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RESEARCH REGARDING THE CONSTRUCTIVE OPTIMIZATION OF THE WORKING ELEMENTS OF DEEP SOIL LOOSENING EQUIPMENTS

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Abstract: *The operations of deep soil loosening without return of furrow have certain positive effects upon the improvement of the aeration conditions, penetrability, on the capacity of precipitations storage, development of roots system etc., but it is also a big energy consumer. In this paper, an optimization method of the working organs for deep soil loosening equipment to reduce the need for material used in their manufacture is presented. Improving the deep soil loosening equipment working elements will ensure the improvement of soil fertility and reduce the manufacturing costs of such equipments, making it accesible for the small and average farmers.*

Key words: *deep soil loosening, optimization, equipment.*

1. Introduction

The soil, is the loosened and fertile layer from the crust of the earth, it came into being and continues its development on the expense of the rocks and minerals, under the influence of natural factors and the more or less inspired activity of man [4].

The main property of the soil is fertility, its capacity to satisfy concomitantly and continuously the necessary of water and nutritious substances for the plants. From the viewpoint of the fertility level, the soils differ very much, but soil without fertility does not exist.

From the point of view of production, soil is therefore an unlimited means, which represents the vital condition for the existence and the perpetuation of human generations. Its production power can be increased continuously by means of a proper exploitation [1].

One of the soil operations having positive effects on fertility is the deep soil loosening, which has the main purpose of removing the negative effects of soil subsidence.

The efficiency of the sub-soiling work depends, among other things, on the depth of the operations. Therefore, at less than 40 cm in crop areas it is inefficient and at considerable depths it becomes expensive [2].

2. Material and Method

In this paper the experimental research object was a fixed working element with a width chisel cap type for deep soil loosening (Figure 1), made by INMA Bucharest. The

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working element is assembled with a supporting element cut out of slate rod with a thickness of 30 mm, on which a width chisel cap type through two screws M12x55 is set. The upper side of the chisel is loaded by means of welding with hard materials to offer a higher resistance to ageing and to obtain its self sharpening during its functioning.

This part was introduced in a finite element analysis program and studied in terms of the strains that occur in the respective material during the functioning process.

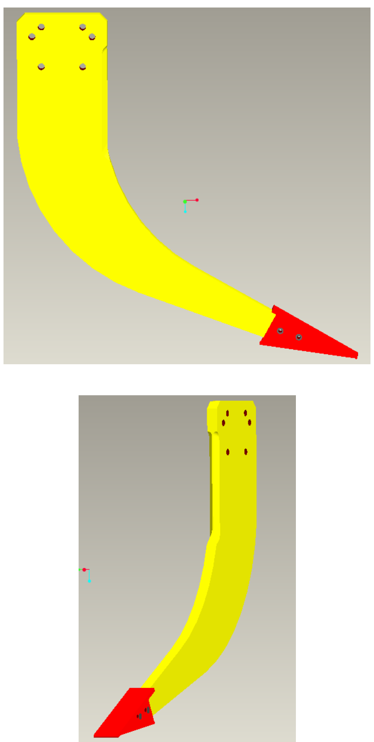

Fig. 1. *Fixed working element with a width chisel cap type for deep soil loosening*

For the analysis of the finite elements of deep soil loosening working element, specialized programs were used for each stage of problem solving as follows: for the 3D model drawing at real dimensions, the Pro Engineer Wildfire 2 programme was used; for the definition of stress conditions, the limitation conditions of the parts' material and for result interpretation - Patran 2008 R2 programme; for equation solving - Nastran 2008 R1 programme.

The structural model chosen for the deep soil loosening working element is presented in Figure 2. The structural model contains 13000 finite elements of tetrahedron type with 4 nods. The characteristics of the metallic material are: $E = 2.1 \cdot 10^5$ N/mm^2 (E -Young module), $\varphi = 0.3$ (φ - Poisson coefficient), $\rho = 7850$ kg/m^3 (ρ - the density of the metallic material) [3].

