ACTA TECHNICA CORVINIENSIS
– Bulletin of Engineering
Tome IX [2016], Fascicule 4 [October – December]
ISSN: 2067 – 3809

[1.]Ştefan S.BIRIŞ, [1.]Edmond MAICAN, [2.]Eugen MARIN, [3.]Sorin BUNGESCU, [2.]Valentin VLĂDUŢ, [1.] Nicoleta UNGUREANU, [1.]Daniel IonVLĂDUŢ, [4.]Atanas ATANASOV

STRUCTURAL STATICAL ANALYSIS OF WORKING BODIES OF AGRICULTURAL CULTIVATORS

[1.]University ”POLITEHNICA” Bucharest, Faculty of Biotechnical Systems Engineering, ROMANIA
[2.]INMA Bucharest, ROMANIA
[3.]USAMVB Timişoara, ROMANIA
[4.]University of Russe, BULGARIA

Abstract: In this paper is presented an advanced methodology for the analysis of stress and strain distribution (statical structural analysis using the finite element method) in the working bodies of agricultural cultivators for seedbed preparation in order to optimize them. The geometrical model of soil working body was develoepd in SolidWorks format before being taken and transferred to the program of analysis with finite elenets (ANSYS), in order to perform the necessary resistance calculations made in linear static domain. The obtained results provide valuable information on proper geometric dimensioning of the working bodies of agricultural cultivators.
Keywords: finite element method, structural statical analysis, working body, agricultural cultivator

INTRODUCTION

Following the expansion of soil degradation processes due to conventional agriculture and technological mistakes, over the years, the so-called conservative agricultural technologies have been studied and implemented in practice. These technologies have contributed substantially to the improvement of soil fertility and productivity and, thus, of other environmental resources. The most important component of conservation technological systems, as in the case of conventional ones, is soil tillage – loosening and processing – and the introduction of seed into the soil. Switching from conventional tillage systems to the conservative ones was not easy and generated a lot of questions that needed relevant answers, scientifically based, some of them being obtained through fundamental and applied research carried out under local specific conditions. Conservative systems are based on the less intense loosening of soil, made by different methods, without furrow return and only while maintaining a given amount of crop residues on soil surface, being considered for this reason as environmental protection strategies.

Agriultural cultivators are equipment with an increasingly widespread for seedbed preparation in order to establish crops, especially in the current conservative cultivation technologies. Besides the fact that these equipment must achieve a soil processing with superior qualitative and energy indices, their weight must be as small as possible and their reliability must be as good as possible. Currently, it is possible to shorten spectacularly the cycle of conception-design-testing-production of such equipment by using the finite element method for the analysis of stress and strain distribution of their resistance elements (frames, tool holders, working tools, etc.).

MATERIAL AND METHOD

The experimental model of technical equipment for conservative processing of soil is semi-mounted and works in aggregate with tractors in range of 330-550 HP.

Theequipment (Figure 1) consists of: drawbar with towing ring (1); working bodies type knifechisel with extension (2); preceding disks (3); double bearingsupport (4); identification tablet (5); central frame (6); transport train (7); rearroller (8); lights kit (9); hydraulic installation for folding of lateral frames (10);); hydraulic installation for working depth adjustment of the discs (12); disc levening bar (13).

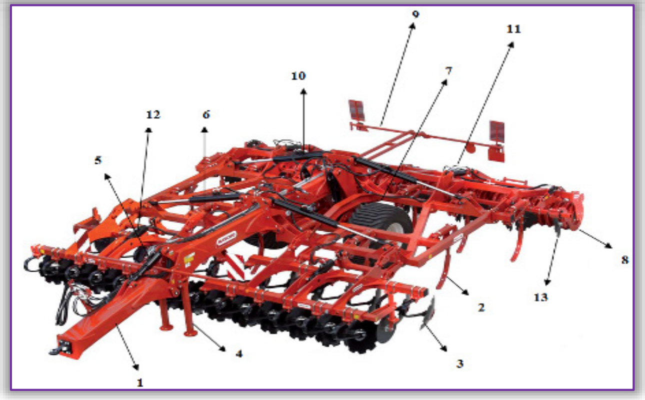

Figure 1 – Technical equipment for conservative soil processing – three-dimensional view

