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OPTIMIZING THE FORMS AND DIMENSIONS OF A FIELD CULTIVATOR WORKING KNIVES

Abstract: *The paper presents some considerations regarding the optimisation of working bodies of a field cultivator for soil preparation also known as combiner. Calculations in deformable body mechanics, thermal conduction, dynamic analysis, etc. lead to global systems of equations with many unknowns. The solution of these equation systems is dependent on the electronic computer, which have a great deal of efficiency compared to the matrix formulations of the problems*

Key words: *Field cultivator, Optimization of working bodies.*

1. INTRODUCTION

The objective of the proposed theme consists in the modelling of the working bodies followed by a behavioural simulation of them. This approach is attractive taking into consideration that is fast, cheap and enough accurate.

2. OPTIMIZATIONS OF THE KNIVES

2.1. Geometric modelling

The geometry, the dimensions, the place and size of the loads and the degrees of freedom shall be established and, where appropriate, the symmetry and /or stressing plans shall be highlighted to reduce the size of the and the calculus time of the problem solving.

We will deal with the design, construction and optimization of the soil working organs of the combinators.

For this purpose, two types of active organs were taken into consideration: reversible dagger and arrowhead with equal wings (see figure 1).

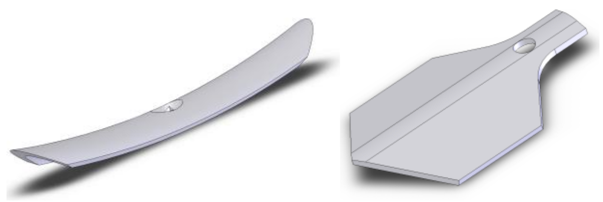

Fig. 1 Reversible chisel knife. Arrow knife with equal wings.

Both types are mounted on simple "S" shaped elastic supports, with work depths of 4-18 cm depending on the form of the stand.

The working depth is adjusted by means of adjusting devices to the combination wheels, but also by the proper use of elastic supports with a relative positioning angle of 44^0 (for depths of 100-180 mm) and 60^0 (for depths of 40 -120 mm)

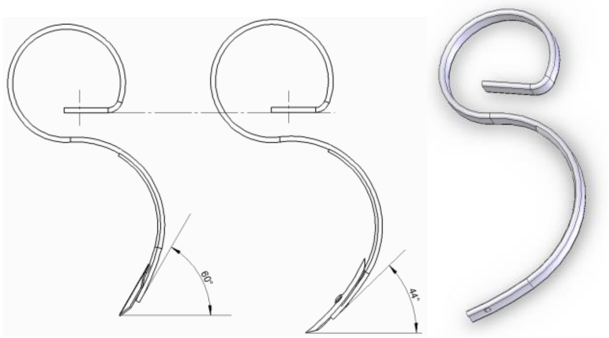

Fig. 2 Holders with knives at 60^0 şi 44^0. Elastic holder.

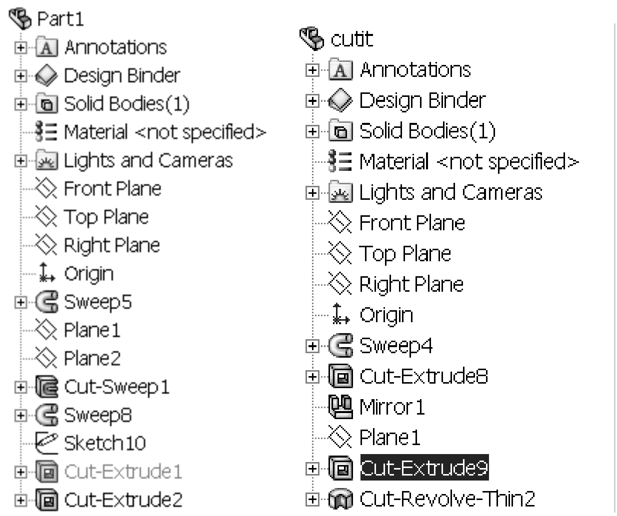

Fig. 3 The CSG tree of the holder and the knife.

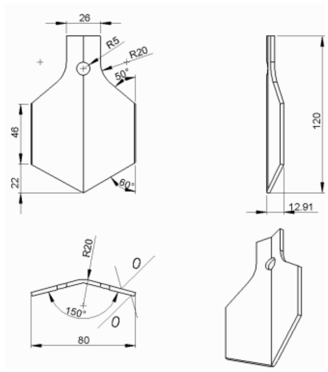

Fig. 4 Arrow shape knife.

