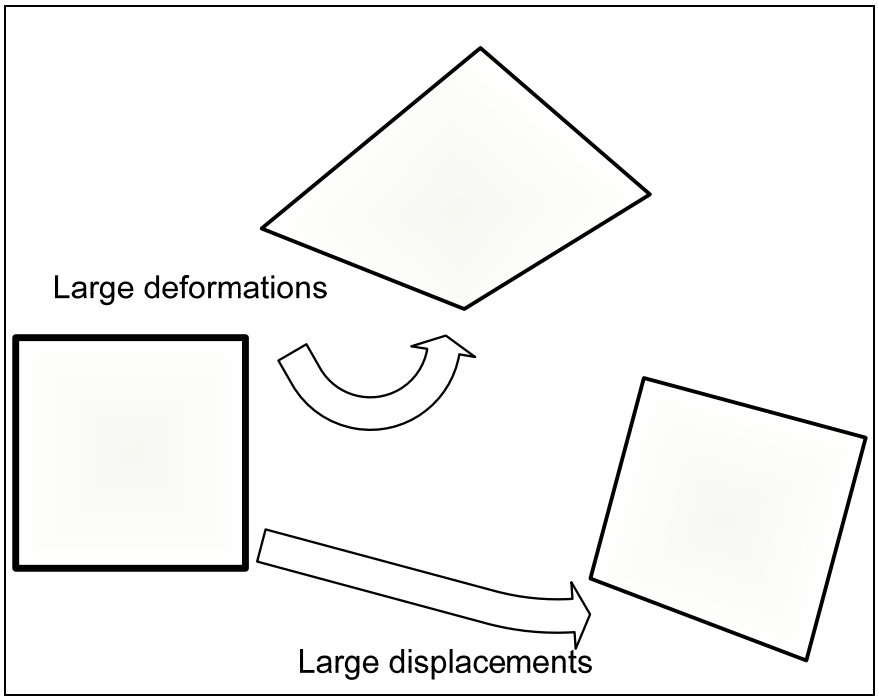



Figure 1. Examples of geometric nonlinearity: large displacements and large deformations

## 2. FEM MODELING OF GEOMETRIC NONLINEAR BEHAVIOR

For analyzing of geometric nonlinear phenomenon follow theories can be applied:

- general geometric nonlinear theory,
- geometric nonlinear theory in strict sense (second-order theory),
- "linearized" second-order theory and
- so-called "P-Δ" methods.

The greatest accuracy of numerical solution can be achieved using general nonlinear theory and the lowest accuracy is obtained by applying "P-Δ" methods.

Geometric nonlinear theory in strict sense assumed linear relations between displacements and deformations on deformed model of structures. This model is simple and because of quality approximation it can be used in modeling most of structural problems.

According to "linearized" second-order theory equilibrium equations are linear. The widest application of this theory is in analyzing of so-called "bifurcational stability" of construction although in some cases solution is not adequate. The main disadvantage of this theory is analyzing of undeformed structure, what is particularly significant in problems of stability of structural systems with large displacements.

The main problem in geometric nonlinear analysis is testing stability of structural system, i.e. determining of critical load. The critical load depends on the system topology (Figure 2), which may occur following cases:

- due to increasing of load, stiffness of system increases,
- after decreasing, stiffness of system is increasing, but it can be a point where buckling may occur and
- loss of stability is realized by suddenly transition to a new equilibrium branch ("snap-trough" effect).

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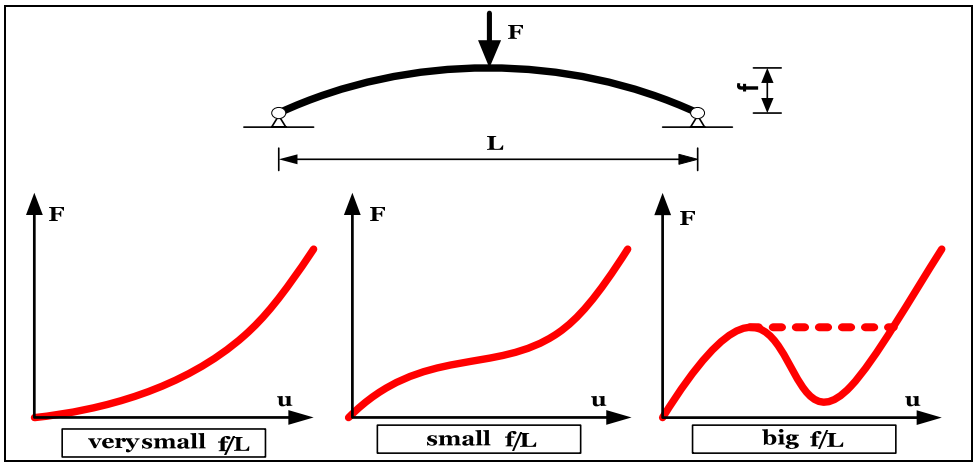


Figure 2. Topology of system and geometric nonlinear behavior

Determining of critical load parameter by standard bifurcation buckling solution is appropriate for solving stability problems if the longitudinal and lateral load ratio is small. In case that structure has large displacements, it is necessary to use incremental-iterative solution.

### 2.1. Linear buckling analysis

Verification of stability in geometric nonlinear analysis is determining of critical load for which the tangent stiffness matrix of FEM model becomes singular. The critical load is obtained by solving homogeneous problem according to "linearized" second-order theory:

$$([K_0]+\lambda[K_G])=0 \quad (1)$$

where:
$[K_o]$ – linear stiffness matrix,
$[K_G]$ – geometric stiffness matrix and
$\lambda$ - factor of critical load.

Linear buckling analysis uses $K_o$ and $K_G$ based on the undeformed geometry of the structure, which is the main disadvantage of this theory. Because most buckling problems are nonlinear, the buckling analysis should be based on the tangent stiffness and incremental methods.

### 2.2. Incremental geometric nonlinear analysis

One of the methods for solving nonlinear problems is incremental methods. They use the tangent stiffness, which for single degree of freedom problem is the slope of the load versus displacement, $k_t=dF/du$. Tangent stiffness matrix is obtained as the sum of linear and geometric stiffness matrix of FEM model. Incremental methods are based on the approximation of total load on a range of smaller part – increments. The incremental loads are added successively and in each increment they are linear. The solution of nonlinear problem is obtained as sum of all linear incremental solutions. Better quality of approximations can be achieved using a number of increments, but numerical efficiency can be reduced.

In general case, nonlinear problem can be presented as:

$$[K_t]\{\Delta u\}+\lambda\{F\}=0 \quad (2)$$

$$\{P\}+\lambda\{F\}=0 \quad (3)$$

where:
$\{P\}$ – vector of generalized forces of FEM model and
$\{F\}$ – vector of load.

Incremental vector of displacements is obtained:

$$\{\Delta u\}_i = [K_t]^{-1}\Delta\lambda_i\{F\} \quad (4)$$

where:

$$\{\Delta u\}_i = \{u\}_{i+1} - \{u\}_i \quad (5)$$

$$\{\Delta F\}_i = \{F\}_{i+1} - \{F\}_i \quad (6)$$

$$\Delta\lambda_i = \lambda_{i+1} - \lambda_i \quad (7)$$

The tangent matrix is formulated for the beginning of increment, and for the first increment is used linear matrix stiffness.

The incremental solution error is appearing because of linearization in each increment and it can be corrected by applying of some iterative procedures. The main advantages of incremental concept are step-by-step procedure which corresponds to the basic principles of FEM and possibility to verify changes in: loads, mechanical-reological properties of material, geometry of structural system, and modeling effect of those changes on structural behavior.

## 3. NUMERICAL EXAMPLES

As an illustration of previous consideration several numerical tests will be given. All examples are based on geometric nonlinear theory and "linearized" second-order theory. Figure 3 show FEM model of cantilever with rotation of fixed support.

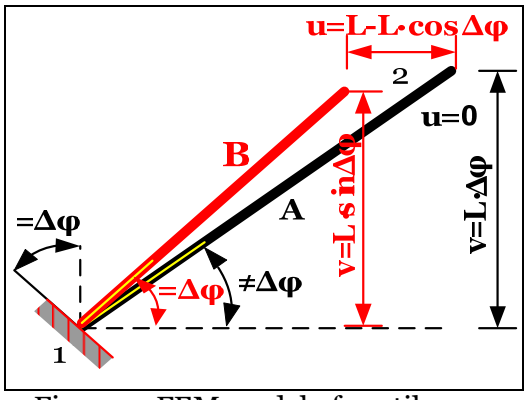



Figure 3. FEM model of cantilever - "linearized" second-order theory (A) and geometric nonlinear theory (B)

For $\Delta\varphi=+45^o$ node 2 has displacements and according to "linearized" second-order theory it is: "$v=L\cdot\Delta\varphi$" and "$u=0$". According to incremental solution the high solution accuracy is achieved: "$v=L\cdot\sin\Delta\varphi$" and "$u=L-(\cos\Delta\varphi-1)$".

In the next numerical test (Figure 4) shallow arch is analyzed. For iterative correction of incremental solution three methods were analyzed: Newton-Raphson iteration (NR), modified Newton-Raphson iteration (MNR) and method of initial stiffness (MIS). The results are shown in Table 1.

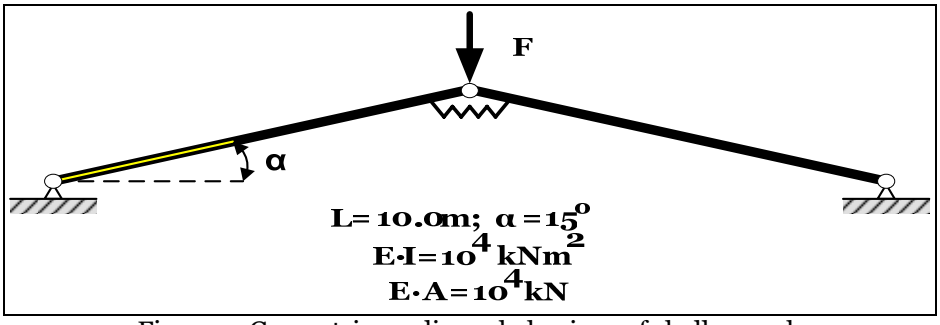



Figure 4. Geometric nonlinear behaviour of shallow arch

Table 1. Load F for different methods of analysis

| Load F (kN) | 20 | | 60 | | Fcr (kN) | |
|---|---|---|---|---|---|---|
| Fixed support ratio (%) | 100 | 0 | 100 | 0 | 100 | 0 |
| Linear theory | 10.53 | 14.93 | 31.59 | 44.78 | / | / |
| "Linearized" second-order theory | 10.88 | 15.78 | 34.96 | 53.41 | 587.2 | 346.8 |
| MIS | 10.98 | 16.33 | 36.45 | 67.61 | 149.3 | 69.12 |
| MNR | 10.98 | 16.33 | 36.44 | 67.61 | 149.2 | 69.10 |
| NR | 10.98 | 16.33 | 36.44 | 67.65 | 149.2 | 69.10 |
| Exact solution | 10.99 | 16.35 | 36.55 | 68.60 | 149.1 | 69.09 |

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The differences in solution (up to 25%) occur because of changes of tangent stiffness matrix due to correction of geometry system. Incremental-iterative solution with 20 increments provides greater accuracy than "linearized" second-order theory. Advantages of incremental solution occur when the ratio of critical load and applied load is high. Critical load is 69.09kN for fixed support ratio of 0% and 149.1kN for ratio of 100%. According to "linearized" second-order theory Fcr=346.75kN for 0% and Fcr=587.2kN for 100% ratio, which is too high error.

Third numerical test illustrate disadvantage of "linearized" second-order theory. Figure 5 show FEM model of frame with rigid and hinge interface condition between beam and column. The beam has 2I240 and column has I240 cross section. The material is assumed to remain linear elastic at all times, with E=210GPa. It will be analyzed critical load of a FEM model for "linearized" second-order theory (*) and for geometric nonlinear theory (**).

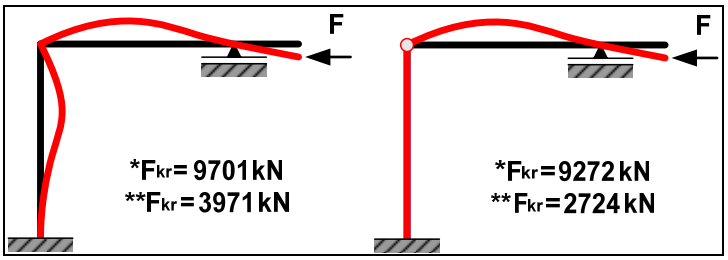



Figure 5. Numerical test for critical load of FEM model

The results of stability analysis of FEM models shows a difference in the buckling forms, as well as the value of critical force (Δ=244% for FEM model with rigid interface conditions and Δ**=340% for FEM model with hinge interface condition).

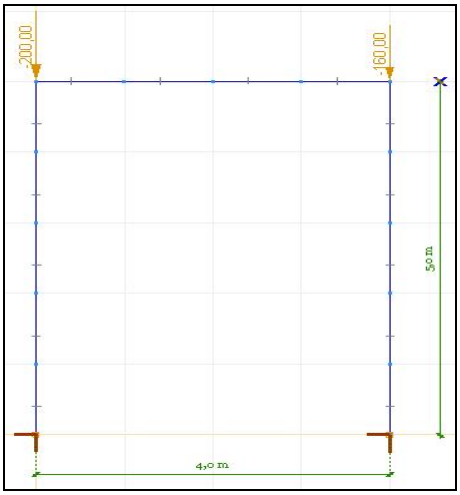



Figure 6. FEM model of frame structure

Next numerical test, Figure 6, show FEM model of frame structure loaded by two vertical forces. On response diagram "load-displacement", Figure 7, load parameter Ldp=1 is the value of critical load when the structure, after hardening, loses stability. Response diagram illustrate linear relation between load and displacement up to ~Pcr/2, which indicates an error if linear model is applied.

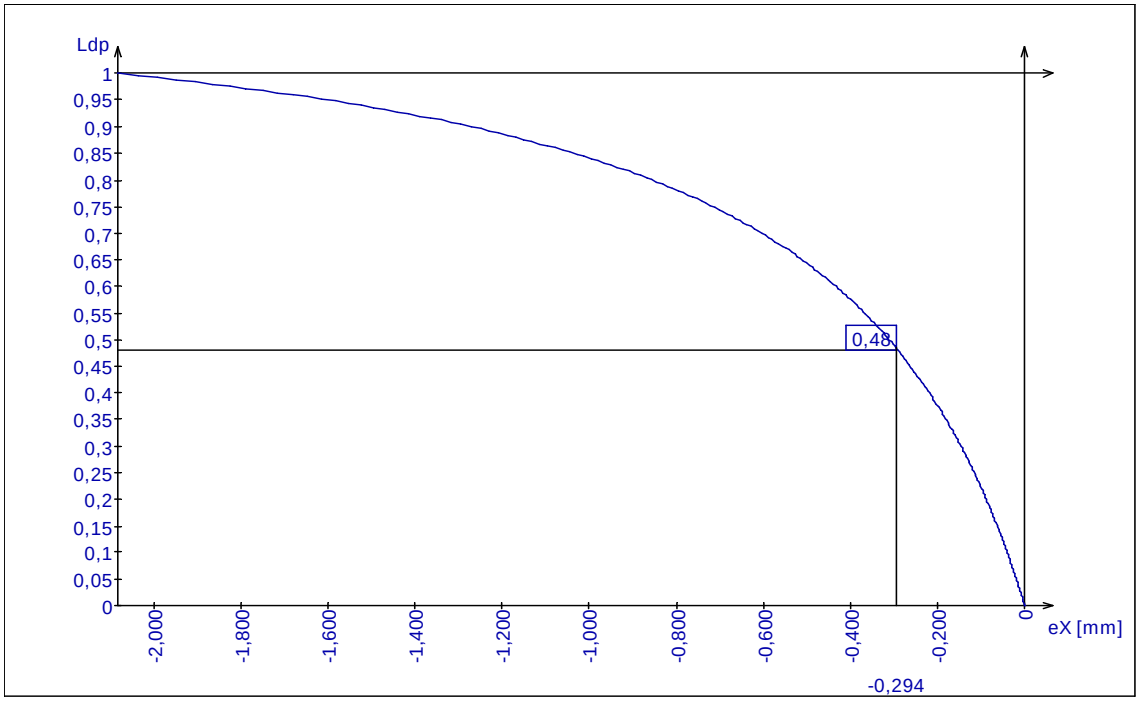



Figure 7. FEM model and response diagram of frame structure

## 4. CONCLUSIONS

In this paper geometric nonlinearity problems were analyzed. Determining of critical load and stability verification of the structure through the different concepts were presented. For adequate FEM numerical analysis of structural system advantages and disadvantages of implemented mathematical models must be emphasized, because the results can be different.

This paper emphasized advantages of incremental-iterative concept comparing to standard buckling analysis. The main disadvantage of incremental concept for adequate approximation is determining the size and number of increments. Difficulties to determine the solution exactly without analytical or experimental solutions is also disadvantage of incremental concept.

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# SOME GENERALISATION OF THE BARTLE, DUNFORD AND SCHWARTZ INTEGRABILITY MODEL

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**ABSTRACT**

In [4] the author introduces the notion of pseudosubmeasure as generalization of the submeasure concept [2], and studies some proprieties of the pseudosubmeasure functions with values in a pseudometric space.
The purpose of this paper is to develop an integration theory for these functions, with respect to a semigroup valued measure, using families of pseudosubmeasure and the associated topological rings.
AMS Subject Classification Code (2000):28A20, 28B15

## 1. PRELIMINARIES

The notions and the notations used here follow the paper [4].