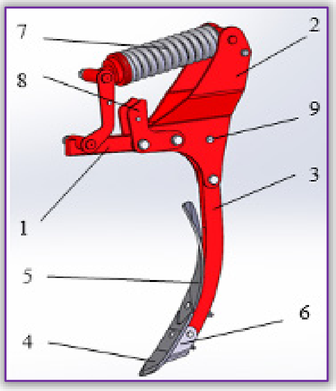

Figure 2 – Main working body of the cultivator

Soil working body (Figure 2) is designed to dislodge the soil to a depth of up to 25 cm, to raise, stir and turn crop residues, is mounted on the frame of technical equipment for conservative soil processing. Soil working body consists of a support (1) on which are mounted two support plates (2) on one hand, for assembling a rigid support (3) provided with a chisel (4) for soil decompaction, an extension (5) for slight twisting of crop residues and a cutting knife (6) of the bottom of the furrow and on the other hand, for assembling a pretensioned spring (7) which allows absorbing most part of the towing tension and of the plates (8) for the limitation of the spring stroke.

The geometric model of soil processing in conservative system was developed in SolidWorks format and transferred to the analysis program with finite elements (ANSYS), in order to perform the required resistance calculations, which were made in linear static domani. In figure 4 is presented the meshed model of the working body. Given that the investigated structure was modeled geometrical three-dimensional, it was chosen that in the meshing process to use a 3D finite element, of Solid type. His is a three-dimensional element, of rectangular shape, with 20 nodes (on each corner and at each mid side) with three degrees of freedom on each node: nodal translations in the directions of OX, OY and OZ axis. The element supports the theory of plasticity, hiperplasticity, large specific displacements and strains; the material used S355OL52.

In figure 5 is presented dthe geometrical shape of the finite element, used in the meshing process. The rectangular shape of the finite element represents the native shape, whereas the other shapes, found in the right side of the figure, represent degenerated forms, that may arise in the case of complex geometries as shapes (in areas in which are found junction radius, thickness variations etc.).

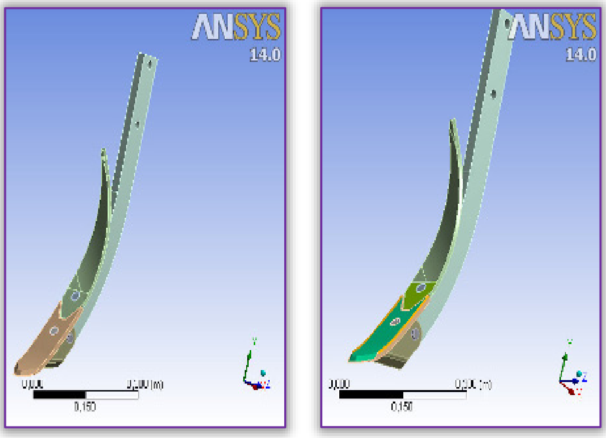

Figure 3 – Geometric model of working body taken in ANSYS

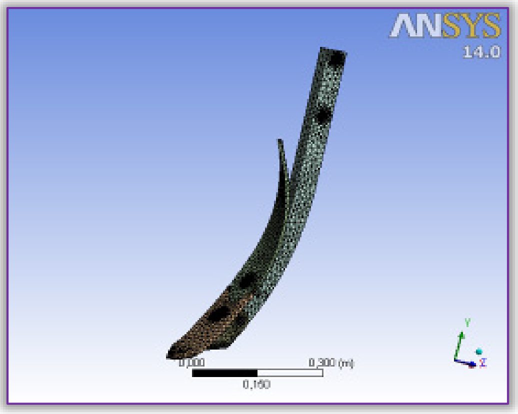

Figure 4 – Meshed model of the working body

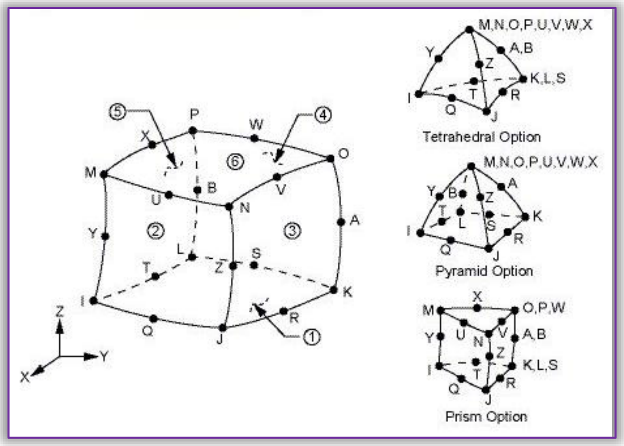

Figure 5 – Geometry of the finite element

RESULTS

The results of the static analysis of the working of the cultivator are presented in the following figures. These consist of: distribution of total deformation, distribution of normal pressures on the coulter of the working body, distribution of equivalent stress by the Von Mises criterion in both the coulter and the wing of the working body, but also in support of the working body.

