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## TRIBOLOGY CENTER AT THE TECHNICAL UNIVERSITY - SOFIA

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**Abstract:** Researches, development, educational and organizational activities during the 39 years of the Tribology Center at the Technical University of Sofia are presented in the paper. Together with the Society of Bulgarian Tribologists and the Balkan Tribological Association, the Tribology Center follows the objectives of the scientific, edifying and practical development of tribology on national and international level. Exchanging research, teaching and conceptual experience, participating in common projects and carrying for the advance of the specialists in industry and science, the Tribology Center promotes tribology in Bulgaria, on the Balkans, in Europe and worldwide.

**Keywords:** university education, tribology research and development, investigations of tribosystems

### 1. FACULTY OF INDUSTRIAL TECHNOLOGY (FIT) AT SOFIA

The Faculty of Industrial Technology hosts the Tribology Center (Laboratory of Tribology). FIT prepares specialists in the field of Mechanical Engineering and Technologies. Since 1945, the first academic year, till now many thousands of engineers have been prepared and have found professional realization in Bulgaria and in many other countries all over the world. In its structure enter:

- Department "Materials Science and Technology" hosting the "Laboratory of Tribology".
- Department "Technology of Machine Tools and Manufacturing"
- Department "Theory of Mechanisms and Machines"
- FIT educates students in BSc and MSc specialties in the professional field "Machine Engineering". The BSc programs are: Machine-building technology and machinery; Industrial technology; Computer aided design and technology in machine-building; Advanced industrial technologies (in English).

The degree MSc is provided in the programs:

- Machine-building technology and machinery.
- Computer aided design and technology in machine-building.
- The two subjects trained in TRIBOLOGY in the regular schedules for Master degree: Dynamics and tribology of machines and Engineering triboecology.

A part of the 30 doctoral students prepare PhD theses on tribology in the teaching program of the Faculty.

### 2. TRIBOLOGY CENTER AT THE FACULTY OF INDUSTRIAL TECHNOLOGY

#### 2.1 Background

In 1974 Prof. Nyagol Manolov founded the Laboratory of Tribology, which developed in Coordination Center on Tribology and Tribology Center.

In 1975 Section on friction and wear in machines at the Scientific-Technical Unions of Machine building was founded. In the period 1984-1989 was the preparation (in 1984 at the International

Conference Intertribo, Strbske Pleso, Slovakia) and the admission (1985) of Bulgaria as member of the International Tribology Council, directed by Prof. H.P.Jost, as well as the preparation and admission of Bulgaria as member of the International Council of Selective Transfer and Frictional Coatings - ICSTFC, guided by Prof. D. N. Garkunov and Prof. Gottlieb Polzer. The Conception for the development of tribology in Bulgaria up to the year 2000 (updated later up to 2020) was also developed and published.

1993 is the year of the legal establishment of the Society of Bulgarian Tribologists, a non-profit organization. Since 1985 the Tribology Center as member of the International Tribology Council participates actively in the organization of international forums. In 1993 the Society was at the root of the founding of the Balkan Tribological Association in Sofia and carried out the 1<sup>st</sup> and the 6<sup>th</sup> International Tribology Conferences BALKANTRIB, in Sofia in 1993 and in Sozopol in 2008.

The Society of Bulgarian Tribologists with actual president Assoc. Prof. Dr. Mara Kandeve organizes the annual international tribological conference BULTRIB. In collaboration with the Interdisciplinary Civic Academy INGA the Society founded the National Expert Council on Tribology in 2002. The Laboratory of Tribology at the Faculty of Machine Technology in the Technical University - Sofia hosts since 2004 the meetings of the Interuniversity Seminar "Tribology and Interdisciplinarity" named after Prof. Manolov. The Society realizes periodical publishing activity in the field of tribology and related problems.

Another priority of the activities of the Society is the integration of research, education and practice, stimulating for example innovative business initiations, development of production technologies and laboratory services.