Let $D$ be an ordered set with the smallest element $d_0$ .On this set we define a mapping: $(d_1, d_2) \to d_1 + d_2$ with the following properties:

(P1) $d_o + d = d + d_0; \forall d \in D$

(P2) $d_1 + d_2 = d_2 + d_1; \forall d_1, d_2 \in D$

(P3) $d_1 \le d_2 \Rightarrow d + d_1 \le d + d_2; \forall d \in D$

There exists a subset $D_1 \subseteq D$ left directed such that

(P4) $\forall d \in D_1, \exists d_1 \in D$ so that $d_1 + d_1 \le d$ .

**Definition 1.1.** *A pseudometric on a set X is a D-valued function* $p : X \times X \to D$ *so that:*

(i) $p(x, y) = d_0 \Leftrightarrow x = y$

(ii) $p(x, y) = p(y, x), x, y, z \in X$

(iii) $p(x, y) \le p(x, z) + p(z, y); x, y, z \in X$.

*A set X together with a pseudometric* $\rho$ *is called a pseudometric space and is denoted by* $(X, \rho, D)$.

**Remark 1.2.** *Every uniform space* $(X, \mathcal{U})$ *is pseudosemimetrizable,* [4].

Let $\mathcal{S}$ be a ring (or algebra) of subsets of fixed set $S$.

**Definition 1.3.** *A pseudosubmeasure on a ring* $\mathcal{S} \subset \mathcal{P}(S)$ *is a mapping* $\gamma : \mathcal{S} \to D$ *such that:*

($S_1$) $\gamma(\emptyset) = d_0$

($S_2$) $E \subseteq F \Rightarrow \gamma(E) \le \gamma(F), E, F \in \mathcal{S}$

($S_3$) $\gamma(E \cup F) \le \gamma(E) + \gamma(F), E, F \in \mathcal{S}$

*If* $\gamma$ *has the propert that* $\gamma(A) = d_0 \Rightarrow A = \emptyset$, *then mapping* $p : \mathcal{S} \times \mathcal{S} \to D$; $\rho(A, B) = \rho(A \Delta B)$ *is a pseudometric on* $\mathcal{S}$ *invariant to translation* $\Delta$ *(symmetric difference).*

Let $\Gamma = \{\gamma_i : \mathcal{S} \to D\}_{i \in I}$ be a family of pseudosubmeasure on $\mathcal{S} \subset P(S)$ and consider the family $\Omega_\Gamma = \{\nu_{K,d} : K = finite \subseteq I, d \in D_1\}$, where $\nu_{K,d} = (A \in \mathcal{S} : \gamma_i(A) \le d, a \in K\}$.

Then there exist a FN-topology $\tau(\Gamma)$ on $\mathcal{S}$ so that $\mathcal{S}(\Gamma) = (\mathcal{S}, \Delta, \cap, \tau(\Gamma))$ is a topical ring. Let $(X, \rho, D)$ be a pseudometric space.

By generalizing the model established in [3], we introduce an uniform structure on $X^S$ in the following way: To every $K = finite \subset I, d \in D$ ,we associate the set:

$$\mathcal{W}_k(D) = \{(f, g) \in X^S \times X^S ; \gamma_i\{s \in S; \rho(f(s), g(s)) \ge d\} < d, i \in K\}$$

Then, the family $\{W_k(d); d \in D_1, K = finite \subset I\}$ forms a base for an uniform structure $\mathcal{U}_\Gamma$ on $X^S$. We denote $X^S(\Gamma) = (X^S, \mathcal{U}_\Gamma)$. The map $f \in X^S$ is a $\mathcal{S}$-step function if there exists $x_i \in X, E_i \in \mathcal{S}, i = 1,2,...,n$ $x_i \ne x_j, E_i \cap E_j = \emptyset, i \ne j, S = \bigcup_{i=1}^{n} E_i$ so that $\forall s \in E_i$ imply $f(s) = x_i, i = 1,2,...,n.$

The space of $\mathcal{S}$-step functions will be denoted by $\mathcal{E}(\mathcal{S}, X)$.

**Definition 1.4.** *The function* $f \in X^S$ *is* $\Gamma$ *- pseudosubmeasurable if f belongs to the closure of* $\mathcal{E}(\mathcal{S}, X)$ *in* $X^S(\Gamma)$.

*We denote by* $\mathcal{M}[\mathcal{S}, \Gamma, X]$ *the set of these functions.*

**Definition 1.5.** *Let* $\{f_a\}$ *be a generalized sequence in* $\mathcal{M}[\mathcal{S}, \Gamma, X]$ *and* $f \in \mathcal{M}[\mathcal{S}, \Gamma, X]$. *If* $f_a \to f$ *in* $X^S(\Gamma)$, *then* $\{f_a\}$ *converges to* $f$ *in* $\Gamma$ *- pseudomeasures and we denote* $f_a \xrightarrow{r} f$.

## 2. BASIC ASSUMPTIONS

Let $S$ be a nonempty set, $\mathcal{S} \subset P(S)$ be an algebra of subsets of $S$ and consider a family of pseudosubmeasures $\Gamma = \{\gamma_i : \mathcal{S} \to D\}_{i \in I}$.

Let $(X_i, \rho_i, D^i), i = 1,2,3$ be three pseudometric abelian semigroups for which the addition is uniformly continous with respect to the pseudometric $\rho_i$).

In the sequel we consider an additive set function $\mu : \mathcal{S} \to X_2, \mu(\emptyset) = 0$ , and we will choose a family of pseudosubmeasures as it will be specified.

The maps which are to be integrated with respect to $\mu$ will belong to $X_1^S$ and the integral with take values in $X_3$ or its completion $\hat{X}_3$.

Suppose that a separate continuous bilinear map exists $X_1 \times X_2 \to X_3; (x, y) \mapsto x \cdot y$ so that:

i) $x \cdot 0 = 0 \cdot y = 0, (x \in X_1, y \in X_2)$

ii) $(x_1 + x_2) \cdot (y_1 + y_2) = x_1 \cdot y_1 + x_1 \cdot y_2 + x_2 \cdot y_1 + x_2 \cdot y_2, (x_1, y_1 \in X_1, x_2, y_2 \in X_2).$

Finally we suppose that $\Gamma_\mu, \mu$ and the above bilinear map are chosen so that the following continuity axioms are satisfied:

C1) For avery $F \in \mathcal{S}$ and every $d' \in D_1^3$ there exists $d' \in D_1^1$ with the following property: for any $n \in N$, if $\rho_1(x_i, y_i) < d', i = 1,2,...,n$ and $\{E_i\}$ is sequence of pairwise disjoint set from $\mathcal{S}$ then: $\rho_3\left(\sum_{i=1}^{n} x_i \mu(E_i \cap F), \sum_{i=1}^{n} y_i \mu(E_i \cap F)\right) < d.$

C2) For any $x \in X_1$, $\lim_{\substack{E \to \emptyset \\ E \in \mathcal{S}}} x\mu(E) = 0.$

### 3. INTEGRABLE FUNCTIONS

Let $f \in \mathcal{E}(\mathcal{S}, X)$ be a $\mathcal{S}$-step function.

**Definition 3.1.** *For $E \in \mathcal{S}$, the integral of $f$ on $E$ is by definition* $\int_E f d\mu = \sum_{i=1}^{n} x_i \mu(E_i \cap E).$

*We denote by $\mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ the set of $\Gamma_\mu$-integrable step functions.*

**Theorem 3.2.** (i) *Relatively to the operation $(f + g)(s) = f(s) + g(s)$, the space $\mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ is a subsemigroup of $X_1^3$.*

(ii) *For $E \in S$, the map $f \to \int_E f d\mu$ from $\mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ to $X_3$ is additive.*

(iii) *For $f \in \mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ the map $E \to v(E), v(E) = \int_E f d\mu, E \in \mathcal{S}$ is an additive function.*

(iv) *For $f \in \mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$;* $\lim_{E \xrightarrow{\Gamma_\mu} 0} v(E) = \lim_{E \xrightarrow{\Gamma_\mu} 0} \int_E f d\mu = 0$

The proof follows from definition 3.1 and axioms $C_1$ and $C_2$. The extension of the integral from step functions to the arbitrary functions in $X_1^S$ is based on the following result:

**Lemma 3.3.** *Let $\{f_a\}$ be a generalized sequence from $f \in \mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$, which is Cauchy in $X_1^S(\Gamma_\mu)$. For $\left\{\int_E f_\alpha d\mu\right\}$ to be a Cauchy sequence in $X_3$ uniform with respect to $E \in \mathcal{S}$ it is necessary and sufficient that:*

*a) For any neightbourhood $V$ of $0$ in $X_3$ there exists an index $\alpha_0, K = finite \subset I$ and $d \in D$, so that : $\alpha \geq \alpha_0$ and $\gamma_i(E) < d, i \in K$ imply $\int_E f_\alpha d\mu \in V$*

*b) For sny neighbourhood V of 0 in $X_3$ there exists and index $\alpha_0$ and $F \in \mathcal{S}$ so that $\int_E f_\alpha d\mu \in V$ if $\alpha \geq \alpha_0$ and $E \in \mathcal{S}, E \subset S - F$.*

**Proof. Necessity.** For any neighbourhood $V$ of 0 in $X_3$ there exists a symmetric entourage $W$ of the uniform structure from $X_3$ so that $W^2(0) \subseteq V$.

Let $\alpha_0$ be so that $\left(\int_E f_\alpha d\mu, \int_E f_{\alpha_0} d\mu\right) \in W$ for any $E \in \mathcal{S}$ if $\alpha \geq \alpha_0$.

From Theorem 3.2., IV, it results that exists $d \in D_1, K = finite \subset I$ so that we have: $\int_E f_{\alpha_0} d\mu \in W(0)$ if $\gamma_i(E) < d, i \in K$.

Therefore $\int_E f_\alpha d\mu \in V$ if $\alpha \geq \alpha_0$ and $\gamma_i(E) < d, i \in K$, that is the condition a).

The condition b) is obtained by taking $E = \{s \in S : f_{\alpha_0}(s) \neq 0\}$. We have $F \in \mathcal{S}$, and $\int_E f_{\alpha_0} d\mu = 0$ for all $E \in \mathcal{S}$ with $E \subset S - F$.

**Sufficiency.** Let $W$ be a symmetric entourage for $X_3$ and let $\alpha_0, K = finite \subset I$, $d \in D_1$ and $F$ be chosen depending on the neightbourhood $W(0)$ according to the conditions a) and b) simultaneously. For $F$ and $W$, let entourage $U$ from $X_1$ be chosen according to axiom $C_1$.
We write: $F_{\alpha\alpha'} = \{s \in S; (f_\alpha(s), f_{\alpha'}(s)) \notin U\}, F_{\alpha\alpha'} \in S$.

Since $\{f_\alpha$ is Cauchy in $X_1^S(\Gamma_\mu)$ there exists $\alpha_1 \geq \alpha_0$ so that $\gamma_i(F_{\alpha\alpha'}) < d, i \in K$ for $\alpha, \alpha' \geq \alpha_1$. For $E \in \mathcal{S}$ in the semigroup $X_3 \times X_3$, we can write:

$$\left(\int_E f_\alpha d\mu, \int_E f_{\alpha'} d\mu\right) = \left(\int_{E \cap F_{\alpha\alpha'}} f_\alpha d\mu, \int_{E \cap F_{\alpha\alpha'}} f_{\alpha'} d\mu\right) + \left(\int_{E \setminus (F_{\alpha\alpha'} \cup F)} f_\alpha d\mu, \int_{E \setminus (F_{\alpha\alpha'} \cup F)} f_{\alpha'} d\mu\right) +$$

$$\left(\int_{E \setminus (F_{\alpha\alpha'} \cap F)} f_\alpha d\mu, \int_{E \setminus (F_{\alpha\alpha'} \cap F)} f_{\alpha'} d\mu\right) \in W(0) \times W(0) + W(o) \times W(0) + W \subseteq W^2 + W^2 + W^2, \alpha, ' \geq \alpha_1$$

**Corollary 3.4.** *Let $\{f_\alpha\}$ and $\{g_\beta\}$ be two generalized sequences from $\mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$, convergent in $X_1^S(\Gamma_\mu)$ to the same function.*

*If $\left\{\int_E f_\alpha d\mu,\right\}$ and $\left\{\int_E g_\beta d\mu\right\}$ are generalized Cauchy sequences in $X_3$ uniformly in $E \in \mathcal{S}$, then for any entourage W from $X_3$ there exists $\alpha_0$ and $\beta_0$ so that if $\alpha \geq \alpha_0$, $\beta \geq \beta_0$ it results that $\left(\int_E f_\alpha d\mu, \int_E g_\beta d\mu\right) \in W$, uniformly in $E \in \mathcal{S}$.*

**Proof.** Given a symmetric entourage $W_1$ from $X_3$ so that $W_1^2 + W_1^2 + W_1^2 \subseteq W$ we choose an entourage $U$ from $X_1$ corresponding to $W_1$ according to axiom $C_1$.

We write $F_{\alpha\beta} = \{s \in S; (f_\alpha(s), g_\beta(s)) \notin U\}\}$. From the previous Lemma it results that there exits $\alpha_0, \beta_0, d \in D, K = finite \subset I$ so that if $F \in \mathcal{S}$ and $\alpha > \alpha_0, \beta > \beta_0, \gamma_i(E) < d, i \in K$, $E \subset S - F$, $E \in \mathcal{S}$ we have $\int_E f_\alpha d\mu \in W_1(0)$ and $\int_E f_\beta d\mu \in W_1(0)$

By hypothesis there exist if $\alpha_1 \geq \alpha_0$ and $\beta_1 \geq \beta_0$ so that for $\alpha > \alpha_1, \beta > \beta_1$, we have $\gamma_i(F_{\alpha\beta}) < d, i \in K$. Expressing the pair $\left(\int_E f_\alpha d\mu, \int_E g_\beta d\mu\right)$ in the same way as in the proof of the sufficiency from Lemma 3.3., the result is obtained.

**Definition 3.5.** *The function $f \in X_1^S$ is called $\Gamma_\mu$- integrable of there exists a generalized sequence $\{f_\alpha$ from $\mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)\}$ so that $f_\alpha \xrightarrow{\Gamma_\mu} f$ and $\left\{\int_E f_\alpha d\mu,\right\}$ is a generalized Cauchy sequence in $X_3$, uniformly in $E \in \mathcal{S}$. Then the $\Gamma_\mu$-integral is the element from $\hat{X}_3$ the completion of $X_3$, defined by: $\int_E f_\alpha d\mu = \lim_\alpha \int_E f_\alpha d\mu$.*

From the Corollary 3.4 it results that above $\Gamma_\mu$-integral is properly defined. We denote by $\mathcal{L}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ the set of $\Gamma_\mu$-integrable functions from $\mathcal{M}[\mathcal{S}, \Gamma_\mu, X_1]$.

It is obvious that $\mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3) \subset \mathcal{L}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ and the $\Gamma_\mu$-integral restricted to $\mathcal{E}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ coincides with the $\Gamma_\mu$-integral from Definition 3.1.

**Theorem 3.6.** *Relatively to the operation of addition the set $\mathcal{L}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ is a subsemigroup of $X_1^S$*

(i) *For $E \in \mathcal{S}$, the mapping $f \to \int_E f d\mu$ of $\mathcal{L}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ in $\hat{X}_3$ is additive:*

$$\int_E (f+g) d\mu = \int_E f d\mu + \int_E g d\mu,\ f, g \in \mathcal{L}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$$

(ii) *For $f \in \mathcal{L}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ the mapping $E \to \nu(E) = \int_E f d\mu, E \in \mathcal{S}$ is additive:*

$$\nu\left(\bigcup_{i=1}^n E_i\right) = \sum_{i=1}^n \nu(E_i),\ E_i \cap E_j = \emptyset, i \neq j, \nu(\emptyset) = 0$$

(iii) *For $f \in \mathcal{L}(\mathcal{S}, \Gamma_\mu, X_1, X_3)$ we have:* $\lim_{\substack{\Gamma_\mu \\ E \xrightarrow[E \in \mathcal{S}]{}}} \nu(E) = 0$

The proof follows from Corollary 3.4. and the definition 3.5.

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# THE BENDING OF THE FINITE ELASTIC ROD ON ELASTIC FOUNDATION UNDER THE ACTION OF CONCENTRATED LOADS

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**Abstract**

The paper gives solution in the distributions space $D'_+$ for the boundary-value problems regarding the bending of the elastic rods on elastic foundation. The expression of the rod deflection is given with the help of the fundamental solution in $D'_+$ of the operator which describes the rod bending. We admit that on the rod act uniformly distributed loads of intensity $q$, as well as a concentrated load of value $P$. We have considered a straight homogeneous elastic rod of finite length $\ell$, and with constant cross-section, supported in point $O$ and with elastic fixing in point $A$. The rod lies on an elastic foundation of Winkler type. The deflection of the rod as well as the reactions in the rod ends is given.

## 1. INTRODUCTION

In solving the problem of the bending of the finite elastic rod on elastic foundation under the action of concentrated loads we come across difficulties owing to these concentrated loads and moments.

The general and unitary method to deal with the problems concerning discontinuous loading is the distribution theory. In the framework of this theory a single equation which contains the boundary and jump conditions is obtained.

The distribution theory was used in [2], [6], [7], [8] and [9] for analyzing beams with discontinuities. A bending problem with discontinuities in which the distribution theory isn't systematically applied, being a combination between classical mathematical analysis and the distribution theory, is studied in [10]. In [2] and [6] using the distribution theory in a systematic manner we study the bending problem with discontinuities of a finite elastic rod on elastic foundation under the action of concentrated loads.