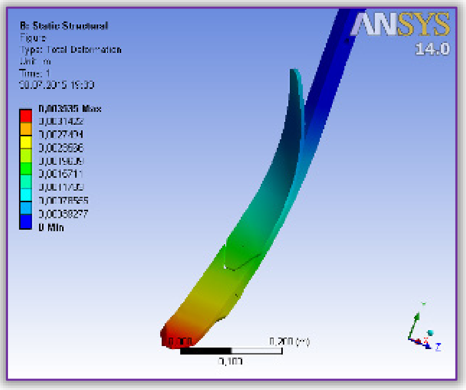

Figure 6 – Distribution of total deformation

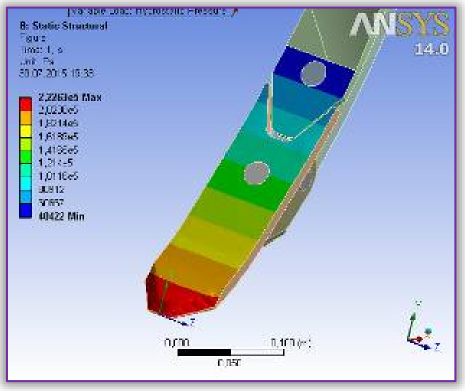

Figure 7 – Distribution of normal pressures on the working body

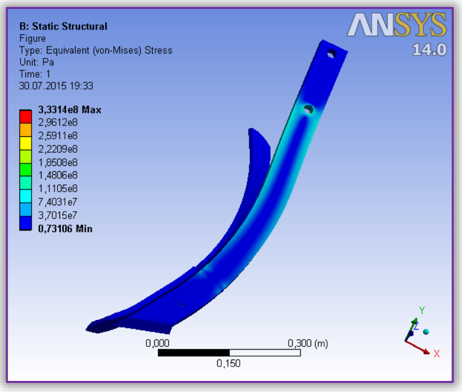

Figure 8 – Distribution of equivalent stress

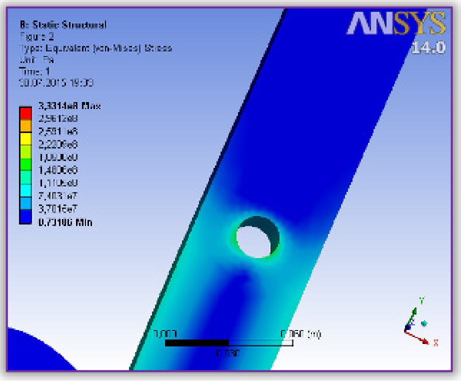

Figure 9 – Detail of the distribution of equivalent stress

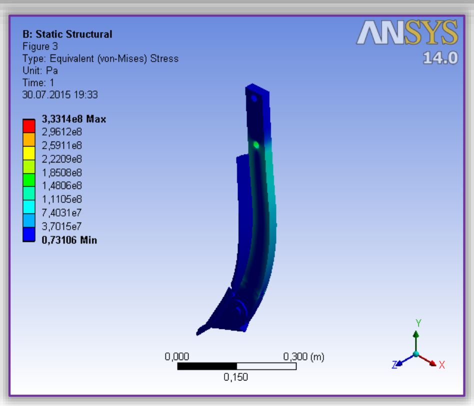

Figure 10 – Distribution of equivalent stress in the support of the working body

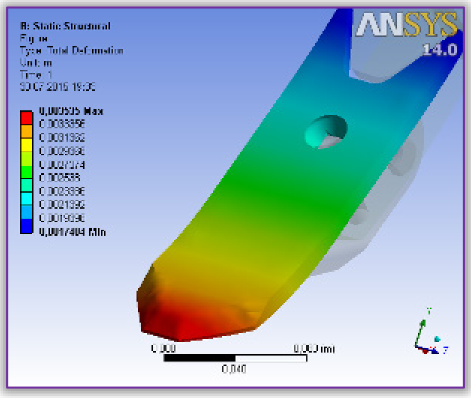

Figure 11 –Distribution of deformation on the coulter of the working body

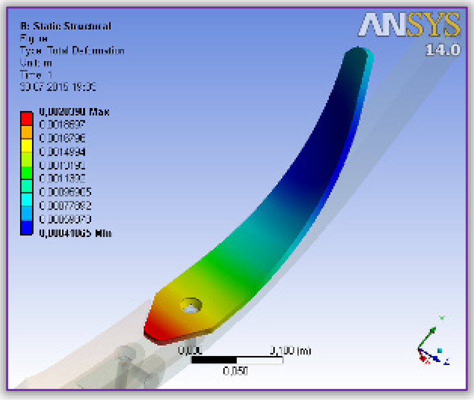

Figure 12 – Distribution of deformation on the working body wing

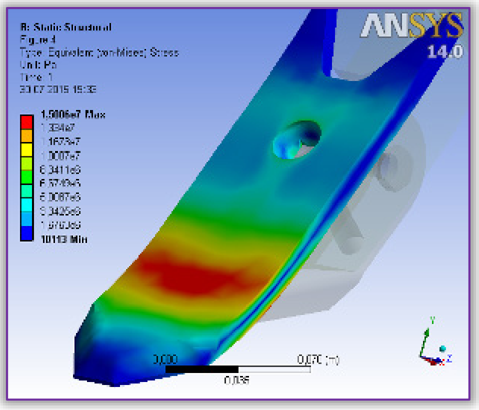

Figure 13 – Distribution of stress on the coulter of the working body

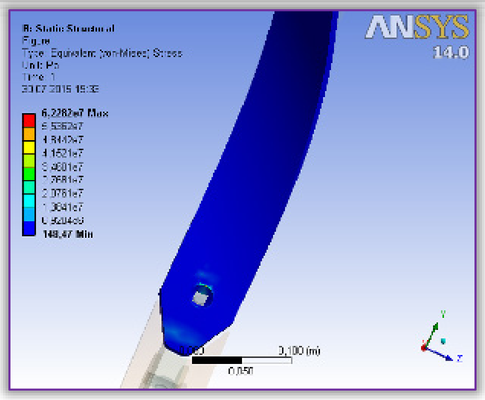

Figure 14 – Distribution of stress on the working body wing

CONCLUSIONS

» Theoretical structural static analysis of the working body can be used to determine deformations in plastic field;
» This analysis can be used as a tool for determining the mechanical strength and hence the reliability of the working;
» To obtain a conclusive result on the active organ deformation resistance, static structural analysis is completed with tests under real working: the stand - Hidropuls or in expoitation).

ACKNOWLEDGEMENTS

This work was supported by UEFISCDI based on 181/2014 financing program.

REFERENCES

[1.] Benites J. (2000) - Manual on integrated soil management and conservation practices The Challenge of Agricultural Sustainability for Asia and Europe, FAO Land and Water Bulletin, No. 8, pp. 1-4.
[2.] Bhatti M.A. (2003) - Finite Element Analysis. Theory and Applications, Zephyr Copier, Iowa State University;