## 2.2 Main topics of activity

- **In the field of science and methodology:** development of the interdisciplinary paradigm of tribology and the theory of contact approach: principles, models, general law of contact interaction, functional atom of tribology; modeling and simulation of contact processes.
- **Institutional, educational and informational activities:** preparation of specialists – Master of Science, PhD students, experts; laboratories, centers, technological parks, conferences, seminars, editing and publishing of manuals, journals, books, conceptions. In the teaching of tribology: two subjects on tribology in the regular schedules for Master degree: Dynamics and tribology of machines and Engineering Triboecology.
- **Services and applied activities:** Industrial applications: Tribotechnologies for regeneration of worn details by means of deposition of composite wear-resistant coatings; Ecological tribotechnology for regeneration of air automotive filters, etc. Laboratory testing: Services using procedures and devices for testing friction, wear, lubrication, hermeticity and reliability of coatings, materials and contact systems.

## 2.3 The concept of contact approach in tribology

Tribology is the interdisciplinary science of contact interaction, concerning friction, wear, lubrication, hermeticity and other processes in the interface of contacting surfaces. The modern conception of tribology according to its interdisciplinary paradigm has broader scope: tribology is defined as science of contacts, contact networks and contact interaction of bodies regardless of their nature and physical condition. Tribology is the first science conferred to the excluded third (e.g. the contact) in the bipolar model. So, the tribological approach is also contact approach. According to the paradigm of tribology every existing thing includes three basic principles: body, counterbody and contact between them. The dyad body-counterbody is transformed in triad body-contact-counterbody called "Functional atom".

## 3. EXAMPLES FROM THE RESEARCH STUDIES

### 3.1 Tribological studies of wear-resistant powder flame coatings deposited

The coatings are obtained in a flame medium of acetylene and oxygen mixture. The powders are combinations of super-alloys of different content and properties. The coatings have high adhesion

with the base surface due to chemical bonds; they have various hardness (up to 70 HRC) and resilience. Compared to the widely used in the country technologies like welding, metalizing, cold overlaying, chrome plating, nitriding, above tribotechnology has the advantage to give coatings with wear-resistance 3 to 8 times higher than that of the non-coated new detail.

This tribo-technology allows not only regeneration of the dimensions of the worn elements, but also improves the wear-resistance of surfaces of new elements. The method is used in the Laboratory of Tribology at the TU-Sofia for regeneration of various details, mainly of the automotive transport: shafts; engine rotors, bearing surfaces; engine covers, bearing grooves, surface cracks; cages of pumps; different wheels; rotation elements and turbines; fans and reduction gears; dies and moulds.

### 3.2 Composite coatings. Nano-structured nickel coatings

Nanostructured composite coatings are obtained by electroless nickel plating method EFTTOM-NICKEL developed at the Faculty of Industrial Technology in Sofia. The method allows getting Ni coatings containing nanosize particles of various natures – silicon carbide, diamond, boron nitride, etc. E.g. the density of the SiC nanoparticles in the coating is 5÷7 vol. percent.

Ni electro-chemical coatings on steel containing diamond nano-particles with average size 100 nm are studied in the Tribology Center. In the search of improvement of wearresistance, coatings were obtained at



Fig. 3. Equipment for the electroless deposition of Ni composite coatings

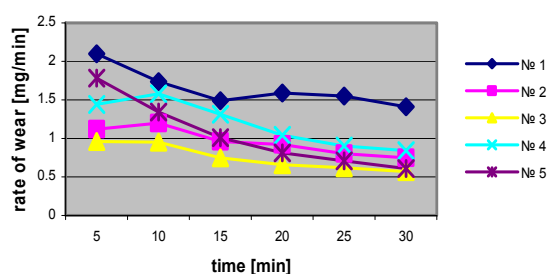


Fig. 4. Abrasive wear of nano-structured nickel coatings deposited on folio extrusion shafts

various concentrations of the nano-particles in the solution and at various values of current density. A procedure is developed for the study of wear parameters (linear wear, wear rate, wear intensity and wear-resistance) of the coatings under conditions of dry friction with abrasive surface.

3.3 Selective transfer and self-organization studies. Frictional coatings

Tribologists have the task to keep the destruction as small as possible or to stop it, in order that the system comes to the equilibrium process between destruction and regeneration. Exactly this happens in the processes of selective transfer of material between contacting surfaces. This phenomenon is assisted by the rubbing of brass under the special conditions of selective transfer. D. N. Garkunov and G. Polzer are of the first researchers in theory and practice of the selective transfer of material during friction. Common works are carried out between the Tribology Center in Sofia and the Tribology Group of Prof. Polzer in Zwickau, and recently in Schoenfels, Germany. Main purpose is wear reducing through frictional coatings and regeneration of worn surfaces without joint dismantling. Copper frictional coatings in the case of nonabrasive treatment of steel or cast iron surfaces, their production with the assistance of selective transfer of materials between the friction surfaces are mainly considered. As illustration a steel shaft to be coated is both subjected to rotation and to the pressure of the brass stick in the presence of a special lubricant.

