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THE MODELLING ON THE COMPUTER OF THE STRESS AND DEFORMATION STATES IN THE CASE OF THE BODIES OF THE PLOUGH WITH LAMELLAR MOULDBOARDS, USING THE PROGRAMME WITH FINITE ELEMENT "COSMOS/M"

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Abstract - *In speciality reference material from our country and in the countries with an advanced agriculture it hasn't appeared yet a calculation methodology with a view to projection's optimization of these mouldboards and on this line, the current paper, tries to bring a contribution in this field, benefiting by the advantages on which it presents the application of the analysis method with finite elements respectable programme of computer "COSMOS/M".*
By means of "Finite Elements Method" (FEM) respectively of "COSMOS/M" programme it could be performed the stress and deformation state's modelling in lamellar mouldboard, finally the authors achieving two subprogrammes of calculus. On the basis of this subprogrammes, a complete study of the stress and deformation state was effected, using the "Finite Elements Method" (FEM).
Following the analysis with finite elements were calculated all the component parts of the stress and deformation tensor from the network's knots, as well as, from the centre of each finite element, for two working regime.

1. INTRODUCTION

The modelling of the stresses and deformations' distribution on the surface of the working mechanisms of the agricultural machinery presents a different significance.

The cognition of the stresses and deformations' distribution on the surface of the working mechanisms of the agricultural machinery, in varied conditions from exploitation, can offer an ample experimental and theoretical material to the researchers. On the basis of this material, the researchers can perform a judicious projection of the structure and sizes of the agricultural machinery's mechanisms.

The estimate of the factors' variation boundaries which influence the strengths at wear it is also permited.

As part of the Strength of Meterials Department from the "Politehnica" University, Timişoara were studied the lamellar mouldboard, which equiped the Vari-Diamant plough of Lemken German company and the prototype lamellar mouldboard achieved by MAT Craiova. The study pursued the determination of the maximum requirement zones, where can appear fissures or even breaks during the working process, using F.E.M. and respectively COSMOS/M programme. For this, there were used: the INTEL PII DESHUTES 350 MHz computer and respectively the COSMOS/M programme achieved by a famous company from Santa Monica, California.

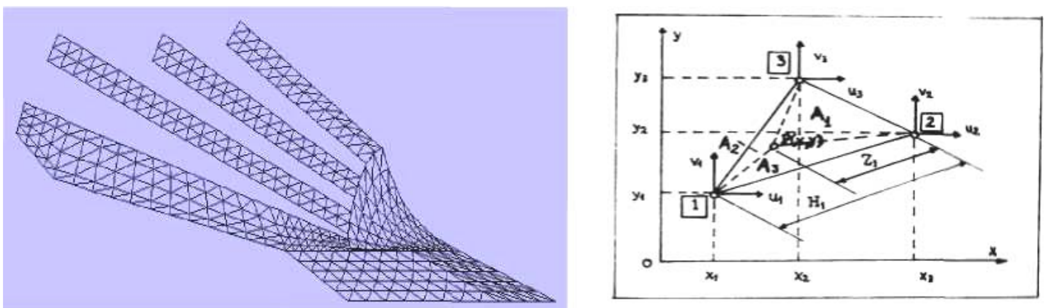
2. THEORETICAL CONSIDERATIONS REGARDING THE UTILIZATION OF THE FINITE ELEMENT METHOD (F.E.M.) IN THE STRESSES' DISTRIBUTION'S DETERMINATION ON THE MOULDBOARDS' SURFACE WITH LAMELLAS

Benefiting by the advantages of the calculation precision which was demonstrated by the utilization of F.E.M. in the ensembles' projection with special spatial configuration and distribution, the authors staff performed researches with a view to definitization of the most suited digitization system that can be applied at the stresses' distribution's determination in the moldboards' lamellas of this type.

It also becomes precise the matric mathematical expressions which permit the active surface's modeling of the lamellar moldboard.

From the performed thorough studies resulted that for the lamellar mouldboard's surface's digitization, the most suited model for this working mechanism is the variant with triangular elements.

In picture 1 it presents the manner of digitization with triangular finite elements of the Lemken lamellar mouldboard and respective the studied triangular finite element.



a. b.

PICTURE 1. THE MANNER OF DIGITIZATION OF THE LAMELLAR MOULDBOARD (a).
THE STUDIED TRIANGULAR FINITE ELEMENT (b).

Equation (1) represents the fundamental equation of F.E.M. written for an "e" element of the lamellar moldboard’s structure. Equation (2) represents the fundamental equation of F.E.M. written for the whole

$$[K]_e\{u\}_e = \{Q\}_e \qquad (1)$$

$$[K]\{u\} = \{Q\} \text{ where } [K] = \sum_1^n [K]_e ; \{Q\} = \sum_1^n \{Q\}_e \qquad (2)$$

Relation (3) represents the matrix of the crucial forces for the case when there is taken in consideration only the stresses distributed on the volume unit.