In this paper we study the bending of a straight homogeneous elastic rod of finite length, with constant cross-section, supported in the left end and with elastic fixing in the right end, which lies on an elastic foundation of Winkler type.

We determine the deflection of the rod as well as the reactions of the rod ends. The obtained result allows a global analysis of the influence of the each term: support, elastic fixing and the concentrated load.

## 2. THE STUDY OF THE BENDING OF THE FINITE ELASTIC ROD

Let be $OA$ a straight homogeneous elastic rod of finite length $\ell$, and with constant cross-section, supported in point $O$ and with elastic fixing in point $A$, which lies on an elastic foundation of Winkler type [1]. We admit that on the rod act uniformly distributed loads of intensity $q$, as well as a concentrated load of value $P$ applied in point $c \in (0, \ell)$.

We shall denote by $v(x),\ x\in[0,\ell]$ the deflection of the rod. We denote by $\tilde{\partial}_x=\frac{\tilde{d}}{dx},\ \partial_x=\frac{d}{dx}$ the derivative in classic sense and the derivative in distribution sense, respectively.

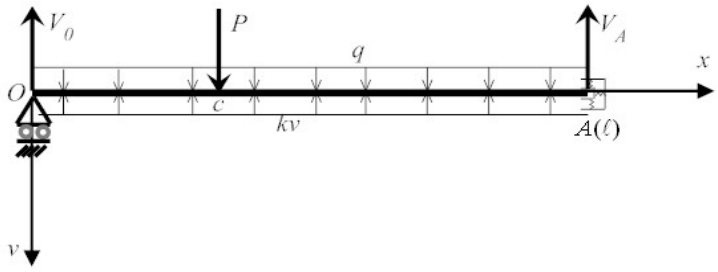



Fig. 2.1. Elastic rod supported on an elastic foundation

For a Winkler model, it is assumed that the reaction of the elastic foundation $q_e(x),\ x\in[0,\ell]$ exerted on the rod is proportional to its deflection at that point and is independent from the deflection of other parts of the foundation hence.

$$q_e(x)=-kv(x),\qquad x\in[0,\ell], \tag{2.1}$$

where $k$ is called the rigidity coefficient of the elastic foundation.

We shall denote by $D'(\square)$ the distribution (continuous linear functional) defined on the test functions space $D(\square)$, which are indefinite derivable functions with compact support.

We denote by $D'_+\subset D'(\square)$ the distributions from $D'(\square)$ having the supports on $[0,\infty)$. We mention that the distributions from $D'_+$ represent a convolution algebra without divisors of zero. We observe that $\tilde{v}(x)=\begin{cases}v(x), & x\in[0,\ell],\\ 0, & x\notin[0,\ell],\end{cases}$ represents a function type distribution from $D'_+$, because its support is in $[0,\ell]\subset[0,\infty)$.

We denote by the symbol $[\ \ ]_a$ the jump of a certain value at point $x=a$.

Due to the way in which the rod is fixed the boundary conditions are

$$\begin{gathered}\tilde{v}(0+0)=0,\ \tilde{v}(0-0)=0,\ \tilde{v}(\ell+0)=0,\ \tilde{v}(\ell-0)=0,\\ \tilde{\partial}_x^2\tilde{v}(0+0)=0,\tilde{\partial}_x^2\tilde{v}(0-0)=0,\ \tilde{\partial}_x^2\tilde{v}(\ell+0)=0,\ EI\tilde{\partial}_x^2\tilde{v}(\ell-0)=k_1\tilde{\partial}_x\tilde{v}(\ell-0).\end{gathered} \tag{2.2}$$

From the boundary conditions (2.2) we have

$$\begin{gathered}[\tilde{v}]_0=\tilde{v}(0+0)-\tilde{v}(0-0)=0,\ [\tilde{v}]_\ell=\tilde{v}(\ell+0)-\tilde{v}(\ell-0)=0,\\ [\tilde{\partial}_x\tilde{v}]_0=\tilde{v}'(0+0)-\tilde{v}'(0-0)=\tilde{v}'(0+0),\ [\tilde{\partial}_x\tilde{v}]_\ell=\tilde{v}'(\ell+0)-\tilde{v}'(\ell-0)=-\tilde{v}'(\ell-0).\end{gathered} \tag{2.3}$$

According to [2] for the deflection $\tilde{v}$ we have the expression

$$\tilde{v}(x)=\begin{cases}0, & x\notin[0,\ell)\\ \dfrac{q}{4EI\omega^3}\displaystyle\int_0^x u(x-t)dt-\dfrac{V_0}{4EI\omega^3}H(x)u(x)+\dfrac{P}{4EI\omega^3}H(x-c)u(x-c) & \\ +\dfrac{1}{4\omega^3}\tilde{v}'(0+0)H(x)u_2(x), & x\in[0,\ell]\end{cases} \tag{2.4}$$

where $\omega=\sqrt[4]{\frac{k}{4EI}}$. We mention that we introduce the real-valued functions $u,u_1,u_2,u_3\in C^\infty(\square)$ having the expression:

$$\begin{aligned}u(x)&=\cosh\omega x\sin\omega x-\sinh\omega x\cos\omega x,\\ u_1(x)&=u'(x)=2\omega\sinh\omega x\sin\omega x,\\ u_2(x)&=u''(x)=2\omega^2\left(\cosh\omega x\sin\omega x+\sinh\omega x\cos\omega x\right),\\ u_3(x)&=u'''(x)=4\omega^3\left(\cosh\omega x\cos\omega x\right).\end{aligned} \tag{2.5}$$

We have

$$u^4(x)=u_3'(x)=-4\omega^4u(x).$$

From here results

$$u^{(4k)}(x)=\left(-4\omega^4\right)^k u(x),\qquad u^{(4k+1)}(x)=\left(-4\omega^4\right)^k u_1(x),$$
$$u^{(4k+2)}(x)=\left(-4\omega^4\right)^k u_2(x),\qquad u^{(4k+3)}(x)=\left(-4\omega^4\right)^k u_3(x).$$

Because any natural number $n\geq 4$ can be written under the form $n=4k+p,\ p=0,1,2,3;\ k\in\square$, we have:

Any $n\geq 4$ order derivative of the function $u\in C^{\infty}(\square)$ represents a multiple of one of the functions $u, u_1=u', u_2=u'', u_3=u'''$ namely

$$u^{(n)}(x)=\begin{cases}\left(-4\omega^4\right)^k u(x), & n=4k\\ \left(-4\omega^4\right)^k u_1(x) & n=4k+1\\ \left(-4\omega^4\right)^k u_2(x) & n=4k+2\\ \left(-4\omega^4\right)^k u_3(x) & n=4k+3\end{cases}\quad k=1,2,3,\ldots$$

Using the formula $\int_0^x f(x-t)dt=\int_0^x f(t)dt$ the deflection $\tilde{v}$ can be written under the form

$$\tilde{v}(x)=\begin{cases}0, & x\notin[0,\ell)\\ \dfrac{q}{4EI\omega^3}\int_0^x u(t)dt-\dfrac{V_0u(x)}{4EI\omega^3}+\dfrac{\tilde{v}'(0+0)u_2(x)}{4\omega^3}, & x\in[0,c)\\ \dfrac{q}{4EI\omega^3}\int_0^x u(t)dt-\dfrac{V_0u(x)}{4EI\omega^3}+\dfrac{\tilde{v}'(0+0)u_2(x)}{4\omega^3}+\dfrac{Pu(x-c)}{4EI\omega^3}, & x\in[c,\ell]\end{cases}\tag{2.6}$$

We observe that in this relation of the deflection $\tilde{v}$ appear only two unknowns, namely: the reaction $V_0$ in $O$ and the rotation of rod to the right in point $O$, $\tilde{v}'(0+0)$. These unknowns as well as the unknowns $V_A, m_A, \tilde{v}'(\ell-0)$ representing the reaction and moment in the $A$ as well as the rotation of rod to the left in point $A$, respectively, will be determined from the following conditions:

$$q\int_0^{\ell}u(t)dt-V_0u(\ell)+Pu(\ell-c)+EI\tilde{v}'(0+0)u_2(\ell)=0,\tag{2.7}$$

$$q\int_0^{\ell}u_1(t)dt-V_0u_1(\ell)+Pu_1(\ell-c)+EI\left[\tilde{v}'(0+0)u_2(\ell)-4\omega^3\tilde{v}'(\ell-0)\right]=0,\tag{2.8}$$

$$q\int_0^{\ell}u_2(t)dt-V_0u_2(\ell)+Pu_2(\ell-c)+4\omega^3m_A-4\omega^4EI\tilde{v}'(0+0)u(\ell)=0,\tag{2.9}$$

$$q\int_0^{\ell}u_3(t)dt-V_0u_3(\ell)+Pu_3(\ell-c)-4\omega^3V_A-4\omega^4EI\tilde{v}'(0+0)u_1(\ell)=0,\tag{2.10}$$

$$m_A=k_1\tilde{v}'(\ell-0),\tag{2.11}$$

where $k_1$ represents a proportionality factor.

The relations (2.7)-(2.10) was obtained from the condition that the support of the deflection should be $[0,\ell]$, namely $\operatorname{supp}\tilde{v}=[0,\ell]$.

From the above system of equations we shall obtain the unknowns $V_0$, $V_A, m_A, \tilde{v}'(\ell-0)$ and $\tilde{v}'(0+0)$.

We have the expression

$$V_0=\frac{k_1\left(b_1u_2(\ell)-b_0u_3(\ell)\right)+EI\left(b_2u_2(\ell)+4\omega^4u(\ell)b_0\right)}{EI\left(u_2^2(\ell)+4\omega^4u^2(\ell)\right)-k_1\left(u_3(\ell)u(\ell)-u_2(\ell)u_1(\ell)\right)},\tag{2.12}$$

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$$\tilde{v}'(0+0)=\frac{1}{EI}\frac{EI\left(b_2u(\ell)-b_0u_2(\ell)\right)+k_1\left(b_1u(\ell)-b_0u_1(\ell)\right)}{EI\left(u_2^2(\ell)+4\omega^4u^2(\ell)\right)-k_1\left(u_3(\ell)u(\ell)-u_2(\ell)u_1(\ell)\right)}, \tag{2.13}$$

$$\tilde{v}'(\ell-0)=\frac{u_2(\ell)\left(b_1u_2(\ell)-b_2u_1(\ell)\right)+4\omega^4u(\ell)\left(b_1u(\ell)-b_0u_1(\ell)\right)+u_3(\ell)\left(b_2u(\ell)-b_0u_2(\ell)\right)}{4\omega^3\left[EI\left(u_2^2(\ell)+4\omega^4u^2(\ell)\right)-k_1\left(u_3(\ell)u(\ell)-u_2(\ell)u_1(\ell)\right]\right.}, \tag{2.14}$$

$$m_A=k_1\frac{u_2(\ell)\left(b_1u_2(\ell)-b_2u_1(\ell)\right)+4\omega^4u(\ell)\left(b_1u(\ell)-b_0u_1(\ell)\right)+u_3(\ell)\left(b_2u(\ell)-b_0u_2(\ell)\right)}{4\omega^3\left[EI\left(u_2^2(\ell)+4\omega^4u^2(\ell)\right)-k_1\left(u_3(\ell)u(\ell)-u_2(\ell)u_1(\ell)\right]\right.}, \tag{2.15}$$

where

$$\begin{aligned} b_0&=\frac{q}{\omega}-\frac{q}{\omega}\frac{u_3(\ell)}{4\omega^3}+Pu(\ell-c),\\ b_1&=qu(\ell)+Pu_1(\ell-c),\\ b_2&=q\omega^2u_1(\ell)+Pu_2(\ell-c),\\ b_3&=qu_2(\ell)+Pu_3(\ell-c). \end{aligned} \tag{2.16}$$

## 3. CONCLUSIONS

As it was pointed out in [2] the distribution theory represents the adequate framework to solve the boundary-value problems regarding the bending of the elastic rods on elastic foundation when we have external discontinuities (e.g. discontinuous loading) and internal discontinuities (e.g. owning to the mechanical properties).

In this way the difference between continuous loads and discontinuous loads is vanish.

The classical method of solving the problems in which appear discontinuities is the partition of the rod into segments (which have distinct mechanical and geometrical properties). We obtain a system of boundary (the ends of the segments rod) value problems so that the solution of the problem on each rod segment is continuous. To solve the problem with discontinuities we must take into account the continuity conditions at the interface of the rod segments.

The obtained result allows a global analysis of the influence of the each term: support, elastic fixing and the concentrated load.

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# Further Considerations on the Formal Verification of Number Theoretical Algorithms *

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**Abstract.** We discuss experimental results of an automatic approach for inferring polynomial loop invariants of P-solvable loops implementing interesting number-theoretic algorithms. The method relies on techniques from symbolic summation and polynomial algebra, and is implemented in the software package `Aligator` written in *Mathematica*.

## 1 Introduction

To verify and/or analyze programs containing loops one needs to discover some properties of loops automatically. Such properties are known as loop invariants. Powerful techniques for finding loop invariants are thus crucial for further progress of software verification and program analysis.

Research into methods for automatically generating loop invariants has a long history, starting with the works of [18, 5]. However, due to the limited arithmetic operations among program variables, the problem of invariant inference has recently become a challenging research topic [12, 16, 4, 14, 15, 9].

In [9, 11] we introduced an automatic approach for polynomial invariant generation, that, contrarily to [12, 16, 4] does not use a priori fixed invariant templates, and it is applicable to a richer class of loops than the one introduced in [15]. These invariants are of the form $p_1 = 0 \wedge \cdots \wedge p_r = 0$, where $p_1, \ldots, p_r$ are polynomials over the program variables. In the sequel we will call a *polynomial equality* any equality of the form $p = 0$, where $p$ is a polynomial. Thus an invariant is polynomial if it is a conjunction of polynomial equalities.

The loops for which our method automatically infers polynomial invariants are characterized by the following conditions: (i) they contain only assignments to variables and conditional statements; (ii) tests conditions are omitted; (iii) the variables in assignments range over numeric types, such as integers or rationals; (iv) the variables can be expressed as a polynomial of the initial values of variables (those when the loop is entered), the loop counter, and some new variables, where there are algebraic dependencies among the new variables. We call such loops *P-solvable*. There are many natural examples of P-solvable loops in real-life programs.

Our method for invariant generation first translates conditional statements within the loop into a sequence of loops, called inner loops. Then all loop conditions are ignored,

* Work was partly done while the first author was at RISC-Linz, Austria.

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turning the loop into a non-deterministic program. Next symbolic summation methods are applied to the inner loops to determine if the output values of their variables can be expressed using symbolic expressions in their input values and inner loop counters. If yes, a collection of potential polynomial invariants is generated using a Gröbner basis algorithm to eliminate loop counters. The invariant property of these polynomials are then checked using the weakest precondition strategy, and valid polynomial invariants of P-solvable loops are thus derived. Moreover, we proved that under some conditions the method computes *all* polynomial invariants, i.e. it computes a Gröbner basis of the ideal of polynomial invariants. However, we could not find any example of a P-solvable loop for which our approach fails to be complete. We thus conjecture that the imposed completeness conditions cover a large class of imperative programs, and the completeness proof of our approach without the additional assumptions is a challenging task for further research.

Exploiting the symbolic manipulation capabilities of the computer algebra system *Mathematica*, our approach is implemented in a new software package called `Aligator` [9]. Using `Aligator`, a complete set of polynomial invariants is successfully generated for numerous imperative programs working on numbers.

The purpose of this paper is to illustrate our approach on examples implementing interesting algorithms working on numbers. Finding invariants for such loops may be a very hard and creative work since non-trivial mathematical knowledge and intuition may be required. The ultimate goal of this paper is to emphasize the value of applying algebraic techniques for computer aided verification We hope that the experimental results will provide practical justification for the relevance of our method. For technical details and correctness of the approach we refer to [9, 11].

## 2 P-solvable Loops and Invariants

In this section we first briefly recall fundamental facts from polynomial algebra and recurrence solving. Then our algorithm for P-solvable loops will be presented.

We assume that $\mathbb{K}$ is a field of characteristic zero (e.g. $\mathbb{Q}$, $\mathbb{R}$, etc.), and by $\bar{\mathbb{K}}$ we denote its algebraic closure. Throughout this paper, $X = \{x_1, \ldots, x_m\}$ $(m > 1)$ denotes the set of loop variables with initial values $X_0$, and $\mathbb{K}[X]$ is the ring of polynomials in the variables $X$ with coefficients from $\mathbb{K}$.

**Polynomial Ideals and Invariants.** As observed in [13], the set of polynomials $p$ such that $p = 0$ is a polynomial invariant forms a polynomial ideal, called *polynomial invariant ideal*. The challenging part in polynomial invariant inference is thus to systematically compute a *basis* of this ideal. For doing so we rely on [1], and try to algorithmically compute a Gröbner basis $\{p_1, \ldots, p_r\}$ $(p_i \in \mathbb{K}[X])$ of the polynomial invariant ideal. The conjunction of the polynomial equations corresponding to the polynomials from such a computed basis (i.e. $p_i(X) = 0$) would thus completely characterize the polynomial invariants of the loop. Namely, any other polynomial invariant could be derived as a logical consequence of $p_1 = 0 \wedge \cdots \wedge p_r = 0$.

In the process of deriving such a finite basis of the polynomial invariant ideal, we leverage methods from algorithmic combinatorics, as presented below.

**Recurrences and Closed Forms.** From the assignments statements of a P-solvable loop, recurrence equations of the variables are built and solved, using the loop counter

$n$ as the recurrence index. Solutions of recurrence equations are called *closed-forms*, and they express the value of each program variable in a loop iteration as a function of $n$ and some given initial values.