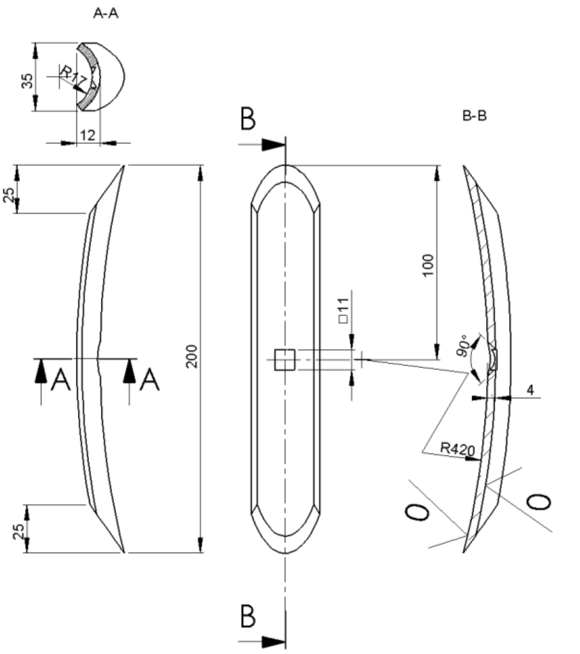

Fig. 5 Chisel shape knife.

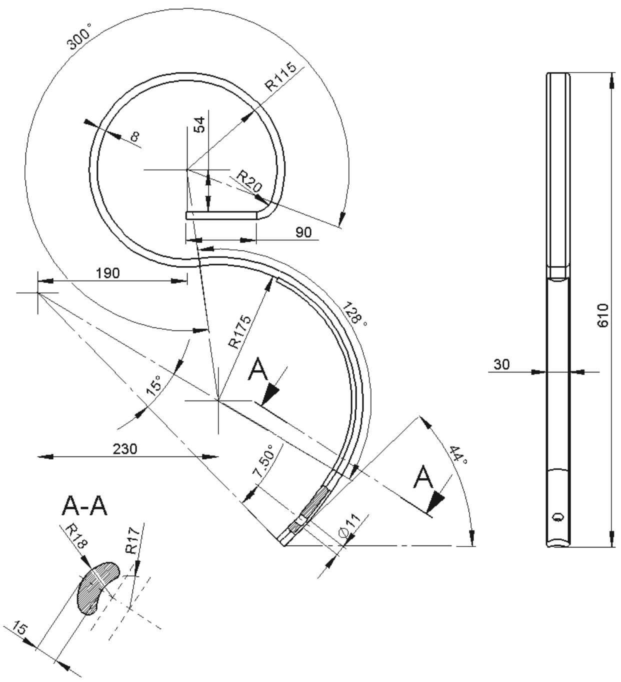

Fig. 6 The dimensioned drawing of the 44^0 holder.

2.2. The meshing

The meshing problem is a compromise: the more nodes the better is the approximation of reality, the more exponentially the processing time, which is prohibitive for most PCs.

In this case, an adaptive mesh with optimization of the matrix was used.

The elements used were of the solid brick type with curved edges requiring 3 refineries to fall within the 10% initial error limit.

When applying the network, the following defining parameters of the structure were automatically checked and corrected:

Table 1

Defining parameters of the mesh

Distortions	< 0,1 %	Deformation	< 0,2 %
Dead angles	< 90 ^{0}	Middle knot migration	< 50 %

The type of finite element to be used is determined, and a finite element structure is constructed, in which the number, density and finite element definition mode is set by the user.

More types of finite elements can be used for a single structure, in order to achieve the best approximation of the actual problem;

Following the meshing, 23936 elements with 35469 knots were obtained, with an average dimension of 1.303 mm for the elastic support knife assembly.

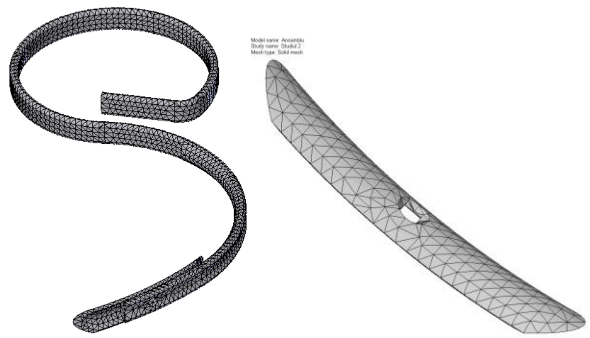

Fig. 7 Meshing of knife and knife support – assembly.