Different machines were designed and constructed at the Department Tribotechnik in Zwickau' Higher Technical School, corresponding to the principles of the frictional deposition and the ideas of the selective transfer. Many pieces of the devices „MBZ 1" for shaft coatings and „MBZ 3 A" for application in rotating machines were manufactured (see Figs. 5, 6), e.g. the „MBZ 3 A" for engine cylinders was produced in 30 items. Unfortunately there is not sufficient use of the advantages of the deposition of copper frictional coatings in the overall practice.

Important features of the coatings deposited during friction under selective material transfer mode: Low wear of components at nonabrasive treatment of steel/cast iron, and lower hydrogen wear of the coated surfaces; lower inclination for welding and seizure between the surfaces; possibility for dismantling-free restoration of worn units/couples. The practical implementation of copper frictional coatings is of high importance and was realized in Germany, Russia, Kazakhstan, Poland, etc.

### 3.4 Tribotechnology for regeneration of air automotive filters TREFA

Air automotive filters are regenerated for more than 15 years in the Tribology Center - Sofia. After regeneration they show high quality and reliability at the same operation characteristics as the new filter, and with several times lower price. It leads to economic ecological effect. In 2010 TREFA tribotechnology for regeneration of air filters under the special conditions of mining industry was implemented in Kazakhstan. The Tribology Center has a joint program for cooperation with the company Rudservice K in the city of Jezgizkan, Kazakhstan, which is an element of a corporation for the production and recovery of copper, gold, silver, etc.

### 3.5 The Project of the first CEEPUS Network on Tribology

The Project CIII-BG-0703-01-1213 "Modern Trends in Education and Research on Mechanical Systems - Bridging Reliability, Quality and Tribology" was accepted in May 2012. Project coordinator is Assoc. Prof. Dr. Juliana Javorova of the University of Chemical Technology and Metallurgy, Sofia. 10 European countries take part: Austria, Bosnia & Herzegovina, Bulgaria, Croatia, Hungary, Macedonia, Poland, Romania, Serbia, Slovakia. Coordinator for the Technical University of Sofia is Assoc. Prof. Dr. Mara Kandeve. Coordinator from the side of Bosnia and Herzegovina is Prof. Dr. Gordana Globocki-Lakic.

The 1<sup>st</sup> CEEPUS Workshop on the Project was held in Sofia on 18.10.2012. After the successful completion of the 1<sup>st</sup> year, the first CEEPUS Tribology Network is approved for the 2<sup>nd</sup> year (2013-2014). The 2<sup>nd</sup> CEEPUS Workshop in the Tribology Network is to be held during the International Conference BULTRIB'13 (24-26.10.2013) in Sofia.

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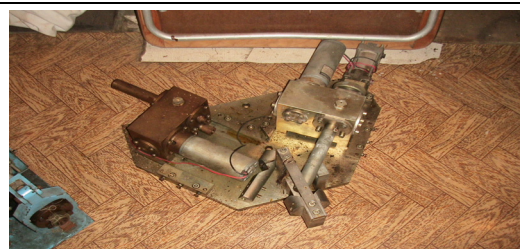


Fig. 5. View of the brass-coating device MBZ 3A

coated engine cylinder



MBZ 3 as core of MBZ 4

Fig. 6. The brass-coating device applied in automatic machine

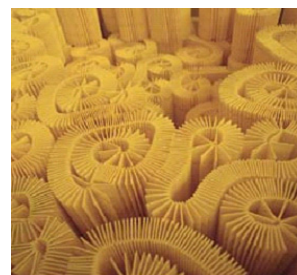


Fig. 7. The surface to be cleaned

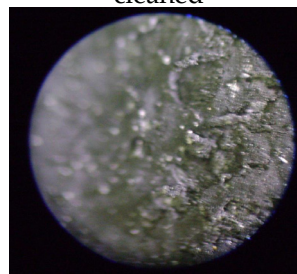


Fig. 8. The filtering element before regeneration