In our research, we handle special classes of recurrence equations, i.e. those that are either C-finite [19] or Gosper-summable [3]. C-finite recurrences always admit closed forms [2], whereas closed forms of Gosper-summable recurrences can be computed, if they exist, using the decision algorithm given by [3]. For example, the closed form solution of the C-finite recurrence $x[n+1] = 2 * x[n] + 1$ (corresponding to the loop assignment $x := 2 * x + 1$) is $x[n] = 2^n * x[0] + 2^n - 1$, where $x[n]$ denotes the value of variable $x$ at loop iteration $n$ and thus $x[0]$ is the initial value of $x$ (i.e. before entering the loop); whereas the closed form the Gosper-summable recurrence $y[n+1] = y[n]+2$ (corresponding to the loop assignment $y := y + 2$) is $y[n] = y[0] + 2n$, where $y[n]$ denotes the value of variable $y$ at loop iteration $n$ and $y[0]$ is the initial value of $y$.

We only consider P-solvable loops whose assignment statements describe Gosper-summable or C-finite recurrences. Moreover, P-solvability of loops requires the existence of *polynomial* closed form solutions of each variable, i.e. closed forms are polynomial expressions in loop counter, initial values and some new variables, where there are polynomial relations, so-called *algebraic dependencies*, among the new variables. Computing the algebraic dependencies reduces once again to compute a Gröbner basis of the ideal of all algebraic dependencies [7]. For example, the ideal of algebraic dependencies among $a = 2^n$ and $b = 4^n$ is generated by the polynomial relation $a^2 - b = 0$; note that this relation holds for *any* $n \in \mathbb{N}$.

**P-solvable Loops and Invariants.** We consider P-solvable loops as below.

$$\texttt{While}[b, s_0; \texttt{If}[b_1 \texttt{ Then } s_1 \texttt{ Else } \ldots \texttt{ If}[b_{k-1} \texttt{ Then } s_{k-1} \texttt{ Else } s_k]\ldots]; s_{k+1}] \quad (1)$$

where $b_0, \ldots, b_{k-1}$ are boolean expressions, and $s_0, \ldots, s_{k+1}$ are sequences of assignments. As mentioned, in our approach to invariant generation all tests are omitted, and the loops are turned into non-deterministic programs [11]. Using regular expression like notation, loop (1) can be thus equivalently written as

$$(S_1|S_2|\ldots|S_k)^*, \text{ where } S_i = s_0; s_i; s_{k+1} \text{ for all } i = 1, \ldots, k. \quad (2)$$

Loop (1) is P-solvable iff the *inner* loops $S_i^*$ from (2) are P-solvable. Namely, the variables of each $S_i^*$ can be expressed as a polynomial of the initial values of variables (those when the loop is entered), the inner loop counter, and some new variables, where there are algebraic dependencies among the new variables. In the sequel we write $S_i^{j_i}$ to mean the $j_i$-times repeated execution of $S_i$, where $j_i \in \mathbb{N}$ denotes the loop counter of $S_i$.

We have now all necessary ingredients to synthesize our invariant generation algorithm for P-solvable loops with assignments and (nested) conditionals. This is achieved in Algorithm 2.1, as given below.

**Algorithm 2.1 P-solvable Loops with Nested Conditionals**
**Input:** P-solvable loop (1) with $k$ conditional branches and assignments
**Output:** Set $GI$ of polynomial invariants for (1) among $X$ with initial values $X_0$
**Assumption:** $k \geq 1, j_i \in \mathbb{N}, i = 1, \ldots, k$

1 Transform loop (1) into loop (2) with $k$ P-solvable inner loops $S_1^*, \ldots, S_k^*$
2 for each $S_i^{j_i}$, $i = 1, \ldots, k$ do
3 Compute the closed form system of the P-solvable loop $S_i^{j_i}$:

$$\begin{cases} x_1[j_i] = q_{i,1}(j_i, y_{i1}, \ldots, y_{is}) \\ \vdots \\ x_m[j_i] = q_{i,m}(j_i, y_{i1}, \ldots, y_{is}) \end{cases}, \text{where} \quad \begin{array}{l} y_{ir} \in \bar{\mathbb{K}}, \\ q_{i,l} \in \bar{\mathbb{K}}[j_i, y_{i1}, \ldots, y_{is}], \\ q_{i,l} \text{ are parameterized by } X_0, \\ r = 1, \ldots, s, \ \ l = 1, \ldots, m \end{array}$$

4 Compute the ideal $A_i = I(j_i, y_{i1}, \ldots, y_{is})$ of algebraic dependencies for the new variables $y_{is}$ from the closed form of $S_i^{j_i}$
5 endfor
6 Compute the merged closed form of $S_1^{j_1}; \ldots; S_k^{j_k}$:

$$\begin{cases} x_1[j_1, \ldots, j_k] = f_1(j_1, y_{11}, \ldots, y_{1s}, \ldots, j_k, y_{k1}, \ldots, y_{ks}) \\ \vdots \\ x_m[j_1, \ldots, j_k] = f_m(j_1, y_{11}, \ldots, y_{1s}, \ldots, j_k, y_{k1}, \ldots, y_{ks}) \end{cases}, \text{with}$$

$f_l \in \bar{\mathbb{K}}[j_1, y_{11}, \ldots, y_{1s}, \ldots, j_k, y_{k1} \ldots, y_{ks}]$,
the coefficients of $f_l$ are given by the initial values $X_0$ before $S_1^{j_1}; \ldots; S_k^{j_k}$

7 Let $A = \sum_{i=1}^{k} A_i$
8 Compute $PI_1 = (\langle x_1 - f_1, \ldots, x_m - f_m \rangle + A) \cap \mathbb{K}[x_1, \ldots, x_m]$
9 for each permutation $(w_1, \ldots, w_k) \neq (1, \ldots, k)$ over $\{1, \ldots, k\}$ do
10 Compute the *merged* closed form of $S_{w_1}^{j_{w_1}}; \ldots; S_{w_k}^{j_{w_k}}$:

$$\begin{cases} x_1[j_1, \ldots, j_k] = f_1(j_{w_1}, y_{w_1 1}, \ldots, y_{w_1 s}, \ldots, j_{w_k}, y_{w_k 1}, \ldots, y_{w_k s}) \\ \vdots \\ x_m[j_1, \ldots, j_k] = f_m(j_{w_1}, y_{w_1 1}, \ldots, y_{w_1 s}, \ldots, j_{w_k}, y_{w_k 1}, \ldots, y_{w_k s}) \end{cases}, \text{with}$$

$f_l \in \bar{\mathbb{K}}[j_1, y_{11}, \ldots, y_{1s}, \ldots, j_k, y_{k1} \ldots, y_{ks}]$,
the coefficients of $f_l$ are given by the initial values $X_0$ before $S_{w_1}^{j_{w_1}}; \ldots; S_{w_k}^{j_{w_k}}$

11 Let $A = \sum_{i=1}^{k} A_{w_i}$
12 Compute $G = (\langle x_1 - f_1, \ldots, x_m - f_m \rangle + A) \cap \mathbb{K}[x_1, \ldots, x_m]$
13 Compute $PI_1 = PI_1 \cap G$
14 endfor

15 From $PI_1$ keep the set $GI$ of those polynomials whose conjunction is preserved by each $S_1, \ldots, S_k$:

$GI = \{p \in PI_1 \mid wp(S_i, p(X) = 0) \in \langle GI \rangle, i = 1, \ldots, k\} \subset PI_1$, where $wp(S_i, p(X) = 0)$ is the weakest precondition of $S_i$ with postcondition $p(X) = 0$

16 *return* $GI$.

Algorithm 2.1 receives as input a P-solvable loop (1), and transforms it into (2) as its first step. Next, closed forms and algebraic dependencies of each inner loop $S_i^{j_i}$ are computed using the methods presented on page 2 (steps 2-5 of Algorithm 2.1). Further, inner loops are taken in all possible $k!$ permutation orders. For each permutation order, closed forms of inner loops are "merged" to express the behavior of a sequence of inner loops as a polynomial system in the inner loop counters, initial values $X_0$ and some new variables where there are algebraic dependencies among the new variables. Loop counters are next eliminated by Gröbner basis computation, and the ideal of valid polynomial identities after arbitrary inner loop sequences is thus derived (steps 6-12 of Algorithm 2.1). Further, the intersection of the polynomial ideals of all inner loop sequences is computed (step 13 of Algorithm 2.1), and the ideal $PI_1$ of polynomial relations for the *first iteration* of loop (2) with initial values $X_0$ is obtained. Finally, using the weakest precondition strategy, the inductiveness property of polynomials from $PI_1$ is checked, and a set $GI$ of polynomial invariants for (1) is derived (steps 15-16 of Algorithm 2.1).

Note that steps 9-16 are relevant only for P-solvable loops with nested conditionals (i.e. $k > 1$). For loops with assignment statements only, polynomial invariants are computed from the closed form system of the loop by eliminating the variables in the loop counter, using Gröbner basis computation. Moreover, based on the theory of Gröebner bases, the computed set of polynomials is a basis of the polynomial invariant ideal. Hence, our approach for invariant generation in case of P-solvable loops with assignments only is always complete: any further polynomial invariant can be inferred from the computed basis.

Moreover, under additional assumptions on the ideal of polynomial relations among $X$ with initial values $X_0$ corresponding to sequences of $k$ and $k+1$ inner loops, in [11] we proved that our method is also complete for a wide class of P-solvable loop with nested conditionals. Namely, it returns a basis for the polynomial invariant ideal for some special cases of P-solvable loops with conditional branches and assignments. It is worth to be mentioned though that these additional constraints cover a wide class of loops, and we could not find any example for which the completeness of our approach is violated.

## 3 Experimental Results

We now turn our interest on the practical applicability of our method for invariant generation, and illustrate the technique on interesting examples implementing non-trivial number-theoretic algorithms.

Our approach is implemented in a new software package, called `Aligator`[10], written on top of the computer algebra system *Mathematica*. The package combines

algorithms from symbolic summation and polynomial algebra with computational logic in a uniform framework, and is applicable to the rich class of P-solvable loops.

We begin with a loop without conditionals, and illustrate that Algorithm 2.1 is applicable for the special case when $k = 1$ (i.e. loop with only assignments).

EXAMPLE 3.1 Consider the loop implementing an algorithm for computing the integer square root $k$ of a given integer number $a$ [8].

$$\begin{array}{l} k := 0; j := 1; m := 1; \\ \texttt{While}[(m \leq a), \\ \quad k := k + 1; j := j + 2; m := m + j]. \end{array}$$

By applying Algorithm 2.1, the polynomial invariants are derived as follows.

Step 1: Omitting test conditions.
$S_1 : \ k := k + 1; j := j + 2; m := m + j.$

Steps 2-5: Closed form computation.

*System of recurrences:*

$$\begin{cases} k[n+1] &= k[n] + 1 \\ j[n+1] &= j[n] + 2 \\ m[n+1] &= m[n] + j[n+1] \end{cases}$$

where $n \in \mathbb{N}$ is the loop counter

*Recurrence solving:*

$$\begin{cases} k[n] &\underset{Gosper}{=} k[0] + n \\ j[n] &\underset{Gosper}{=} j[0] + 2n \\ m[n] &\underset{Gosper}{=} m[0] + j[0] * n + n(n+1) \end{cases}$$

with $A = \emptyset$.

$k[0]$, $j[0]$ and $m[0]$ denote respectively the initial values of $k$, $j$ and $m$.

Steps 6-8: Variable elimination.

$$\begin{aligned} PI_1 &= \langle k - k[0] - n,\ j - j[0] - 2n,\ m - m[0] - j[0] * n - n(n+1) \rangle + A \cap \mathbb{Z}[k, j, m] \\ &= \langle 2j + j^2 - 4m - 2j[0] - j[0]^2 + 4m[0],\ -j + 2k + j[0] - 2k[0] \rangle \end{aligned}$$

Steps 9-16: Polynomial invariant ideal.

$GI = 2j + j^2 - 4m - 2j[0] - j[0]^2 + 4m[0],\ -j + 2k + j[0] - 2k[0]$ and $PI_1 = \langle GI \rangle$.

In [11], we proved that affine loops are P-solvable. Note that Example 3.1 is affine, and thus P-solvable. Hence, the correctness of Algorithm 2.1 ensures that the returned set $GI$ of invariants is a basis for the polynomial invariant ideal, and our method is complete: any further polynomial invariant can be derived from $GI$.

The automatically inferred invariant for Example 3.1 is thus

$$2j + j^2 - 4m - 2j[0] - j[0]^2 + 4m[0] = 0 \ \wedge \ -j + 2k + j[0] - 2k[0] = 0,$$

yielding

$$1 + 2j + j^2 - 4m = 0 \ \wedge \ 1 - j + 2k = 0$$

by initial values substitutions.

Many interesting algorithms implementing special numbers from algebraic combinatorics can be encoded using P-solvable loops, as also illustrated in the next example.

EXAMPLE 3.2 Consider the loop computing the number of HC-polyominoes for $m \geq 2$ [17, 6].

$$
\begin{aligned}
&g := 1;\ b := 5/16;\ a := 3/4;\ r := 2;\\
&\texttt{While}[i \leq m,\\
&\quad s := t;\ t := r;\ r := 5 * r - 7 * a + 4 * b;\\
&\quad a := t;\ b := s;\ g := 4 * g;\ i := i + 1].
\end{aligned}
$$

For simplicity, we omit a detailed presentation of the steps of Algorithm 2.1, and discuss only the main results obtained from symbolic summation.
The loop body is described by the recurrence equations:

$$
\begin{cases}
r[n+3] = 5 * r[n+2] - 7r[n+1] + 4r[n]\\
a[n+3] = r[n+2]\\
b[n+3] = r[n+1]\\
g[n+3] = 4g[n+2]\\
i[n+3] = i[n] + 1
\end{cases}
$$

where $n \geq 0$ is the loop counter. The recurrences of $r$ and $g$ are C-finite, and hence they can be solved by the methods presented on page 2. The recurrence of $i$ is both Gosper-summable and C-finite, and thus it admits closed form solution which is computed in our approach by the Gosper-algorithm [3]. The closed forms of $r$ and $g$ yield algebraic exponential sequences in $n$, whose ideal of algebraic dependencies is derived as discussed on page 2. Further, by Gröbner basis computation for eliminating the variables in $n$ from the closed form system of the loop, we obtain a *basis* of the polynomial invariant ideal, as given below.

$$
\begin{aligned}
&\{31\,g\,a[0]^3 - 69\,g\,a[0]^2\,b[0] + 56\,g\,a[0]\,b[0]^2 - 16\,g\,b[0]^3 - 31\,a^3\,g[0] + 69\,a^2\,b\,g[0] -\\
&56\,a\,b^2\,g[0] + 16\,b^3\,g[0] + 32\,a^2\,r\,g[0] - 47\,a\,b\,r\,g[0] + 20\,b^2\,r\,g[0] - 10\,a\,r^2\,g[0] +\\
&7\,b\,r^2\,g[0] + r^3\,g[0] - 32\,g\,a[0]^2\,r[0] + 47\,g\,a[0]\,b[0]\,r[0] - 20\,g\,b[0]^2\,r[0] - g\,r[0]^3 +\\
&10\,g\,a[0]\,r[0]^2 - 7\,g\,b[0]\,r[0]^2\},
\end{aligned}
$$

yielding the polynomial invariant

$$
\begin{aligned}
&496a^3 + 1104a^2b - 896ab^2 + 256b^3 - g + 512a^2r - 752abr + 320b^2r -\\
&160ar^2 + 112br^2 + 16r^3 = 0,
\end{aligned}
$$

by initial values substitutions.

Finally, let us give an example of a P-solvable loop with nested conditionals.

EXAMPLE 3.3 Consider the imperative loop implementing an algorithm for computing the square root $q$ with precision $err$ for a real number $a$ [20].

$$
\begin{aligned}
&r := a - 1;\ q := 1;\ p := 1/2;\\
&\texttt{While}[(2 * p * r \geq err),\\
&\texttt{If}[2 * r - 2 * q * p \geq 0\\
&\quad \texttt{Then}\ r := 2 * r - 2 * q - p;\ q := q + p;\ p := p/2\\
&\quad \texttt{Else}\ r := 2 * r;\ p := p/2].
\end{aligned}
$$

Step 1: Omitting test conditions and loop transformation.

$$S_1: \ r := 2*r - 2*q - p; \ q := q + p; \ p := p/2$$
$$S_2: \ r := 2*r; \ p := p/2.$$

Steps 2-5: Closed form computation of inner loops.

*System of recurrences:*

Inner loop $S_1^{j_1}$:
$j_1 \in \mathbb{N}$
$$\begin{cases} p[j_1+1] = p[j_1]/2 \\ q[j_1+1] = q[j_1] + p[j_1] \\ r[j_1+1] = 2*r[j_1] - 2*q[j_1] - p[j_1] \end{cases}$$

Inner loop $S_2^{j_2}$:
$j_2 \in \mathbb{N}$
$$\begin{cases} p[j_2+1] = p[j_2]/2 \\ q[j_2+1] = q[j_2] \\ r[j_2+1] = 2*r[j_2], \end{cases}$$

where $j_1$ and $j_2$ represent the loop counters of the inner loops.