Relation (4) represents the matrix of the crucial forces for a triangular element which belongs to the lamellar moldboard's structure.

From relation (3) and (4) it is noticeable that the crucial forces are distributed in uniform mode on the three knots, because of the element's

$$\{Q\}_e^{\gamma} = \int_V [N]^T \cdot \{\gamma\} \cdot dV = \int_V \begin{bmatrix} L_1 & 0 \\ L_2 & 0 \\ L_3 & 0 \\ 0 & L_1 \\ 0 & L_2 \\ 0 & L_3 \end{bmatrix} \cdot \begin{Bmatrix} \gamma_x \\ \gamma_y \end{Bmatrix} \cdot dv \qquad (3)$$

$$\{Q\}_e^{\gamma} = \begin{Bmatrix} Q_x \\ Q_x \\ Q_x \\ Q_y \\ Q_y \\ Q_y \end{Bmatrix} = \frac{1}{3} \cdot A \cdot t \cdot \begin{Bmatrix} \gamma_x \\ \gamma_x \\ \gamma_x \\ \gamma_y \\ \gamma_y \\ \gamma_y \end{Bmatrix} \qquad (4)$$

The stresses distributed on the triangular element's surface are taken in consideration through their results applied in the element's knots.

3. THE STRESS AND DEFORMATION STATE'S MODELLING ON THE BODY OF THE PLOUGH WITH MOULDBOARDS WITH STRAIGHT LAMELLAS

By means of "Finite Elements Method" (F.E.M.) respective of "COSMOS" programme it could be performed the stress and deformation state's modeling in lamellar mouldboard.

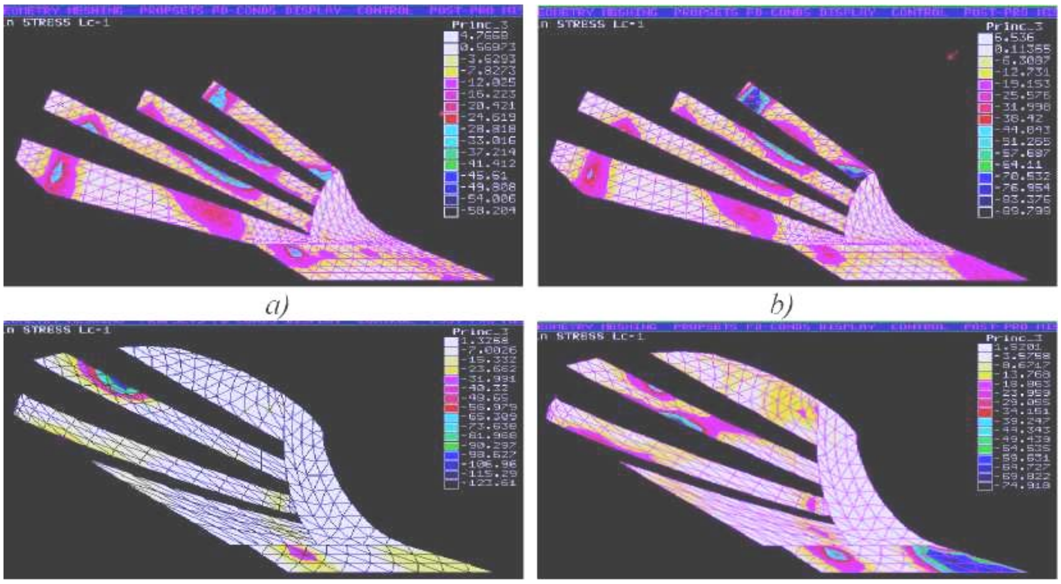
Following the analysis with finite elements there were calculated all the component parts of the stress and deformation tensor from the network's knots, as well as, from the centre of each finite element, for two working regime. With a view to exemplification, in picture 2 it presents the distribution of the main normal stress σ_3 for a = 30 [cm] and a = 35 [cm] for the two types of studied mouldboards.

As in the speciality reference material there aren't specified yet the conditions after which there must be ordered the lamellas, profilographic studies of laboratory on a big number of lamellar mouldboards were imposed. Thus it could be outlined a disposing rule of these lamellas.

On the basis of the coordinates of a big number of experimental obtained points, it could be generated, using the "COSMOS" programme, the evolution of the surfaces in space of these types of mouldboards.

Considering that both the mouldboard and the ploughshare enter in the plate's category, their surfaces were digitizated using isoparametric finite elements, SHELL3 thin plate type, with three knots on element and five degrees of freedom on knot.