3. Results and Discussions

The natural load of such a working element is made taking into consideration the real stresses at which this parts are subjected in the soil and their interpretation for the equivalent model from the finite elements analysis. For the working element of a deep soil loosening equipment, the action on the surface of the soil was interpreted through a uniformly distributed force on its frontal surface (Figure 2).

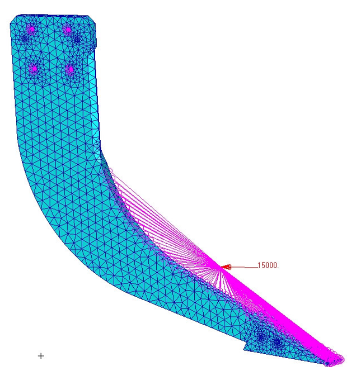

Fig. 2. *Structural modeling of the deep soil loosening working element*

In Figure 3 the model details, geometry, loads and limit conditions are presented (the model is static).

For the case in which the load is equivalent to the maximum traction resistance obtained in the field-laboratory experimental researches (15000 N) and this load is uniformly distributed on the frontal surface of the working element to the depth of 50 cm, the main results are: the equivalent strain (Von Mises) and the relative displacement resulted in the structure, are presented in Figures 4, 5 and 6.

It is noticed that the maximum value of the strain in the structure (the deep soil loosening working element), is located in the clamping holes area and it amounts to 41.4 MPa.

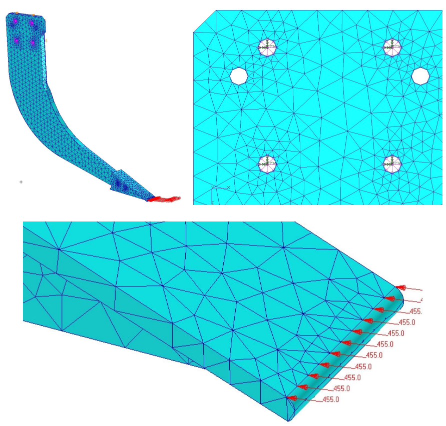

Fig. 3. *The model, geometry, loads and limits conditions* (*fixation*)

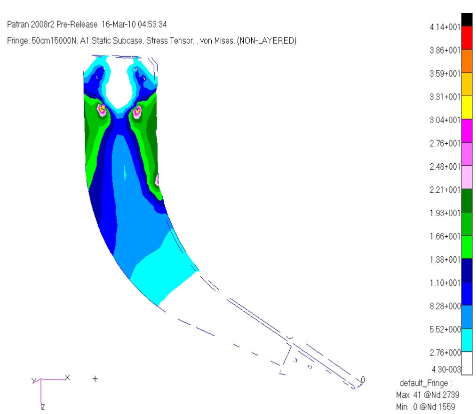

Fig. 4. *The equivalent strain* (*Von Mises*) *in the working element, for a uniformly distributed load of 15000 N*

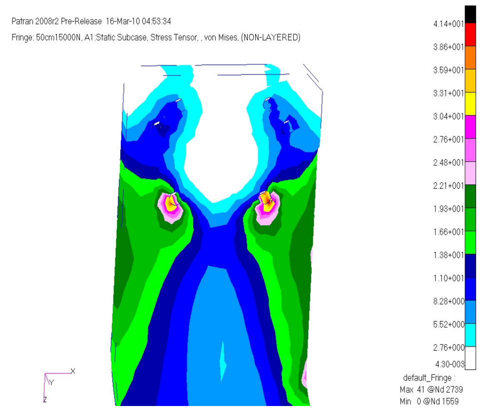

Fig. 5. *The equivalent strain* (*Von Mises*) *in the working element, for a uniformly distributed load of 15000 N - detail of the clamping area*