*Recurrence solving:*

Inner loop $S_1^{j_1}$:
$j_1 \in \mathbb{N}$
$$\begin{cases} p[j_1] \ _{C-\overline{finite}} \ \frac{1}{2^{j_1}} * p[0_i] \\ q[j_1] \ _{Cosper} \ q[0_{j_1}] + 2*p[0_{j_1}] - \frac{1}{2^{j_1-1}} * p[0_{j_1}] \\ r[j_1] \ _{C-\overline{finite}} \ 2^{j_1} * (r[0_{j_1}] - 2*q[0_{j_1}] - 2*p[0_{j_1}]) - \\ \qquad \frac{1}{2^{j_1-1}} * p[0_{j_1}] + 2*q[0_{j_1}] + 4*p[0_{j_1}] \end{cases}$$

Inner loop $S_2^{j_2}$:
$j_2 \in \mathbb{N}$
$$\begin{cases} p[j_2] \ _{C-\overline{finite}} \ \frac{1}{2^{j_2}} * p[0_{j_2}] \\ q[j_2] \quad = \quad q[0_{j_2}] \\ r[j_2] \ _{C-\overline{finite}} \ 2^{j_2} * r[0_{j_2}], \end{cases}$$

where $p[0_{j_1}], q[0_{j_1}], r[0_{j_1}]$ are the initial values of $p, q, r$ before entering the inner loop $S_1^{j_1}$. Similarly, $p[0_{j_2}], q[0_{j_2}], r[0_{j_2}]$ are the initial values of $p, q, r$ before entering the inner loop $S_2^{j_2}$.

*Introducing new variables and computing algebraic dependencies:*

Inner loop $S_1^{j_1}$:

$j_1 \in \mathbb{N}$
$x = 2^{j_1}, y = 2^{-j_1}$
$$\begin{cases} p[j_1] = y * p[0_{j_1}] \\ q[j_1] = q[0_{j_1}] + 2*p[0_{j_1}] - 2*y*p[0_{j_1}] \\ r[j_1] = x * (r[0_{j_1}] - 2*q[0_{j_1}] - 2*p[0_{j_1}]) - \\ \qquad 2*y*p[0_{j_1}] + 2*q[0_{j_1}] + 4*p[0_{j_1}] \end{cases}$$

$A_1 = \langle x*y - 1 \rangle$

Inner loop $S_2^{j_2}$:

$j_2 \in \mathbb{N}$
$u = 2^{j_2}, v = 2^{-j_2}$
$$\begin{cases} p[j_2] = v * p[0_{j_2}] \\ q[j_2] = q[0_{j_2}] \\ r[j_2] = u * r[0_{j_2}] \end{cases}$$

$A_2 = \langle u*v - 1 \rangle$

Steps 6-8: Polynomial relations of $S_1^{j_1}; S_2^{j_2}$.

*Merging closed forms:*

For the inner loop sequence $S_1^{j_1}; S_2^{j_2}$, the initial values of the loop variables $p[0_{j_2}]$, $q[0_{j_2}]$ and $r[0_{j_2}]$ before entering loop $S_2^{j_2}$ are given respectively by the values of the variables $p[j_1]$, $q[j_1]$ and $r[j_1]$ after $S_1^{j_1}$. Thus, by replacing the closed form expressions of $p[j_1]$, $q[j_1]$, and $r[j_1]$ in the closed forms $p[j_2]$, $q[j_2]$ and $r[j_2]$, we get the closed form system for the values of loop variables $p[j_1, j_2]$, $q[j_1, j_2]$ and $r[j_1, j_2]$ after $j_1$-times repeated execution of $S_1$ followed by $j_2$-times repeated execution od $S_2$. Writing respectively $p$, $q$ and $r$ instead of $p[j_1, j_2]$, $q[j_1, j_2]$ and $r[j_1, j_2]$, the obtained merged closed form is as follows.

Closed form system of $S_1^{j_1}; S_2^{j_2}$:

$$\begin{cases} p = v * y * p[0] \\ q = q[0] + 2 * p[0] - 2 * y * p[0] \\ r = u * \Big(x * (r[0] - 2 * q[0] - 2 * p[0]) - 2 * y * p[0] + 2 * q[0] + 4 * p[0]\Big) \end{cases}$$

with $A = \langle u * v - 1,\ x * y - 1 \rangle$,

where $p[0], q[0], r[0]$ are respectively the initial values of the loop variables $p, q, r$ before the first iteration of the P-solvable loop with nested conditionals (i.e. before $S_1^i; S_2^j$). We denote

$$\begin{aligned} I_1 = \langle & p - v * y * p[0], q - (q[0] + 2 * p[0] - 2 * y * p[0]), \\ & r - u * \Big(x * (r[0] - 2 * q[0] - 2 * p[0]) - 2 * y * p[0] + 2 * q[0] + 4 * p[0]\Big) \\ & u * v - 1,\ x * y - 1 \rangle. \end{aligned}$$

*Variable elimination:*

$$PI_1 = I_1 \cap \mathbb{R}[p, q, r] = \langle q^2 - q[0]^2 + 2 * p * r - 2 * p[0] * r[0] \rangle.$$

Steps 6-8: Polynomial relations of $S_2^{j_2}; S_1^{j_1}$.

*Merging closed forms:*

Closed form system of $S_2^{j_2}; S_1^{j_1}$

$$\begin{cases} p = y * v * p[0] \\ q = q[0] + 2 * p[0] - 2 * y * p[0] \\ r = x * (u * r[0] - 2 * q[0] - 2 * v * p[0]) - 2 * y * v * p[0] + 2 * q[0] + 4 * v * p[0] \end{cases}$$

with $A = \langle x * y - 1,\ u * v - 1 \rangle$,

where $p[0], q[0], r[0]$ are the initial values of the loop variables $p, q, r$ before the first iteration of the P-solvable loop with nested conditionals (i.e. before $S_2^j; S_1^i$). We denote

$$\begin{aligned} I_2 = \langle & p - v * y * p[0],\ q - q[0] - 2 * p[0] + 2 * y * p[0] \\ & r - u * \Big(x * (r[0] - 2 * q[0] - 2 * p[0]) - 2 * y * p[0] + 2 * q[0] + 4 * p[0]\Big) \\ & u * v - 1,\ x * y - 1 \rangle. \end{aligned}$$

*Variable elimination:*

$G = I_2 \cap \mathbb{R}[p, q, r] = \langle q^2 - q[0]^2 + 2 * p * r - 2 * p[0] * r[0] \rangle$.

*Polynomial relations of inner loop sequences:*
$PI_1 = PI_1 \cap G = \langle q^2 - q[0]^2 + 2 * p * r - 2 * p[0] * r[0] \rangle$.

Steps 15-16: Polynomial invariants of P-solvable loop with conditionals.

$$GI = \{q^2 - q[0]^2 + 2 * p * r - 2 * p[0] * r[0]\},$$

and thus $PI_1 = \langle GI_1 \rangle$. The derived set $GI$ is hence a basis of the polynomial invariant ideal, and our method is complete: any further polynomial invariant can be derived from $GI$.

The automatically inferred polynomial invariant for Example 3.3 is thus

$$q^2 - q[0]^2 + 2 * p * r - 2 * p[0] * r[0] = 0,$$

from which, by substituting the concrete values for the symbolically treated initial values $p[0], q[0], r[0]$, we obtain:

$$a - 2 * p * r - q^2 = 0.$$

## 4 Conclusions

An automatic approach for polynomial invariant generation for P-solvable loops was discussed, and illustrated on a number of examples implementing non-trivial number-theoretic algorithms. For all examples we could find, and thus in particular for the examples discussed in the paper, a basis for the polynomial invariant ideal was derived by using recurrence solving, polynomial algebra and computational logic. The successful application of our approach underlines the value of using algebraic techniques for computer aided verification.

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# Considerations on the Calculus Algorithm of the Fluid's Velocity Potential through Profile Grids

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**Abstract.**
Based on the results of [10] and [11], in this paper we present some practical aspects of the usage of the calculus algorithm for the study of the compressible fluid's stationary movement through profile grids, on an axial–symmetric flow–surface, in variable thickness of stratum.

**Keywords:** boundary element method, hydrodynamic networks, fluid's velocity potential, Fredholme integral equation, Lagrange interpolation

## 1 Introduction

In this paper we present practical aspects of the usage of the calculus algorithm for the study of the compressible fluid's stationary movement through profile grids, on an axial–symmetric flow–surface, in variable thickness of stratum. More precisely, we show the applicability of the boundary element methods (BEM) with real values, and the possibility of solving the integral equation of the velocity potential by using the successive approximation method w.r.t. the parameters $\rho$ (fluid's density) and $h$ (thickness variation of fluid stratum), and using the Lagrangian interpolation formula through five points for the calculation of the derivatives of the velocity potential.

The rest of the paper is organized as follows: in section 2 we state the problem and some theoretical considerations that are needed. In section 3 we present the calculus algorithm for the study of the compressible fluid's stationary movement, together with its practical aspects. Section 4 concludes with some ideas for the future work.

## 2 Presenting the Problem

The fundamental equations (from the CVBEM method) in the problem of the compressible fluid's movement on a axial-symmetric flow–surface, in variable thickness of stratum, could be ( [5], [6], [7]):

$$\begin{aligned} w(z) &= \overline{V}_m + \int_{L_0} H(z,\zeta)w(\zeta)d\zeta + i\iint_{D_{0^*}^-} H(z,\zeta)\widehat{q}(\zeta)d\xi d\eta \\ F(z) &= \overline{V}_m \cdot z + \Gamma \cdot G(z,\zeta_A) + \int_{L_0} H(z,\zeta)F(\zeta)d\zeta + i\iint_{D_{0^*}^-} G(z,\zeta)\widehat{q}(\zeta)d\xi d\eta \end{aligned} \tag{1}$$

where:

$A$ – is a fixed point on the base profile $L_0$;

$t$ – is the grid step;

$\Gamma$ – is the circulation around $L_0$.

$$\begin{aligned} H(z,\zeta) &= \tfrac{1}{2ti}\operatorname{ctg}\tfrac{\pi}{t}(z-\zeta) \\ G(z,\zeta) &= \tfrac{1}{2\pi i}\ln\sin\tfrac{\pi}{t}(z-\zeta) \\ \widehat{q}(\zeta) &= 2\tfrac{\partial w}{\partial\zeta} = -\left[v_x\tfrac{\partial \ln p^*}{\partial\xi} - v_y\tfrac{\partial \ln p^*}{\partial\eta}\right], \qquad p* = \tfrac{\rho\cdot h}{\rho_0} \end{aligned} \tag{2}$$

where:

$\rho$ – is the fluid's density,

$h$ – is a function that represents the thickness' variation of the fluid stratum.

$D_{0^*}^-$ – bounded simple convex domain, defined as:

$$D_{0^*}^- : \left[-\frac{t}{2} < \xi < \frac{t}{2}, -\left(t+\frac{l}{2}\right) < \eta < \left(t+\frac{l}{2}\right)\right] \tag{3}$$

where:

$l$ – is the projection of $L_0$ profile's frame on the $Oy$ axis.

Our purpose is to solve the fundamental equations (1) (obtained from the CVBEM method) using (BEM) in real variables. For doing so, we consider the fundamental integral–equation of the complex potential $F(z) = \varphi + i\psi$ and transform it into an integral equation with real variables, i.e. we build the integral equation of the velocity potential $\varphi(s)$ ($\psi(s)$ is the flow rate function).

**Theorem 2.1.** *[7], [11] In the subsonic motion of the compressible fluid through the profile grid, on an axial–symmetric flow–surface, in variable thickness of stratum, the velocity potential $\varphi(s)$, $s \in L_0$ is the solution of the integral equation (4):*

$$\varphi(s) + \int_{L_0} \varphi(\sigma)\frac{dM(s,\sigma)}{d\sigma}d\sigma = b(s) + \iint_{D_{0^*}^-} \widehat{q}(\sigma)N(s,\sigma)d\xi d\eta \tag{4}$$

*where:*

*$s(x_0, y_0)$ and $\sigma(\xi,\eta)$ are the curvilinear coordinates of the fixed point $A$ on the $L_0$ base profile;*

$$
\begin{aligned}
b(s) &= 2\left(x_0 v_{mx} + y_0 v_{my}\right) + \Gamma M\left(s, \sigma_A\right) + \int\limits_{L_0} \left[\psi(s) - \psi(\sigma)\right] \tfrac{dN}{d\sigma} d\sigma \\
M(z_0, \zeta) &= \tfrac{1}{\pi} arctg \tfrac{th\frac{\pi}{t}(\eta - y_0)}{tg\frac{\pi}{t}(\xi - x_0)} \\
N(z_0, \zeta) &= \tfrac{1}{\pi} \ln \sqrt{\tfrac{1}{2}\left[ch\tfrac{2\pi}{t}(\eta - y_0) - \cos\tfrac{2\pi}{t}(\xi - x_0)\right]}
\end{aligned}
\tag{5}
$$

$v_{mx}$, $v_{my}$ *are the components of the asymptotic mean velocity* $v_m$.

**Proposition 2.1.** *[10],[11] In the case of an axial-subsonic movement of a perfect and compressible fluid through profile grids, the flow rate function is determined from the boundary condition (6):*

$$\psi(s) = u_0 \cdot \int_0^s p^\star(s) \left(\frac{R}{R_0}\right) ds, \qquad u_0 = \omega R_0, \tag{6}$$

*where:*

- $\omega$ *is the angular rotation velocity of the profile grid;*
- $R_0$ *defines the origin of the axis system related to the turbine's axis.*

Equation (4) is an integro–differential equation. In this section, we will show a possibility of solving this equation applying the *method of successive approximation* (the iteration method), using also the result from [8] about the order of the term containing the double integral expression:

$$\varphi_{\widetilde{q}}(s) = \iint\limits_{D_{0^\star}^-} \widetilde{q}(\sigma) N(s, \sigma) d\xi d\eta. \tag{7}$$

**Proposition 2.2.** *[10], [9] In the case of the subsonic movement of the compressible fluid through the profile grid on an axial–symmetric flow–surface, in variable thickness of stratum, the integral equation of the velocity potential* $\varphi : D_{0^\star}^- \to \Re$ *is solvable by applying the method of successive approximations w.r.t. the parameter* $p^\star = \frac{\rho \cdot \hbar}{\rho_0}$.

*Proof.* For isentropic processes , by the Bernoulli–equation, we obtain:

$$\rho = \rho_0 \left(1 - \frac{\gamma - 1}{2} \frac{v^2}{c_0^2}\right)^{\frac{1}{\gamma - 1}}, \quad v^2 = v_\tau^2 + v_n^2, \quad v_\tau = \frac{d\varphi}{ds}, \quad v_n = \frac{1}{p^\star} \frac{d\psi}{ds} \tag{8}$$

where:

- $\gamma$ is the adiabatic constant;
- $c_0$ is the sound velocity in the zero velocity point;
- $v_\tau$ and $v_n$ are, respectively, the tangential and normal velocities on $L_0$ .

In the first approximation it is assumed that $\rho = \rho_0 = \text{constant}$ and $p^\star = p^{\star(0)} = \text{constant}$. Thus, from (2), it results that $q^{(0)}(\sigma) = 0$. Hence, in the integral equation (4) the double integral (7) is neglected and results the following Fredholme integral equation of second type, with continuous nucleus:

$$\varphi^I(s) + \int_{L_0} \varphi^I(s) \frac{dM(s,\sigma)}{d\sigma} d\sigma = b^I(s) \tag{9}$$

From solving equation (9) we obtain $\varphi^I(s)$, and furthermore from (6), (8), (12) $\psi^I$, $\rho^I$ are obtained. Finally, using the relation:

$$p^\star = \frac{\rho \cdot h}{\rho_0}, \qquad \bar{q}(\sigma) = -\text{grad}\varphi \cdot \text{grad} \ln p^\star, \tag{10}$$

a $p^{\star I}$ and $\bar{q}^I(\sigma)$ are determined.

In the second iteration $p^\star = p^{\star I}$ is assumed and for the determination of $\varphi^{II}(s)$ the following Fredholme integral equation of second type, with continuous nucleus, will be solved:

$$\varphi^{II}(s) + \int_{L_0} \varphi^{II}(s) \frac{dM(s,\sigma)}{d\sigma} d\sigma = b^{II}(s) + \iint_{D_{0^\star}^-} q^I(\sigma) N(s,\sigma) d\xi d\eta, \tag{11}$$

where a $\psi^I$ and $b^{II}(s)$ are previously calculated from (6) and (5), respectively.

From solving equation (11), we obtain $\varphi^{II}$. Furthermore, from (6), (8), (12) and (10) $\psi^{II}$, $\rho^{II}$, $p^{\star II}$ and $\bar{q}^{II}(\sigma)$ are obtained, respectively. Next, the third approximation might be done by assuming $p^\star = p^{\star II}$, and so on.

□

**Proposition 2.3.** *[10] Having given the values of the velocity potential on each element of the $L_0$ profile's division, the tangential velocity $v_\tau$ may be calculated in each division element of the $L_0$ basic profile's boundary by the formula, given by the Lagrange interpolation method through five points:*

$$\begin{aligned} & v_{\tau i} = \varphi'(s_i) = \tfrac{2}{3h}(\varphi_{i+2} - \varphi_{i-2}) - \tfrac{1}{12h}(\varphi_{i+4} - \varphi_{i-4}), \\ & h = \Delta s_i = s_{i+1} - s_{i-1}, \\ & i = 1, 3, 5, \ldots, 2n-1, \end{aligned} \tag{12}$$

*where $n$ denotes the number of division elements and by $s_i$ we refer to the $i^{th}$ element of the division of $L_0$.*

To ensure the practical functionality of proposition 2.2, i.e. to indicate the solving method of the Fredholme integral equation of second type obtained in each approximation step (equation (6), (11) ), let us formulate and prove two more propositions.