2.3. Specify loads and boundary conditions

Links are established through the annulment of the degrees of freedom of the nodes corresponding to these supports, and the supports are introduced. In this way, the user has the possibility to choose from various possible variants, solutions for specifying connections and loads.

The applied load is evenly distributed on the face that meets the ground and has the value of 1.0000.000 N / m2 (10 daN / cm2). It was considered, simplified, that the load should be oriented horizontally.

The contact between the two pieces was considered as rigid (no empty spaces and no penetration).

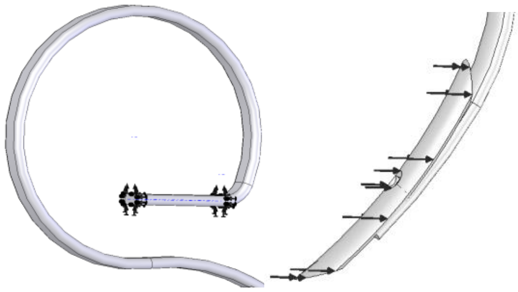

Fig. 8 Boundary conditions.

In fact, due to the loosening of the thread and the deformations, the stiffening is made almost only by means of the fastening screw and not by contact along the support as shown in Figures 9 and 10.

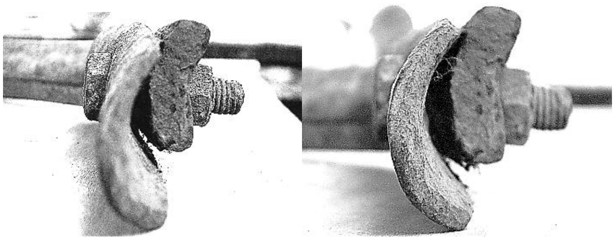

Fig. 9 Bad knife - holder contact/positioning.

Fig. 10 Good contact knife - holder.

2.4. Choice of materials and thermal treatments.

The supports are made of alloy steel sheet metal forgings for machine construction with good wear resistance: 65Mn10 SR-ISO 791-80, 4mm thick.

This steel has a tensile strength of at least 1000 N / mm2 and undergoes a heat treatment of low tempering and tempering to a hardness of 52-58HRC.

2.5. Data processing

Launching the execution program, launching, preceded by a check of the input data (usually, graphical checks are most effective). The volume of the results calculated by the finite element method is very high.

Primary results are the displacements of the structure nodes, implicitly the deformed structure at a certain scale. Based on these displacements, stress vectors are determined at the level of the nodes of the structure or at the level of the finite elements.

The results can be obtained in the form of lists of values of sizes of interest in graphic form. in a presentation with color spectra or izovalorice lines. in user-specified value sequences.

Deformations and strains, regardless of type, can be rendered at the level of the entire structure or only for certain isokriteria zones.

Thereafter, the main and / or tangential main stresses (if any) can be obtained, respectively the equivalent stresses following various tearing theories.

Analysis of the results of a model often leads to changes in the geometric construction and to the resumption of the calculation process. The optimal solution is obtained by repeated tests and calculations on a specified initial model.

As a rule, with the help of the finite element method, after post processing, the value and distribution of stresses in the critical areas are followed.

Also, considering the properties of the material, the value of deformations is followed, especially if this element has practical significance.

2.6. Von Mises equivalent stresses

It is noted that the support behaves well despite the relatively large load applied.

The stresses in the most demanding areas (colored red) do not exceed the flow limit, having a maximum value of 95.5 N / mm2.

The expansion of these high voltage areas is small located at the short radius connection of the support.

In the remainder of the work the tensions determined by the Von Mises plasticity criterion are kept in the range of 0 - 8 N / mm^2.