The digization network had the variable step, fact that encouraged the increase of the number of elements in the fastening zones, or in which appeared section modifications.



c) d)

PICTURE 2. THE DISTRIBUTION OF THE MAIN NORMAL STRESS σ_3 FOR TWO WORKING REGIME:
a) - Lemken lamellar mouldboard - a = 30 [cm];
b) - Lemken lamellar mouldboard - a = 35 [cm];
c) - MAT Craiova lamellar mouldboard - a = 30 [cm];
d) - MAT Craiova lamellar mouldboard - a = 35[cm][1].

As well as real constants, associated to the group of SHELL 3 elements, we introduce thickness as being of 10 mm at the Lemken mouldboard and of 7 mm at the MAT Craiova mouldboard, and as material properties, the modulus of longitudinal elasticity and modulus of elasticity in shear.

For the calculation of the stresses it considered the situation when, on the ox advancemend direction (the case when the plough meet in the soil an obstacle) acts a concentrated force in the top ploughshare, and on the body of the ploughshare, the breast of the mouldboard and the lamellas it acts a pressure constant distributed, but different as value from a lamella to another respectively from the body of the ploughshare to the breast of the mouldboard.

In tables 1 and 2 are presented the comparative values of the stresses theoretical determined by means of the "COSMOS" programme, in the fastening (embeding) zones of the Lemken lamellar mouldboard (Germany) respectively of the MAT Craiova lamellar mouldboard (Romania), in two working regime. In table 3 are presented the comparative values of the stresses theoretical determined by means of the "COSMOS" programme, in the fastening (embeding) zones of the Lemken lamellar mouldboards respectively in the embeding zones of the MAT Craiova lamellar mouldboards, for a = 30 [cm].

The utilization of "COSMOS" programme enabled the establishing of some statics stresses in laboratory conditions, which were related to those dynamic obtained in experimental conditions in field, from where it resulted an adimensional parameter, which we called "dinamicity

$$C_d = \frac{\sigma_d}{\sigma_s} \quad (5)$$

where: Cd - dinamicity coefficient;
σd - dynamic stress; σ_s - statics stress.

TABLE 1. The comparative values of the stresses theoretical determined by means of the "COSMOS" programme, in the embeding zones of the LEMKEN lamellar mouldboard 3

Fastening/ embeding zone's number of the R.E.T.	Abstat unit	Maximum stress theoretical calculated in the fastening zones, for a = 30 [cm] (Lemken lamellar mouldboard)	Maximum stress theoretical calculated in the fastening zones, for a = 35 [cm] (Lemken lamellar mouldboard).
1	MPa	15,038	25,163
2	MPa	10,216	17,005
3	MPa	15,038	25,163
4	MPa	10,216	17,005
5	MPa	29,502	33,32
6	MPa	10,216	17,005
7	MPa	15,038	25,163
8	MPa	15,038	25,163
9	MPa	39,145	98,581
10	MPa	53,609	123,05
11	MPa	63,252	90,423
12	MPa	29,502	41,478
13	MPa	53,609	57,793
14	MPa	43,966	49,636
15	MPa	39,145	57,793
16	MPa	39,145	57,793
17	MPa	29,502	57,793

TABLE 2. The comparative values of the stresses theoretical determined by means of the "COSMOS' programme, in the embeding zones of the MAT Craiova lamellar mouldboard (Romania)[1][3]

Fastening/ embeding zone's number of the R.E.T.	Abstat unit	Maximum stress theoretical calculated in the fastening zones, for a = 30 [cm] (MAT Craiova lamellar mouldboard)	Maximum stress theoretical calculated in the fastening zones, for a = 35 [cm] (MAT Craiova lamellar mouldboard)
1	MPa	28,857	82,739
2	MPa	9,9342	12,674
3	MPa	47,781	36,029
4	MPa	9,9342	12,674
5	MPa	9,9342	12,674
6	MPa	9,9342	36,029
7	MPa	19,396	47,707
8	MPa	9,9342	12,674
9	MPa	142,4	176,16
10	MPa	28,857	36,029
11	MPa	47,781	59,384
12	MPa	9,9342	12,674
13	MPa	9,9342	12,674

TABLE 3. The comparative values of the stresses theoretical determined by means of the "COSMOS" programme, in the embeding zones of the LEMKEN lamellar mouldboard (Germany) respectively in the embeding zones of the MAT Craiova lamellar mouldboard (Romania) , for a = 30 [cm][1][3]

Fastening/ embeding zone's number of the R.E.T.		Abstat unit	Maximum stress theoretical calculated in the fastening zones, for a = 30 [cm] (Lemken lamellar mouldboard).	Maximum stress theoretical calculated in the fastening zones, for a = 30 [cm] (MAT Craiova lamellar mouldboard)
Lemken	MAT			
2	1	MPa	15,038	28,857
4	2	MPa	10,216	9,9342
5	3	MPa	29,502	47,781
7	4	MPa	15,038	9,9342
8	5	MPa	15,038	9,9342
9	6	MPa	39,145	9,9342
10	7	MPa	53,609	19,396
11	8	MPa	63,252	9,9342
12	9	MPa	29,502	142,4
13	10	MPa	53,609	28,857
14	11	MPa	43,966	47,781
15	12	MPa	39,145	9,9342
17	13	MPa	29,502	9,9342