**Proposition 2.4.** *[10], [11] In the first approximation step, solving the velocity potential's Fredholme integral equation of second type is reduced to the solving of four systems of linear algebraic equations.*

*Proof.* Using the superposition rule of potential streams, we seek the solution of the Fredholme integral equation of second type (9) to be of the form:

$$\varphi^I = \varphi_1^I v_{mx} + \varphi_2^I v_{my} + \varphi_3^I \Gamma + \varphi_4^I u_0, \qquad u_0 = \omega R_0, \tag{13}$$

where $\varphi_k^I$, $k = 1 \div 4$ are the solutions of the system (14) of integral equations:

$$\begin{aligned}
&\varphi_1^I(s) + \int\limits_{L_\circ} \varphi_1^I(\sigma)\tfrac{dM(s,\sigma)}{d\sigma}d\sigma = 2x_0\\
&\varphi_2^I(s) + \int\limits_{L_\circ} \varphi_2^I(\sigma)\tfrac{dM(s,\sigma)}{d\sigma}d\sigma = 2y_0\\
&\varphi_3^I(s) + \int\limits_{L_\circ} \varphi_3^I(\sigma)\tfrac{dM(s,\sigma)}{d\sigma}d\sigma = M(s,\sigma_A)\\
&\varphi_4^I(s) + \int\limits_{L_\circ} \varphi_4^I(\sigma)\tfrac{dM(s,\sigma)}{d\sigma}d\sigma = b_4(s)
\end{aligned} \tag{14}$$

where:

$$b_4(s) = \int\limits_{L_0} \left[\psi^I(s) - \psi^I(\sigma)\right]\frac{dN}{d\sigma}d\sigma. \tag{15}$$

The integral equations (14) could be solved using the Bogoliubov-Krîlov method, conform to which, solving each integral equation reduces to solving a system of linear algebraic equations. Conform to the method, using an arbitrary division, we partition the boundary of $L_0$ in $n$ subintervals $\Delta s = \Delta\sigma$. Note, that the chosen division might be not uniform, for instance at the trailing or the leading edge, where the variation of the function $\varphi_k^I$ is stronger from point–to–point, the length of subintervals might be shorter. In each subinterval, the function $\varphi_k^I$ is assumed to be constant and equal to $\varphi_{kj}^I$ where $j$ represents the number of the middle–points of the considered subintervals. If the first division–points are debited by even numbers, and the division–points of the middle of the subintervals by odd numbers, then, conform to the approximation method, the integral equations (14) can be approximated by the following systems of linear algebraic equations:

$$\varphi_{ki}^I + \sum_{j=1}^{2n-1} \varphi_{kj}^I \Delta M_{ij} = b_{ki}^I, \qquad i = 1,3,5,\ldots,2n-1, \qquad k = 1,2,3,4, \tag{16}$$

where:

$$\begin{aligned}
&b_{1i}^I = 2x_i, && b_{2i}^I = 2y_i, && b_{3i}^I = M_{i,A},\\
&b_{4i}^I = \textstyle\sum_{j=1}^{2n-1} \Delta\psi_{i,j}^I \left(\frac{dN}{d\sigma}\right)_{i,j} \Delta\sigma_j, && \Delta\psi_{i,j}^I = \psi_i^I - \psi_j^I, && \Delta\sigma = \sigma_{j+1} - \sigma_{j-1}.
\end{aligned} \tag{17}$$

Solving the algebraic system (16), we obtain $\varphi_{ki}^I$ in $n$ distinct point from the boundary of $L_0$. Finally, from equations (13), $\varphi_i^I$ is determined in each point of the boundary's division. □

**Proposition 2.5.** *[10], [11] In the second approximation step, the Fredholme integral equation (11) of the velocity potential is reduced to solving four systems of linear algebraic equations.*

*Proof.* From (8) and (10), a $\rho^I$ and a $\widehat{q}^I(\sigma)$ is determined, respectively. Consequently, using the superposition rule of potential streams, we seek the solution of the Fredholme integral equation of second type (11) to be of the form:

$$\varphi^{II} = \varphi_1^{II} v_{mx} + \varphi_2^{II} v_{my} + \varphi_3^{II}\Gamma + \varphi_4^{II} u_0, \qquad u_0 = \omega R_0 \tag{18}$$

where $\varphi_k^{II}$, $k = 1 \div 4$ are the solutions of the system 19 of integral equations:

$$\begin{aligned}
&\varphi_1^{II}(s) + \int_{L_0} \varphi_1^{II}(\sigma)\tfrac{dM(s,\sigma)}{d\sigma}d\sigma = 2x_0 + \iint_{D_{0*}^-} \widehat{q}^I(\sigma)N(s,\sigma)d\xi d\eta \\
&\varphi_2^{II}(s) + \int_{L_0} \varphi_2^{II}(\sigma)\tfrac{dM(s,\sigma)}{d\sigma}d\sigma = 2y_0 + \iint_{D_{0*}^-} \widehat{q}^I(\sigma)N(s,\sigma)d\xi d\eta \\
&\varphi_3^{II}(s) + \int_{L_0} \varphi_3^{II}(\sigma)\tfrac{dM(s,\sigma)}{d\sigma}d\sigma = M(s,\sigma_A) + \iint_{D_{0*}^-} \widehat{q}^I(\sigma)N(s,\sigma)d\xi d\eta \\
&\varphi_4^{II}(s) + \int_{L_0} \varphi_4^{II}(\sigma)\tfrac{dM(s,\sigma)}{d\sigma}d\sigma = b_4^{II}
\end{aligned} \tag{19}$$

where:

$$\begin{aligned}
&b_4^{II}(s) = \tfrac{1}{u_0}\int_{L_0}\left[\psi^{II}(s) - \psi^{II}(\sigma)\right]\tfrac{dN}{d\sigma}d\sigma + \iint_{D_{0*}^-} q^I(\sigma)N(s,\sigma)d\xi d\eta \\
&\psi^{II}(s) = u_0\int_0^s \left(\tfrac{R}{R_0}\right)^2 p^{*I}(s)ds \\
&p^{*I} = \tfrac{\rho^I \cdot h^I}{\rho_0}
\end{aligned} \tag{20}$$

Using the numeric method presented in proposition 2.4, by applying the Bogoliubov-Krâlov method, solving (19) is reduced to solving systems of linear algebraic equations.

These systems of linear algebraic equations will have the form:

$$\varphi_{ki}^{II} + \sum_{j=1}^{2n-1} \varphi_{kj}^{II}\Delta M_{ij} = b_{ki}^I, \qquad i = 1,3,5,\ldots,2n-1, \qquad k = 1,2,3,4, \tag{21}$$

where $b_{1i}^I$, $b_{2i}^{II}$, $b_{3i}^{II}$ and $b_{4i}^{II}$ are obtained by using the Simpson formula for handling the double integral.

Solving the algebraic system (21), we obtain $\varphi_{kj}^{II}$ in $n$ distinct point from the boundary of $L_0$. Finally, from equations (18), $\varphi_i^{II}$ $(i = \overline{1,n})$ is determined in each point of the boundary's division.

□

## 3 The Calculus Algorithm of the Fluid's Velocity Potentials through Profile Grids

1. Given are: the entering values into the profile grids of $p_1$, $v_{1\infty}$, $\alpha_1$ and the asymptotic mean velocity $\overrightarrow{V}_m$; the installation angle $\lambda$; the number of profiles $n$; the density $\rho_0$ and the sound velocity $c_0$ corresponding to the null–velocity point. The functions $h(\sigma)$ and $\frac{R}{R_0}(\sigma)$ are given by their table of values;

2. Conform to the chosen division, the coordinates $\sigma_i(\xi_i, \eta_i)$, $i = 1, 3, 5, \ldots, 2n-1$ are determined. The circulation $\Gamma$ is determined from the Jukovschi-Ciaplighin condition [10], [11];

3. From equation (5), the values of $\Delta M_{i,j}$, $\left(\frac{dN}{d\sigma}\right)_{i,j}$, $i, j = 1, 3, 5, \ldots, 2n+1$ are calculated;

4. Using the trapezoid method, $\psi_i^I$ is calculated from the integral equation (6), and, using (17), $b_{ki}^I$ $(k = 1 \div 4)$ are determined;

5. The linear algebraic system (16) is solved, and, thus, $\varphi_{ki}^I$ is obtained. Furthermore, from (13), $\varphi_i^I$ is also obtained;

6. Using the Lagrange interpolation formula through five points (12), $v_{\tau i}^I$ is calculated. Next, from (8), $v_i^I$ is determined, and, furthermore, $\rho_i^I$ is also obtained;

7. Using $\rho_i^I$ and $h = const$, from the integral (20), by the trapezoid method, a $\psi_i^{II}(\sigma)$ is determined. Using equations (19) and (20), $b_{ki}^{II}$ $(k = 1 \div 4)$ are obtained;

8. The integral equations (19) are solved, transforming them first into a linear algebraic system. Furthermore, $\varphi_{ki}^{II}$ is obtained, and, from (18), $\varphi_i^{II}$ is determined;

9. Using the Lagrange interpolation formula through five points (12), $v_{\tau i}^{II}$ is calculated. Next, from (8), $v_i^{II}$ is determined, and, furthermore, $\rho_i^{II}$ is also obtained. Furthermore, using $\rho_i^I$, the next iteration $\rho_i = \rho_i^{II}$ can be calculated, $h = variable$, and the algorithm continues.

## 4 Conclusion and Further Work

We have shown some practical aspects of the usage of the calculus algorithm for the study of the compressible fluid's stationary movement through profile grids, on an axial–symmetric flow–surface, in variable thickness of stratum, namely :

- the usage of the boundary element method with real values;
- the applicability of the successive approximation method w.r.t. the parameters $\rho$ (fluid's density) and $h$ (thickness variation of fluid stratum) for solving the integral equation of the velocity potential;
- the usage of the Lagrangian interpolation formula through five points for calculating the derivatives of the velocity potential.

Regarding practical applicability of our algorithm, our plans for the near future are:

- make more test cases w.r.t. several input (geometrical and hydrodynamical) values of the velocity potentials taken from practical experiments involving profile grids;
- study the possibility of applying the algorithm (i.e. the approximation methods) for the calculation of other fluid–characteristics.

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# DENSITY OF POLYNOMIAL REPARTITIONS

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**Abstract:**
The present note tries to use the results of mathematic shaping to determine some probability density of polynomial forms. After the determination of a regression curve by a degree previously given, aided by the method of the smallest squares, it will be selected from this curve a domain of definition in which this function will satisfy the conditions of being a probability density.

**Keywords**:
Probability density, Density of polynomial repartitions, coefficient of correlation

## 1. PRELIMINARIES

The present note tries to use the results of mathematic shaping to determine some probability density of polynomial forms.

For example we will consider the following dates, in which the first line represent the independent variable x and second line represent the dependent variable y.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.663 | 1.791 | 1.81 | 1.864 | 1.905 | 1.912 | 1.976 | 2.009 | 2.111 | 2.135 | 2.162 | 2.172 | 2.183 | 2.197 | 2.238 |
| 0.334 | 0.266 | 0.314 | 0.306 | 0.361 | 0.36 | 0.29 | 0.44 | 0.171 | 0.268 | 0.211 | 0.262 | 0.261 | 0.259 | 0.226 |

To determine the regression curve of 3rd degree (g=3) will use the following MathCAD program [1]

ORIGIN≡ 1 $\quad$ $TOL := 10^{-5}$ $\quad$ $g := 3$

$x^T =$

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.663 | 1.791 | 1.81 | 1.864 | 1.905 | 1.912 | 1.976 | 2.009 | 2.111 | 2.135 | 2.162 | 2.172 | 2.183 | 2.197 | 2.238 |

$y^T =$

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.334 | 0.266 | 0.314 | 0.306 | 0.361 | 0.36 | 0.29 | 0.44 | 0.171 | 0.268 | 0.211 | 0.262 | 0.261 | 0.259 | 0.226 |

$n := \text{length}(x)$ $\quad$ $i := 1..n$

$xm := \min(x)$ $\quad$ $xM := \max(x)$

$ym := \text{mean}(y)$ $\quad$ $ym = 0.289$

$j := 1..2 \cdot g + 1$

$S_j := \sum_i (x_i)^{2 \cdot g - j + 1}$ $\quad$ $S^T = (1.09 \times 10^3 \quad 525.332 \quad 254.647 \quad 124.186 \quad 60.957 \quad 30.128 \quad 15)$

$k := 1..g + 1$ $\quad$ $v := 1..g + 1$

$m_{k,v} := S_{v+k-1}$ $\quad$ $m = \begin{pmatrix} 1.09 \times 10^3 & 525.332 & 254.647 & 124.186 \\ 525.332 & 254.647 & 124.186 & 60.957 \\ 254.647 & 124.186 & 60.957 & 30.128 \\ 124.186 & 60.957 & 30.128 & 15 \end{pmatrix}$

$TL_k := \sum_i y_i \cdot (x_i)^{g-k+1}$ $\quad$ $TL^T = (34.754 \quad 17.235 \quad 8.607 \quad 4.329)$

$co := m^{-1} \cdot TL$

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resulting the coefficients of polynomial correlation

$$co^T = (-0.843 \;\; 4.14 \;\; -6.637 \;\; 3.778) \tag{1}$$

and also the regression curve equation is

$$y = -0.843 \cdot x^3 + 4.14 \cdot x^2 - 6.637 \cdot x + 3.778 \tag{2}$$

which in the nodes has this values

$kk := 1..g + 1$ $\qquad Su_i := \sum_{kk} co_{kk} \cdot (x_i)^{g-kk+1}$

$Su^T =$

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.311 | 0.325 | 0.327 | 0.329 | 0.328 | 0.327 | 0.321 | 0.315 | 0.282 | 0.271 | 0.257 | 0.251 | 0.244 | 0.236 | 0.206 |

For the polynomial regression of 3rd degree will be obtained the following values for the correlation coefficient and respectively for the deviation from the regression curve

$$r3 := \sqrt{1 - \frac{\sum_i (y_i - Su_i)^2}{\sum_i (y_i - ym)^2}} \qquad r3 = 0.615 \;, \tag{3}$$

$$St3 := \sqrt{\frac{1}{n} \cdot \left[ \sum_i (y_i - Su_i)^2 \right]} \quad St3 = 0.051 \;. \tag{4}$$

Next we will give attention to a domain on which to choose the expression of probability density.

Distribution density must fulfill the conditions [2]:

$$f(x) \geq 0, \qquad \int_{-\infty}^{\infty} f(x)\, dx = 1 .$$

Because

$$\int_{xm}^{xM} \sum_{kk} co_{kk} \cdot (x)^{g-kk+1} dx = 0.174 \;, \tag{5}$$

using the next program we will determine the limits of a definition domain for a positive function, marked f3(x), restriction of the regression polynomial, so that the integral on this range will be equal with the unit

$var1 := 0.15$ $\qquad var2 := 0.8$

Given

$$\int_{xm-var1}^{xM+var2} \sum_{kk} co_{kk} \cdot (x)^{g-kk+1} dx = 1$$

$tvar := Find(var1, var2)$ $\qquad tvar = \begin{pmatrix} 1.28 \\ 0.141 \end{pmatrix}$ .

We will obtain in this way the values

$tvar_1 = 1.28$ $\qquad tvar_2 = 0.141$

for which

$$\int_{xm-tvar_1}^{xM+tvar_2} \sum_{kk} co_{kk} \cdot (x)^{g-kk+1} dx = 1 \;, \tag{6}$$

where

$xm - tvar_1 = 0.383$ $\qquad xM + tvar_2 = 2.379$ .

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In conclusion, the expression of probability density of 3rd degree is

$$f3(x) := \text{if}\left[xm - tvar_1 < x < xM + tvar_2, \sum_{kk} co_{kk}\cdot(x)^{g-kk+1}, 0\right], \quad (7)$$

and it's graphic is show in figure 1 with the help of the adjoining program

$$nrnod := 1000 \qquad is := 1..nrnod$$

$$xv_{is} := xm - (tvar)_1 - .35 + \frac{is - 1}{nrnod - 1}\cdot\left[xM + tvar_2 + .1 - \left(xm - tvar_1 - .35\right)\right]$$

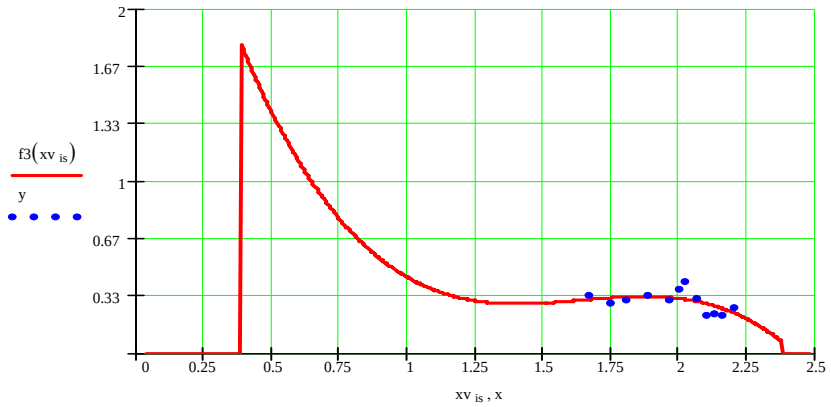



Figure. 1 Probability density of 3rd degree and the distribution of experimental points

The expression of the repartition function is

$$Ftrunc3(x) := \int_{xm - tvar_1}^{x} \text{if}\left[xm - tvar_1 < u < xM + tvar_2, \sum_{kk} co_{kk}\cdot(u)^{g-kk+1}, 0\right] du, \quad (8)$$

and it's graphic is shown in Figure 2.

$$wFtrunc3_{is} := Ftrunc3\left(xv_{is}\right)$$

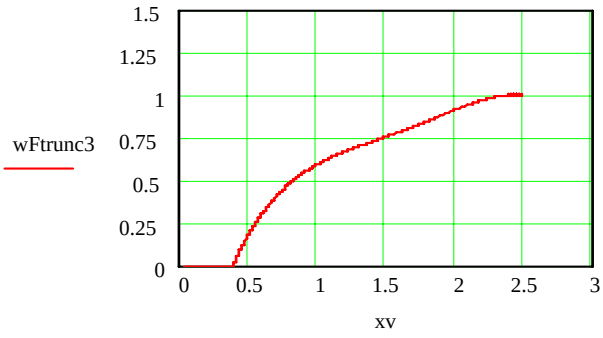



Figure. 2 Repartition function for regression polynomial of 3rd degree

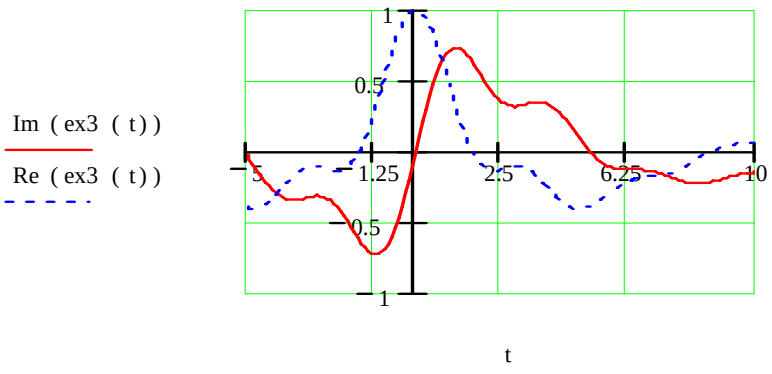



Figure. 3 The real and imaginary part of the characteristic function for the probability density of 3rd degree

The expression of the characteristic function is

$$ex3(t) := \int_{-1}^{6} e^{i\cdot t\cdot x}\cdot\left[ if\left[ xm - tvar_1 < x < xM + tvar_2, \sum_{kk} co_{kk}\cdot(x)^{g-kk+1}, 0\right]\right] dx \tag{9}$$

and it's graphic is shown in figure 3.