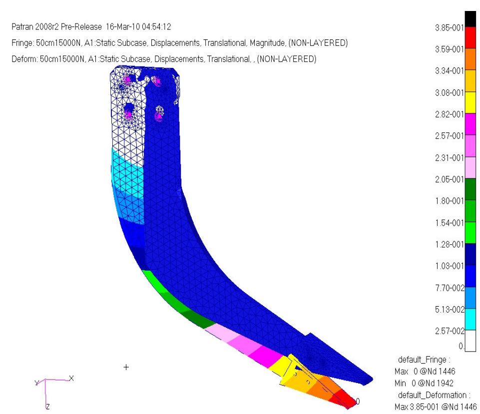

Fig. 6. *The relative displacement status resulted in the subsoiler working element, for a uniformly distributed load of 15000 N*

For the normal types of steel, this value does not lead to material breakdown.

The relative maximum displacement is noticed in the area that is the farthest from the clamping area, in the chisel and it has a value of 0.38 mm.

For the simulation of the maximum effort from this structure (the working element), namely the occurrence of an obstacle in the soil (for example a boulder) at the chisel level, the model is loaded with a force of 15000 N distributed only on the chisel tip (Figure 3). In this case, the equivalent strain (Von Mises) and the relative displacement status, in the structure, are presented in Figures 7 and 8.

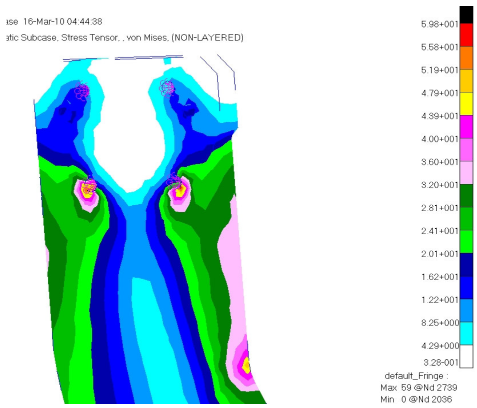

Fig. 7. *The equivalent strain* (*Von Mises*) *in the working element, for a uniformly distributed load on the chisel tip of 15000 N*

It is noticed that the maximum strain from the structure is found still in the clamping area, but its value is of 60 MPa. The maximum relative displacement is found at the top of the chisel and it has a value of 1.54 mm, and at the chisel support tip is of 1.23 mm.

For this type of support a theoretic calculus of the displacement throughout its length and at the tip was made. The maximum displacement has a value of 1.26 mm, while using the finite elements method the displacement was of 1.23 mm, the difference between these two calculations manners being of 2.4%, a value which confirms the modeling programme used in this research.

What results from Figure 7, where the analyzed model of the original working element is presented, is that for the most part of the support (excepting the clamping area), the equivalent strains have relatively reduced values, 3…32 MPa, which means that an excess of material is used and this is reflected in the acquisition price of the deep soil loosening equipment.

Taking this into consideration, the optimization of this working element through the thickness reduction of the support has been attempted.

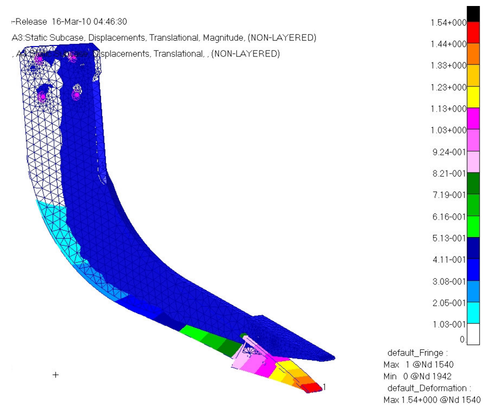

Fig. 8. *The relative displacement status resulted in the subsoiler working element, for a uniformly distributed load on the chisel tip of 15000 N*

Because the original model has a thickness of 30 mm, for the optimized model a thickness of 20 mm was chosen, thickness which is to be found in the Romanian standard of metal sheets (STAS 12187).

The equivalent strains for this model are presented in Figure 9.

In this case the equivalent strains in the structure have increased by 24% in relation to the initial model, whose support thickness was of 30 mm. To maintain the strains from the clamping holes at the level of the initial model the diameter of these holes it was increased to 20 mm.