These low stresses indicate that the support is oversized, allowing optimization of the shape while preserving the mechanical characteristics

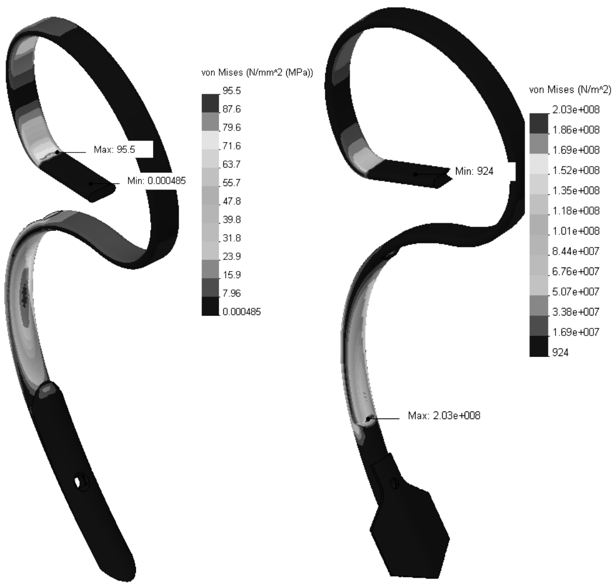

Fig. 11 The tensions of vonMises from the two variants.

2.7. Nodal displacements

From the below image showing the values of the nodal displacements in the support assembly. reversible chisel results, as expected, that the maximum displacements lie at the tip of the knife.

The maximum of these displacements is about 4 mm, not significantly affecting the working depth.

However, in order to keep the work organs in the nominal position and to keep the working depth constant, some manufacturers double the upper part of the stand, ensuring greater rigidity to the assembly.

This is unnecessary, because, anyway, the soil is uneven and the nodal movements do not exceed this unevenness, ensuring the permanent contact of the knife with the soil.

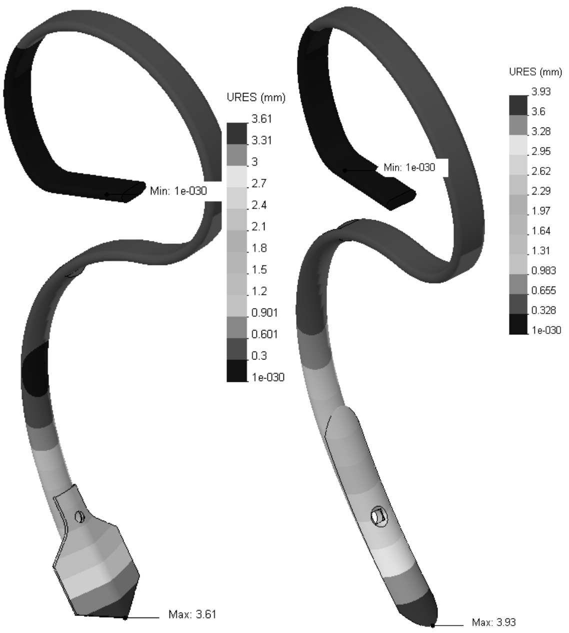

Fig. 12 The nodal displacements in both cases.

2.8. Safety factor

The safety factor evaluates each model node based on an evaluation criterion.
In this case, the flow limit of the material was taken as the following formula:

$$\frac{\sigma_{vonMises}}{\sigma_c} < 1 \qquad (1)$$

A safety factor (Factor Of Safety- FOS) subunit indicates that in that region the material begins to yield.

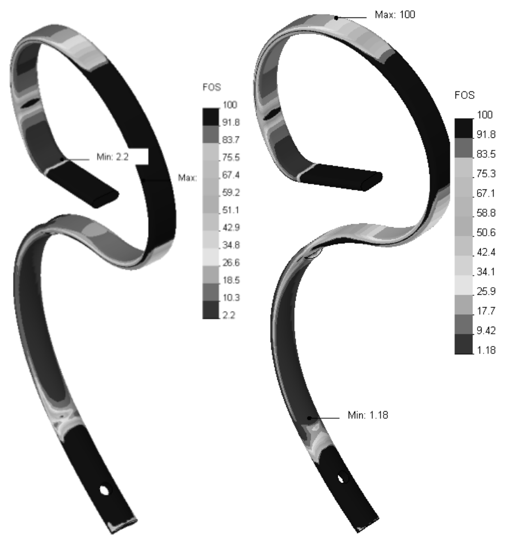

Fig. 13 Variation of the safety factor.

3. CONCLUSIONS

This analysis was aimed at highlighting the tensions and movements that occurred during the working process at the level of the active organs of the combiner.
For this they were modelled and analysed using the linear element linear finite element method. The results of the analysis highlighted the extreme stressing areas of the elastic support as those with short-range connection
The safety factor, taking the flow limit as a criterion, revealed areas where material savings can be made

Analyses performed on the combiner's knives have revealed many optimization possibilities such as reducing the mass of components, improving their performance, reducing fuel consumption per unit of hectare processed.

The results of the study were implemented and verified in practice at AGROMEC STAR Society in Bistrita.

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