If we made a regression of 4th degree (g=4), we will use the program

$g := 4$ $\quad j := 1..2\cdot g + 1$ $\quad S_j := \sum_i (x_i)^{2\cdot g-j+1}$

$k := 1..g + 1$ $\quad v := 1..g + 1$ $\quad m_{k,v} := S_{v+k-1}$ $\quad TL_k := \sum_i y_i\cdot(x_i)^{g-k+1}$

$co := m^{-1}\cdot TL$ $\quad co^T = (42.345 \;\; -332.126 \;\; 972.561 \;\; -1.26\times 10^3 \;\; 609.971)$

from which results the regression polynomial of the following form

$$y = 42.345\cdot x^4 - 332.126\cdot x^3 + 972.261\cdot x^2 - 1.26\cdot 10^3\cdot x + 609.971 \tag{10}$$

which in the nodes has the values

$Su^T =$

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.333 | 0.282 | 0.293 | 0.328 | 0.348 | 0.35 | 0.354 | 0.343 | 0.269 | 0.251 | 0.235 | 0.232 | 0.229 | 0.229 | 0.254 |

For polynomial regression of 4th degree we will obtain the following values for the correlation coefficient and respectively for the deviation from the regression curve

$$r4 := \sqrt{1 - \frac{\sum_i (y_i - Su_i)^2}{\sum_i (y_i - ym)^2}} \qquad r4 = 0.736 \;, \tag{11}$$

$$St4 := \sqrt{\frac{1}{n}\cdot\left[\sum_i (y_i - Su_i)^2\right]} \quad St4 = 0.044 \;. \tag{12}$$

Because

$$\int_{xm}^{xM} \sum_{kk} co_{kk}\cdot(x)^{g-kk+1}\, dx = 0.171 \;, \tag{13}$$

it will determine the limits of the definition domain for regression density of 4th degree. The program used is likewise with the one from previous case, and it will obtain

$$tvar = \begin{pmatrix} 0.15 \\ 0.374 \end{pmatrix} \qquad tvar_1 = 0.15 \qquad tvar_2 = 0.374$$

resulting

$$\int_{xm-tvar_1}^{xM+tvar_2} \sum_{kk} co_{kk}\cdot(x)^{g-kk+1}\, dx = 1 \tag{14}$$

where

$xm - tvar_1 = 1.513$ $\quad xM + tvar_2 = 2.612$ .

In conclusion, the expression of probability density of 4th degree is

$$f4(x) := if\left[ xm - tvar_1 < x < xM + tvar_2, \sum_{kk} co_{kk}\cdot(x)^{g-kk+1}, 0\right], \tag{15}$$

and it's graphic is shown in figure 4

$$nrnod := 1000 \qquad is := 1..nrnod$$

$$xv_{is} := xm - (tvar)_1 - .3 + \frac{is - 1}{nrnod - 1} \cdot \left[ xM + tvar_2 + .3 - \left( xm - tvar_1 - .3 \right) \right]$$

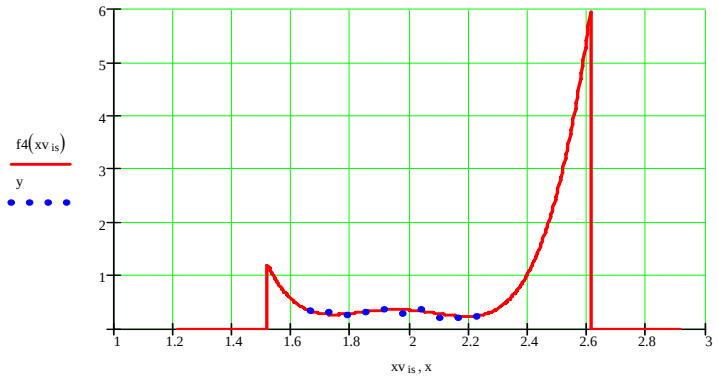



Figure 4. Probability density of 4th degree and the distribution of the experimental points

The expression of the repartition function is

$$Ftrunc4(x) := \int_0^x if\left[ xm - tvar_1 < u < xM + tvar_2, \sum_{kk} co_{kk} \cdot (u)^{g - kk + 1}, 0 \right] du \quad , \qquad (16)$$

and it's graphic is shown in figure 5

$$wFtrunc4_{is} := Ftrunc4\left(xv_{is}\right)$$

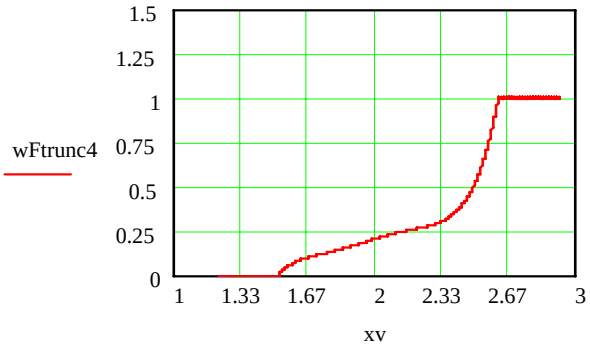



Figure 5. The repartition function for repression polynomial of 4th degree

The characteristic function has the expression

$$ex(t) := \int_{-1}^{6} e^{i \cdot t \cdot x} \cdot \left[ if\left[ xm - tvar_1 < x < xM + tvar_2, \sum_{kk} co_{kk} \cdot (x)^{g - kk + 1}, 0 \right] \right] dx \qquad (17)$$

and it's graphic is shown in figure 6

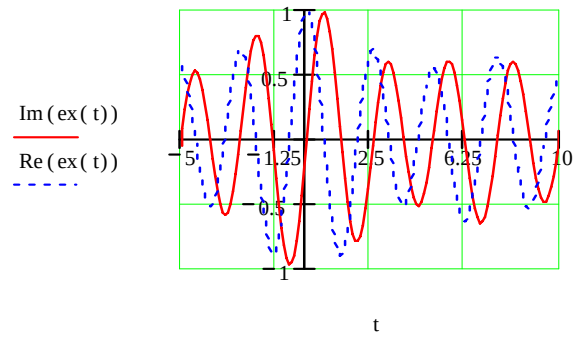



Figure 6. The real and imaginary part of the characteristic function for probability density of 4th degree

In case that we do a regression of 5th degree (g=5), it results de regression polynomial of the following form

$$y = -119.156 \cdot x^5 + 1212 \cdot x^4 - 4911 \cdot x^3 + 9912 \cdot x^2 - 9962 \cdot x + 3988 \qquad (18)$$

which in the nodes has the values

$Su^T =$

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.335 | 0.27 | 0.289 | 0.337 | 0.358 | 0.359 | 0.35 | 0.331 | 0.259 | 0.247 | 0.239 | 0.238 | 0.237 | 0.237 | 0.244 |

For polynomial regression of 5th degree we will obtain the following values for the correlation coefficient and respectively for the deviation from the regression curve

$$r5 := \sqrt{1 - \frac{\sum_i (y_i - Su_i)^2}{\sum_i (y_i - ym)^2}} \qquad r5 = 0.7462 \ , \qquad (19)$$

$$St5 := \sqrt{\frac{1}{n} \cdot \left[ \sum_i (y_i - Su_i)^2 \right]} \quad St5 = 0.043 \ . \qquad (20)$$

Because

$$Int := \int_{xm}^{xM} \sum_{kk} co_{kk} \cdot (x)^{g-kk+1} \, dx \qquad Int = 0.167 \ , \qquad (21)$$

we will determine the limits of the definition domain for the regression density of 5th degree. The program used is likewise with the previous one, and we will obtain

$$tvar = \begin{pmatrix} 0.277 \\ 0.126 \end{pmatrix} \qquad tvar_1 = 0.277 \qquad tvar_2 = 0.126$$

resulting

$$\int_{xm - tvar_1}^{xM + tvar_2} \sum_{kk} co_{kk} \cdot (x)^{g-kk+1} \, dx = 1 \qquad (22)$$

where $xm - tvar_1 = 1.386$ , $xM + tvar_2 = 2.364$ .

The expression of probability density of 5th degree is

$$f5(x) := if\left[ xm - tvar_1 < x < xM + tvar_2, \sum_{kk} co_{kk} \cdot (x)^{g-kk+1}, 0 \right], \qquad (23)$$

and the graphic is shown in figure 7

$nrnod := 1000 \qquad is := 1 .. nrnod$

$$xv_{is} := xm - (tvar)_1 - .7 + \frac{is - 1}{nrnod - 1} \cdot \left[ xM + tvar_2 + .7 - \left( xm - tvar_1 - .7 \right) \right]$$

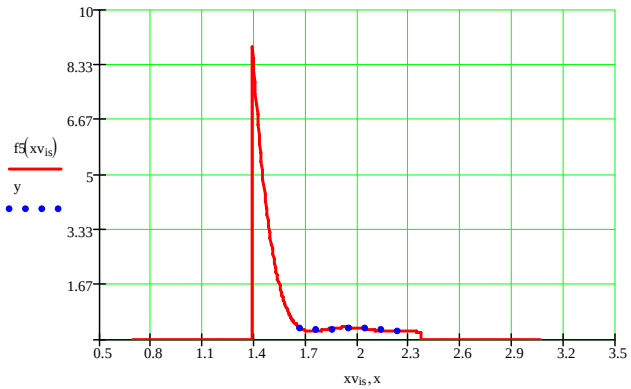



Figure 7. Probability density of 5th degree and repartition of the experimental points

The expression of the repartition function is

$$Ftrunc5(x) := \int_0^x \text{if}\left[xm - tvar_1 < u < xM + tvar_2, \sum_{kk} co_{kk}\cdot(u)^{g-kk+1}, 0\right] du \tag{24}$$

and it's grafic is shown in figiure 8

$$wFtrunc5_{is} := Ftrunc5(xv_{is})$$

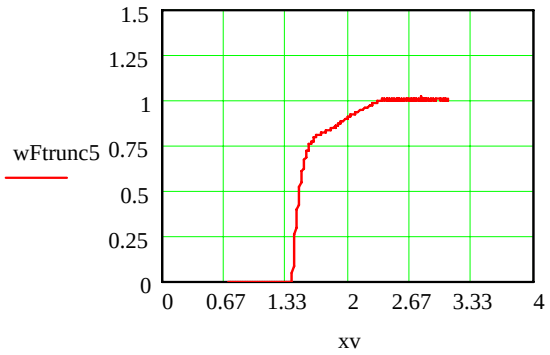



Figure 8. Repartition function for the regression polynomial of 5th degree

The characteristic function has the expression

$$ex(t) := \int_{-1}^{6} e^{i\cdot t\cdot x}\cdot\left[\text{if}\left[xm - tvar_1 < x < xM + tvar_2, \sum_{kk} co_{kk}\cdot(x)^{g-kk+1}, 0\right]\right] dx \tag{25}$$

and it's graphics is shown in figure 9

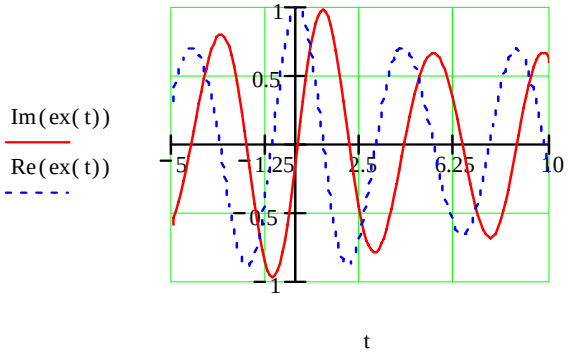



Figure 9. The real and imaginary part of the characteristic function
for probability density of 5th degree

## 2. OBSERVATIONS

For the regression polynomial of 2nd degree we will obtain the regression parable of the following form

$$y = -0.778\cdot x^2 + 2.874\cdot x - 2.323. \tag{26}$$

In this case we will obtain the following values for the correlation coefficient and respectively for the deviation from the regression curve

$$r2 := \sqrt{1 - \frac{\sum_i (y_i - Su_i)^2}{\sum_i (y_i - ym)^2}} \qquad r2 = 0.6131 \tag{27}$$

$$St2 := \sqrt{\frac{1}{n}\cdot\left[\sum_i \left(y_i - Su_i\right)^2\right]} \qquad St2 = 0.051 \quad . \tag{28}$$

Analyzing the form of the parable, shown in figure 10, it's obvious that, on the domain in which the function is positive, the condition cannot be satisfied that integral from it to be equal with the unit.

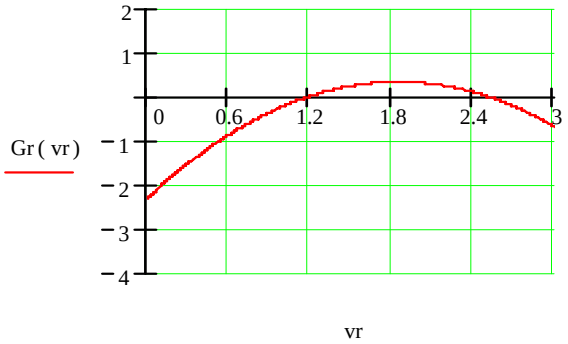



Figure 10. Regression parable

Results that this set of dates, which is obvious a modeling of 2nd degree, it does not accept an appropriate probability density. From the same reason does not accept also probability density of 6th degree.

## 3. CONCLUSIONS

The advantage of polynomial modeling is the fact that from passing from an inferior grade to a superior grade appears every time new coefficients, and by determines this coefficient the regression curve moulds better and better the experimental figures. By increasing the polynomial grade it will be more accurate the modeling, so it's increasing the value of correlation coefficient.

We specify also the fact that the condition that the integral from probability density must be equals with the unit admission, in possible cases, for a fast grade, much more solutions regarding of the pair of the integrating limits (from which one can be predefine). All the obtained densities mould the experimental domain dates identically. Although, in any form of the function of chosen density, the probability that the random variable to take a value into a range, is the same. In generally we are not interested in modeling on relative big ranges, so the modeling is useful, for example, on a range centered in mean value of a independent variable and the length until the 3rd time deviation from the square mean.

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# NUMERICAL METHOD FOR SPATIAL STABILITY ANALYSIS OF A VORTEX STRUCTURE AT HIGH REYNOLDS NUMBERS

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**Abstract**

The investigations concerned the values of parameters for which the vortex become unstable may imply a large amount of measurement, thus one must resort to numerical techniques.
We developed in this paper a spatial stability analysis of a Q type vortex subject to infinitesimal perturbations.
First, the eigenvalue problem governing the linear stability analysis of the non axi-symmetric Q vortex (one of the few known exact solutions to the full Navier-Stokes equations) against normal mode perturbations is investigated for the case of high Reynolds numbers using a spectral collocation technique.
The accuracy of the method is assessed underlying the necessity for the construction of a certain class of interpolant functions satisfying the boundary conditions.
Graphical representations of the spatial eigenfunctions amplitudes are given offering a visualization of the differences between perturbed velocity fields developed for the first unstable axial wavenumber and the least stable one.

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# BOUNDARY ADAPTED SPECTRAL APPROXIMATION FOR SPATIAL STABILITY OF BATCHELOR VORTEX

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**Abstract**:
The main goal of this paper is to develop a methodology for analyzing the non-axisymmetrical swirling flows with helical vortex breakdown by means of linear stability analysis. For the case of high Reynolds numbers the eigenvalue problem governing the linear stability analysis of the Batchelor vortex is investigated using a boundary adapted spectral collocation technique. A symmmetrization is performed eliminating all geometric singularities on the left-hand sides of the governing equations set. The method provides a fairly accurate approximation of the spectrum without any scale resolution restriction.