TABLE 4. The comparative values of the stresses theoretical and experimental determined, in the case of the Lemken mouldboard with straight lamellas[1]

Nr. RET	Working depth [cm]	Abstat unit	Maximum stress experimental determined	Maximum stress theoretical calculated	Dinamicity coefficient
RET1	30	MPa	28.42	24.681	1.15
RET1	35	MPa	29.4	33.32	0.88
RET2	30	MPa	28.81	24.681	1.16
RET2	35	MPa	25.48	25.163	1.01
RET3	30	MPa	1.96	0.57356	3.41
RET3	35	MPa	1.96	0.69024	2.83
RET4	30	MPa	30.87	29.502	1.04
RET4	35	MPa	28.81	25.163	1.14
RET5	30	MPa	57.62	53.609	1.07
RET5	35	MPa	61.74	57.793	1.06
RET6	30	MPa	1.96	0.57356	3.41
RET6	35	MPa	1.96	0.69024	2.83
RET7	30	MPa	49.39	48.788	1.01
RET7	35	MPa	39.2	41.478	0.94
RET8	30	MPa	72.03	68.073	1.05
RET8	35	MPa	86.24	82.266	1.04
RET9	30	MPa	41.16	39.145	1.05
RET9	35	MPa	11.76	8.8478	1.32
RET 10	30	MPa	26.75	24.681	1.08
RET 10	35	MPa	61.74	57.793	1.06
RET 11	30	MPa	51.45	48.788	1.05
RET 11	35	MPa	90.55	90.423	1.001
RET 12	30	MPa	11.76	10.216	1.15
RET 12	35	MPa	32.92	25.163	1.30
RET 13	30	MPa	11.27	10.216	1.10
RET 13	35	MPa	9.8	8.8478	1.10
RET 14	30	MPa	8,03	10,216	0,78
RET 14	35	MPa	9.8	8.8478	1.10
RET 15	30	MPa	4.11	5.395	0.76
RET 15	35	MPa	7.84	8.8478	0.88
RET 16	30	MPa	2.94	0.57356	5.12
RET 16	35	MPa	4.11	5.395	0.76
RET 17	30	MPa	22.54	15.038	1.49
RET 17	35	MPa	37.04	33.32	1.11
RET 18	30	MPa	45.27	39.145	1.15
RET 18	35	MPa	49.49	49.636	0.99

The results obtained in laboratory conditions praised that the calculating stress σ_s was comprised between 0.57...90.42 [MPa], and that experimental determined σ_d was comprised between 1.96… 90.55 [MPa] that is the dinamicity coefficient Cd is comprised between 0.76…1.15 [MPa], which is in the same order of the magnitude. The comparative values of the stresses experimental respectively theoretical determined, for Lemken lamellar mouldboard, are presented in table 4.

4. CONCLUSION

- The stage of the current development of the scientific and technical level permits the utilization of the Finite Element Method as a fundamental theoretical method of the determination of stresses and deformations' distribution on the mouldboard's surface of lamellar type.
- It can be assert that F.E.M., at the level of advanced projection of the agricultural machines, it isn't anymore only a useful instrument, but it is one absolutely necessary.
- In the context of potential's capitalization offered by the COSMOS/M programme in this field, the modeling of the stresses and deformations field became a certainty.
- The theoretical cognition of the stresses and deformations' distribution is of an unchallenged utility in the evolution's estimate of this process, experimental praised in the ground.
- This paper ranges among the first researches in this field and opens the pathway towards new researches bound of implementation in the modern ploughes' engineering of the lamellar mouldboards.
- By the means of F.E.M. respective of "COSMOS" programm it can be elaborated in an efficient mode the stress and deformation state's modeling from lamellar mouldboard, obtaining in this way useful data for the engineering's optimization of this new type of working mechanism of the soil.
- The stresses fields experimental determined in field and respective theoretical by means of "COSMOS" programme, they complete each other, in the sense that as part of the resulted spectrums through the utilization of "COSMOS" programme, in the embedding zones of the lamellas appear much bigger stresses than in the other zones in which they were experimental determined as a result of the stresses concentrators' appearance typical of any joinings and which couldn't be experimental praised.
- For the section's projection's optimization of each lamella is necessary and sufficiently to be taken in consideration the stresses established by means of the "COSMOS" programme in the embeding zones, because their values are the biggest in the distribution of the stresses field along the lamellas.

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