[3.] BirişS.Şt. (2005) - Finite Element Method. Fundamental Concept, Publishing House PRINTECH, Bucharest;
[4.] Chen Y, Munkholm L.J., Nyord T. (2013) - A discrete element model for soil–sweep interaction in three different soils.Soil& Tillage Research 126, pp. 34–41;
[5.] De Miranda S., Ubertini F. (2002) - Recovery of consistent stresses for compatible finite elements, Computer Methods in Applied Mechanics and Engineering, vol. 191 (15–16), pp. 1595-1609;
[6.] Duarte C.A., Hamzeh O.N., Liszka T.J., Tworzydlo W.W. (2001) - A generalized finite element method for the simulation of three-dimensional dynamic crack propagation, Computer Methods in Applied Mechanics and Engineering, vol. 190 (15–17), pp. 2227-2262;
[7.] Javadi A., Hajiahmad A. (2006) - Effect of a New Combined Implement for Reducing Secondary Tillage Operation, Int. J. of Agr. & Biol., Vol. 8, No. 6, pp. 724-727;
[8.] Pisante M., Corsi S., Kassam A. (2010) - The Challengeof Agricultural Sustainability for Asia and Europe, Transist. Stud. Rev., Springer, Vol. 17, No. 4, pp. 662-667;
[9.] Plouffe, C., Richard M.J., Tessier S., Lague C. (1999) - Validations of mold board plow simulations with FEM on a clay soil, Transactions of the ASAE, vol. 42(6): 1523-1529;
[10.] Quaranta G. (2011) - Finite element analysis with uncertain probabilities, Computer Methods in Applied Mechanics and Engineering, vol. 200 (1–4), pp. 114-129;
[11.] Shmulevich I. (2010) - State of the art modeling of soil–tillage interaction using discrete element method, Soil & Tillage Research, vol. 111, pp. 41–53;
[12.] Tamas K., Jori J.I., Mouazen A.M. (2013) - Modelling soil–sweep interaction with discrete element method, Soil & Tillage Research, vol. 134, pp. 223–231.

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809