**Keywords**:
swirling flow, Batchelor vortex, spectral collocation

## 1 Introduction

Most of the vortex stability analyses concerned axisymmetrical vortices with axial flow [1] in order to explain the vortex breakdown phenomenon observed experimentally for the first time on delta wings [2], in pipes [3] and in cylinders with rotating ends [4]. Obviously, the axial symmetry hypothesis is a major simplification having the main benefit of dramatically reducing the computational cost [5]. On the other hand, it introduces important limitations as far as the three-dimensionality and unsteadiness of the flow are concerned.

The present paper focused on developing an analytical and numerical technique for analyzing the eigenvalue problem governing the linear stability of an inviscid swirling fluid flow under small perturbations. This problem is characterized by a system of ordinary differential equations with variable coefficients.

In most cases, the spatially or temporal stability (classified for open flows as in [6]) under infinitesimal perturbations is reduced to the study of an algebraic eigenvalue problem of this type. The study leads to a dispersion relation connecting in fact the growth rate $\omega$ and the axial wavenumber $k$ as a consequence of the condition that nontrivial eigenvalues to exist. Most of the investigations [1], [7] concerned the values of these nondimenional parameters for which the vortex become unstable in the case of either a spatial stability or temporal stability investigation. Since the investigation of this aspect may imply a large amount of measurement, one must resort also to numerical techniques. Although a spatial stability analysis implies the investigation of a nonlinear eigenvalue problem this type of analysis directly provides the frequency ranges of the most unstable modes. In this paper we consider a more general mathematical model for swirling flow stability analysis, starting with the unsteady Euler equations in cylindrical coordinates. In doing so, we can examine both unsteady and circumferentially variable perturbations.

The paper is organized as follows. The eigenvalue problem governing the linear stability analysis for inviscid swirling flows against normal mode perturbations is defined in Section 2. The third section a new radial spectral approximation is proposed and in Section 4 the

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method is applied for the Batchelor vortex case and the actual numerical procedure is presented. The main advantages of the proposed methods are pointed out in Section 5.

## 2. PROBLEM FORMULATION

The governing equations in the case of incompressible and inviscid flow are the Euler equations

$$\nabla \cdot \underline{V} = 0, \frac{\partial \underline{V}}{\partial t} + (\underline{V} \cdot \nabla)\underline{V} = -\frac{1}{\rho}\nabla p \tag{1}$$

The following flow fields decomposition are used: velocity $\underline{V} + \underline{v}$, pressure $p + \pi$ where $(\underline{V}, p)$ is the base flow, and $(\underline{v}, \pi)$ is the perturbation considered small.

Since the base flow obey the Euler equations (1) the evolution of such small perturbations of the basic flow is governed by the linearized Euler equations

$$\nabla \cdot \underline{v} = 0, \frac{\partial \underline{v}}{\partial t} + (\underline{V} \cdot \nabla)\underline{v} + (\underline{v} \cdot \nabla)\underline{V} = -\frac{1}{\rho}\nabla \pi \tag{2}$$

In the linearization process the second order terms in the small perturbations were neglected. Assuming a steady columnar flow the velocity profile is written

$$\underline{V}(r) = [U(r), 0, W(r)] \tag{3}$$

where $U$ represents the axial velocity component $W$ the azimuthal component of the velocity both depending only on radius. Next, we consider the following factorization of the small perturbations

$$[\underline{v}(t,z,r,\theta), \pi(t,z,r,\theta)] = [F(r), iG(r), H(r), P(r)] exp[i(kz + m\theta - \omega t)] \tag{4}$$

Introducing the factorization form (4) into the linearized Euler equations (2) we obtain the following system of first order differential equations

$$k r F + G + r G' + m H = 0 \tag{5a}$$

$$kUG - \omega G + \frac{mWG}{r} + \frac{2WH}{r} - P' = 0 \tag{5b}$$

$$rHkU - rH\omega + m(HW + P) + WG + rGW' = 0 \tag{5c}$$

$$FkU - F\omega + \frac{FmW}{r} + U'G + kP = 0 \tag{5d}$$

where prime denotes differentiation with respect to the radius. This homogenous first order differential system is completed with the following boundary conditions at axis and the far field

$$\begin{cases} G(0) = H(0) = 0, F(0), P(0)\ finite, (m = 0), \\ H(0) \pm G(0) = 0, F(0) = P(0) = 0, (m = \pm 1), \\ F(0) = G(0) = H(0) = P(0) = 0, (|m| > 1), \\ F, G, H, P \to 0, (r \to \infty) \end{cases} \tag{6}$$

Equations (5) and (6) represent an eigenvalue problem.

## 3. BOUNDARY ADAPTED RADIAL SPECTRAL APPROXIMATION

The pseudospectral - collocation method is one of the most used technique for the numerical investigations in hydrodynamic stability problems. Many researchers have demonstrated the applicability of this method with high degree of accuracy to eigenvalue problems governing the linear stability of swirling flows [9-11].

The difference between the classical method and the modified version proposed here is given by the selected spaces involved in the discretization process motivated by the need to adapt the grid points to the singularities of the underlying solution.

In fact the boundary conditions (6) at infinity are applied at a truncated radius distance $r_{max}$ selected large enough such that the numerical results do not depend on this truncated distance.

Following [9] we define the boundary-adapted functions $\{\phi_k\}, k=1...,N$ of *modal* type, i. e. each function provides one particular pattern of oscillation

$$\phi_k(r)=\left(1-\frac{r}{r_{max}}\right)\cdot r\cdot T_k^*(r),\ \{\phi_k\}, k=1...,N \tag{7}$$

with $T_k^*$ the shifted Chebyshev polynomials on $[0,r_{\max}]$. These type of polynomials defined on the physical space are used in order to optimize the interpolative procedure. The choice is based on the condition that the values of the grid points are given by the same elementary analytic expression for all values of N and they did not have to be computed numerically for every N.

The linear transformation that mapps the standard interval $\xi\in[-1,1]$ into the physical range of our problem $r\in[0,r_{\max}]$ and preserves the clustering rate of collocation nodes is defined by the linear transformation

$$r(\xi)=\frac{r_{max}}{2}\xi+\frac{r_{max}}{2} \tag{8}$$

while the inverse transformation is defined

$$\xi(r)=2\frac{r}{r_{max}}-1 \tag{9}$$

The proposed method allowed us to discard the first and last collocation nodes, expansion functions satisfying the boundary conditions from the construction of our modal boundary-adapted basis. In this way the critical singularities which occurred in evaluating terms like 1/r for the numerical treatment of the eigenvalue problem were eliminated. Then the solution is approximated with respect to this expansion set of functions,

$$(F,G,H,P)=\sum_{k=1}^{N}(u_k,v_k,w_k p_k)\phi_k(r) \tag{10}$$

A modified Chebyshev Gauss grid $\Xi=(\xi_j)_{0\le j\le N-1}$ in $[-1,1]$ was constructed

$$\xi_j=\cos\left(\pi+\frac{2j\pi}{2N-2}\right),\ \xi_j\in[-1,1],\ j=0..N-1 \tag{11}$$

In our case the collocation nodes clustered near the boundaries diminishing the negative effects of the Runge phenomenon. Another aspect is that the convergence of the interpolant on the clustered grid towards unknown function is extremely fast.

Each of the basis functions from (7) meet the relations

$$\phi_k(r_1=0)=\phi_k(r_N=r_{\max})=0,$$
$$\phi_k(r_j)\neq 0,\ j=1..N,\ k=2..N-1 \tag{12}$$

which implies that each functions $F,G,H,P$ satisfy the boundary conditions (6).

With (10) the mathematical model takes the form

$$kr\sum_{k=1}^{N}u_k\Phi_k(r)+\sum_{k=1}^{N}v_k\Phi_k(r)+rG'+m\sum_{k=1}^{N}w_k\Phi_k(r)=0 \tag{13a}$$

$$\left(ku_z-\omega+\frac{mu_\theta}{r}\right)\sum_{k=1}^{N}v_k\Phi_k(r)+\frac{2u_\theta}{r}\sum_{k=1}^{N}w_k\Phi_k(r)-P'=0 \tag{13b}$$

$$(rku_z-r\omega)\sum_{k=1}^{N}w_k\Phi_k(r)+m\left(u_\theta\sum_{k=1}^{N}w_k\Phi_k(r)+\sum_{k=1}^{N}p_k\Phi_k(r)\right)+(u_\theta+ru_\theta')\sum_{k=1}^{N}v_k\Phi_k(r)=0 \tag{13c}$$

$$\left(ku_z-\omega+\frac{mu_\theta}{r}\right)\sum_{k=1}^{N}u_k\Phi_k(r)+u_z'\sum_{k=1}^{N}v_k\Phi_k(r)+k\sum_{k=1}^{N}p_k\Phi_k(r)=0 \tag{13d}$$

Let us denote by $[r]=diag(r_i)$, $r_i$ given by (8), $i=0,...,N-1$, $[\phi]=(\phi_{ij})_{\substack{1\le i\le N,\\ 1\le j\le N}}$, $\phi_{ij}=\phi_j(r_i)$, $[U]=diag(U(r_i))$, $[W]=diag(W(r_i))$, $1\le i\le N$. The system (13) can be written $(kM_k+\omega M_\omega+mM_m+M_0)\bar{s}=0$ with $\bar{s}=\left(\bar{f}\quad \bar{g}\quad \bar{h}\quad \bar{p}\right)^T$ and the matrices $M_k$, $M_\omega$, $M_m$ and $M_0$ having the following explicit forms

$$M_k=\begin{pmatrix}[r][\phi] & 0 & 0 & 0\\ 0 & [U][\phi] & 0 & 0\\ 0 & 0 & [rU][\phi] & 0\\ [U][\phi] & 0 & 0 & [\phi]\end{pmatrix} \quad (14); \qquad M_\omega=\begin{pmatrix}0 & 0 & 0 & 0\\ 0 & -[\phi] & 0 & 0\\ 0 & 0 & -[r][\phi] & 0\\ -[\phi] & 0 & 0 & 0\end{pmatrix} \quad (15)$$

$$M_m=\begin{pmatrix}0 & 0 & [\phi] & 0\\ 0 & \left[\frac{W}{r}\right][\phi] & 0 & 0\\ 0 & 0 & [W][\phi] & [\phi]\\ \left[\frac{W}{r}\right][\phi] & 0 & 0 & 0\end{pmatrix} \quad (16); \quad M_0=\begin{pmatrix}0 & [\phi]+[r]D & 0 & 0\\ 0 & 0 & 2\left[\frac{W}{r}\right][\phi] & -D\\ 0 & [W][\phi]+[rW'][\phi] & 0 & 0\\ 0 & [U'][\phi] & 0 & 0\end{pmatrix} \quad (17)$$

By differentiating (10) results

$$F'(r)=\sum_{k=1}^{N}\left\{\left(1-\frac{2r}{r_{max}}\right)u_kT_k^*(r)+\left(1-\frac{r}{r_{max}}\right)ru_kT_k^{*'}(r)\right\} \quad (18)$$

For k = 1 we have $T_1^{*'}(r)=0$ and rewriting (18) we have

$$F'(r)=\left(1-\frac{2r}{r_{max}}\right)u_1T_1^*(r)+\sum_{k=2}^{N}\left\{\left(1-\frac{2r}{r_{max}}\right)u_kT_k^*(r)+\left(1-\frac{r}{r_{max}}\right)ru_kT_k^{*'}(r)\right\} \quad (19)$$

The shifted Chebyshev polynomials meet the recurrence relation

$$T_n^{*'}(r)=\frac{r_{\max}}{4}\frac{(n-1)}{r(r_{\max}-r)}\left[T_{n-1}^*(r)-T_{n+1}^*(r)\right] \quad , n\ge 2 \quad (20)$$

thus

$$F'(r)=\left(1-\frac{2r}{r_{max}}\right)u_1T_1^*(r)+\sum_{k=2}^{N}u_k\left\{\left(1-\frac{2r}{r_{max}}\right)T_k^*(r)+\left(1-\frac{r}{r_{max}}\right)r\frac{r_{max}}{4}\frac{(k-1)}{r(r_{max}-r)}\left[T_{k-1}^*(r)-T_{k+1}^*(r)\right]\right\} \quad (21)$$

The interpolant derivative matrix D from (17) was evaluated by

$$D=\begin{pmatrix}\left(1-\frac{2r_1}{r_{max}}\right)T_1^*(r_1) & E_2(r_1) & E_3(r_1) & ... & E_N(r_1)\\ \left(1-\frac{2r_2}{r_{max}}\right)T_1^*(r_2) & E_2(r_2) & E_3(r_2) & ... & E_N(r_2)\\ ... & ... & ... & ... & ...\\ \left(1-\frac{2r_N}{r_{max}}\right)T_1^*(r_N) & E_2(r_N) & E_3(r_N) & ... & E_N(r_N)\end{pmatrix} \quad (22)$$

where

$$E_k(r)=\left(1-\frac{2r}{r_{\max}}\right)T_k^*(r)+\frac{k-1}{4}\left[T_{k-1}^*(r)-T_{k+1}^*(r)\right], \quad k\ge 2 \quad (23)$$

This algorithm allows us to obtain the eigenvalue, the eigenvector, the index of the most unstable mode, the maximum amplitude of the most unstable mode and the critical distance where the perturbation is the most amplified.

The main advantages of the proposed method consist in reducing the computational time by reducing the matrices order to $(4N-8)^2$ and for a certain spectral parameter N we obtain an exponential decreasing error.

## 4 NUMERICAL RESULTS FOR BATCHELOR VORTEX

The above presented method was tested on a particular benchmark model: the Batchelor or q-vortex [7].

The flow field is characterized by the velocity field $\underline{V}(r)=[U(r),0,W(r)]$ [4],

$$U(r)=a+e^{-r^2},\ W(r)=\frac{q}{r}(1-e^{-r^2}) \tag{24}$$

where $q$ represents the swirl number defined as the angular momentum flux divided by the axial momentum flux times the equivalent nozzle radius and $a$ provides a measure of free-stream axial velocity.

In [7] the numerical investigation of the two-point boundary value problem was based on a shooting method. The properties of the Batchelor vortex are pointed out by considering them as functions of the swirl ratio $q$ and the external flow parameter $a$.

The computed spectrum of the eigenvalue problem is depicted in Figure 1. Graphical representations of the spatial eigenfunction amplitudes of the most unstable mode are given in the Figure 2. For a stabilization of the Gibbs phenomenon a Lanczos type $\sigma$ factor [10] was used,

$$\sigma_k=\frac{\sin\frac{2\pi k}{N}}{\frac{2\pi k}{N}},\ 1\le k\le N \tag{25}$$

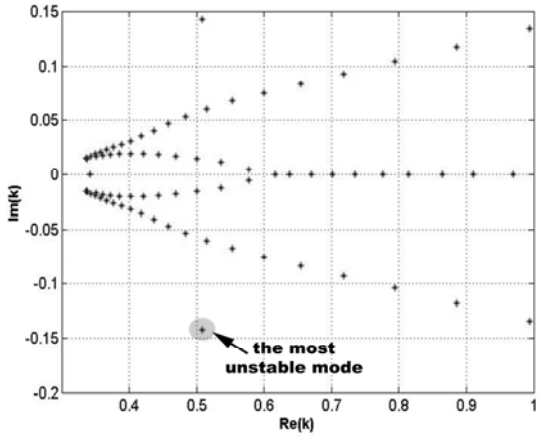



Figure 1. Spectra of the hydrodinamic eigenvalue problem computed at ω = 0.01, m=-3, a = 0, q = 0.1, N = 150.

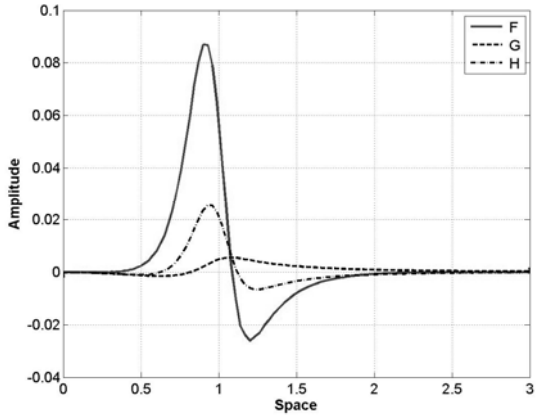



Figure 2. Values of eigenfunction amplitudes of the most unstable mode ω = 0.01, m = -3, a = 0, q = 0.1, N = 150, k = 0.50842-0.14243i.

Table 1. Convergence behaviour of the critical distance for the most unstable mode with ω = 0.01, a = 0, q = 0.1 and m = -3.

| $N$ | Axial wavenumber $k$ | Critical distance $r_c$ |
|---|---|---|
| 100 | 0.64887-3.7433i | 0.00302 |
| 150 | 0.50842-0.14243i | 0.90051 |
| 180 | 0.50847-0.14232i | 0.92294 |
| 250 | 0.50854-0.14216i | 0.95451 |
| 300 | 0.50857-0.14209i | 0.93874 |

## 5. CONCLUSION

In this paper we developed a spectral numerical procedure to investigate the spatial stability of a swirling flow subject to infinitesimal perturbations. Using a spectral collocation technique our numerical procedures directly provided relevant information on perturbation

amplitude for stable or unstable induced modes, the maximum amplitude of the most unstable mode and the critical distance where the perturbation is the most amplified.

The accuracy of the methods is assessed underlying the necessity for the construction of a certain class of orthogonal expansions functions satisfying the boundary conditions. The key issue was the choice of the grid and the choice of the modal trial basis, the scheme based on shifted Chebyshev polynomials provided good results.

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