By reducing the support thickness, the values of the equivalent strains are under the resistance limits of the steel used at its construction, but the problem of buckling occurrence is taken into consideration.

In this sense the original model and the model with the thickness of 20 mm have been verified at buckling loadings. The results of these models are presented in

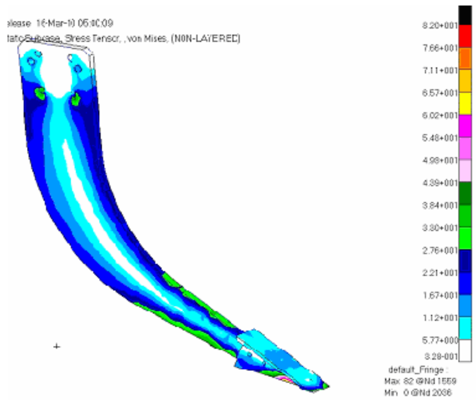

Fig. 9. *The equivalent strain* (*Von Mises*) *in the working element, for a uniformly distributed load on the chisel tip of 15000 N and the material thickness of 20 mm*

Figure 10 for the original model and in Figure 11 for the model with the thickness of 20 mm.

After modeling, for the original working element with a thickness of 30 mm, a buckling coefficient $C_f = 21.4$ was obtained and $C_f = 14.3$ for the working element with a thickness of 20 mm, which means that the support will start buckling at a loading which is 14 times greater than the force applied on the chisel tip (15000 N).

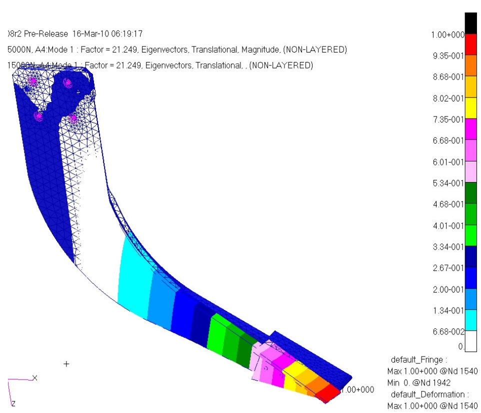

Fig. 10. *Results of buckling verification for the original model with a thickness of 30 mm for a uniformly distributed load on the chisel tip of 15000 N*

Considering the modeling results, the deep soil loosening working element with the thickness of 20 mm can be used in the same conditions as the one having a 30 mm thickness, and there is also a cost reduction for the materials used in the construction of deep soil loosening equipments.

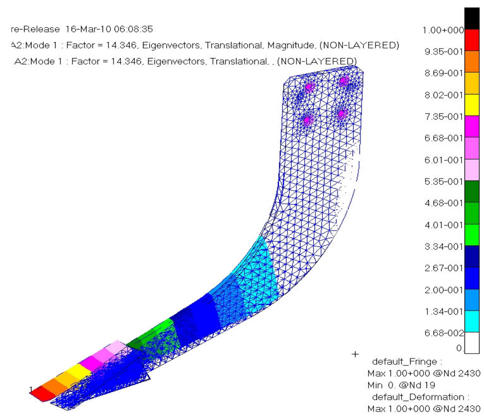

Fig. 11. *Results of buckling verification for the model with a thickness of 20 mm for a uniformly distributed load on the chisel tip of 15000 N*

4. Conclusions

- Through a thickness reduction of the working element support from 30 mm to 20 mm, the equivalent strains in the structure have increased by 24%. To maintain the strains from the clamping holes at the level of the original model, their diameter has been increased to 20 mm.
- Through decreasing the working element support thickness at 20 mm, the values of the equivalent strains are below the resistance limits of the material.
- Considering the obtained results, the deep soil loosening working element with a thickness of 20 mm can be used without problems in the same working conditions as the element having a thickness of 30 mm, thus obtaining an important decrease costs of deep soil loosening equipment.

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