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STUDY ON THE TENSION OF BLADES CUTTING EQUIPMENT PLANT STRAINS USING A FINITE ELEMENT METHOD

BY

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Abstract. This paper presents an application of finite element method to study the tensions arising from vindrovers knife blade during cutting. On the blade was done construction discretized model, on which were set boundary conditions and loading with a cutting force obtained in practice.

The result analysis revealed distribution efforts blade, total strain and effort equivalent unit.

Key words: vindrovers, finite elements, stress, equivalent stress.

1. Introduction

Finite element method is currently the most widespread method of numerical solution in engineering problems (Zienkiewicz, 2005). The method was originally developed for solving problems of elasticity and strength of materials, afterwards being extended to a wide range physics and engineering (Chiorean, 2006).

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Due to the efficiency, at the moment numerical simulation experiment aims to replace the simple cases up to simulating the most complex attempts such as nuclear explosions (Faur & Dumitru, 1997).

Theoretical basis of solving problems by finite element method is represented by domain discretization analyzed in a finite number of subdomains, called finite elements. Field splitting in finite element analysis must be done so as to be completely covered and no overlap should exist. The finite elements unknown function is approximated by polynomial functions, so that there is equality between values and the unknown function approximation, in a number of internal points of the border area, called nodes, representing the points of intersection of lines forming interpolation network or in some particular position, other border points respectively inside the finite element (Maksay & Bistrian, 2008).

Tensile and strain simulations that arise in cutting blades of machines with reciprocating movement, allows the analysis of the loading and thus, can improve the quality of knife design and cutting process.

2. Material and Research Method

For this study we used a razor knife from machines which fit the vindrovers used to harvest green fodder, for which the construction scheme is shown in Fig. 1. The blade edge is smooth with tilting angle of 30º and sharpening angle of 20º. The strain of a lucerne was cut after flowering with a diameter of 3.56 mm, between nodes, the position of the strain plane strain being vertical with respect to the blade plane, resulting a force of 99.83 N.

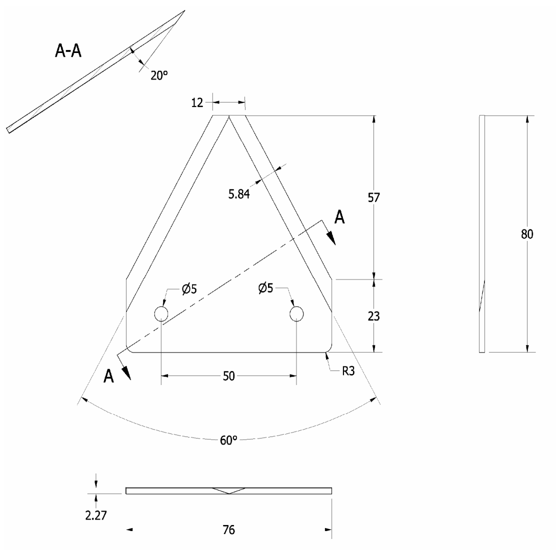

Fig. 1 − The constructive form of blade from vindrovers.

In applying the finite element analysis were following steps: splitting field of finite element analysis, establishment of finite element equations (equations elemental), assembly of the elemental equations in the system of equations of the structure, implementation of boundary conditions and solving the equation system of the structure, making the additional calculations for determining the secondary unknowns.

Material or environmental behavior across a finite element is described by equations called finite elements and elemental equations. These make up a system of equations of the item. Elemental equations can be deducted directly by variational way, method of the waste or residues (Galerkin) or energy balance method.

To simulate the stress and deformation, a finite element analysis program called COSMOS WORKS was used, included as a module in SOLID WORKS. Razor blades are considered to be fixed on holes surfaces for fixing bolts. With the help of the software, the discretized solid model of the blade was created, boundary conditions were applied, the properties of the material were defined and the cutting force was designated.

After analyzing, results were obtained on the deformations, stresses and reactions of the three coordinate axes, tension on three planes, the total strain and equivalent stress.

3. Experimental Results

After entering all the data and running the application, we obtained a series of diagrams of distribution of strains and tensions that arise in the knife blade and are presented in Figs. 2,…,9.

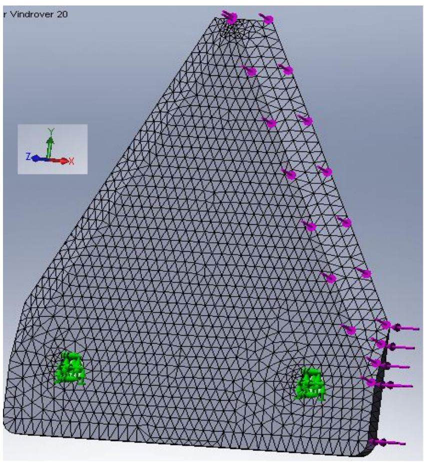

Fig. 2 − The discretized blade.

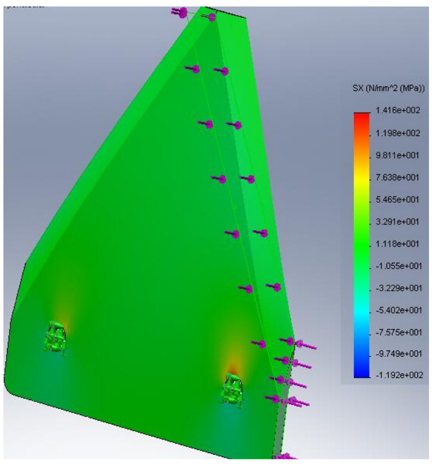

Fig. 3 − Stress distribution σ_x.

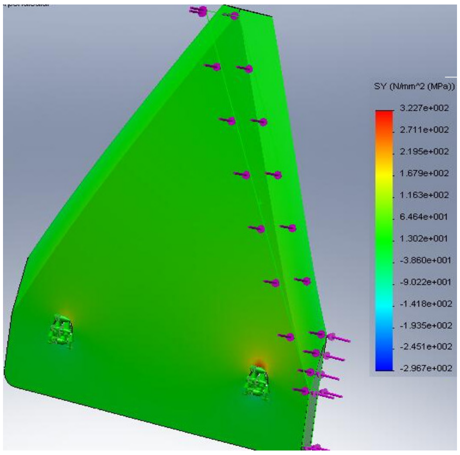

Fig. 4 – Stress distribution σ_y.

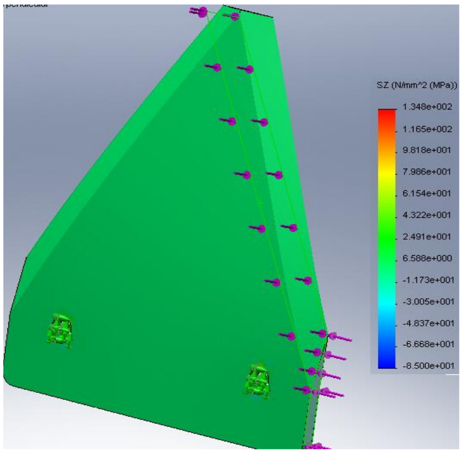

Fig. 5 – Stress distribution σ_z.

After creating the solid model, the finite element mesh in the blade was obtained.

With the cutting force, the uniform distribution of unit stress σ was obtained on the three axes, x (Fig. 3), y (Fig. 4) and z (Fig. 5).

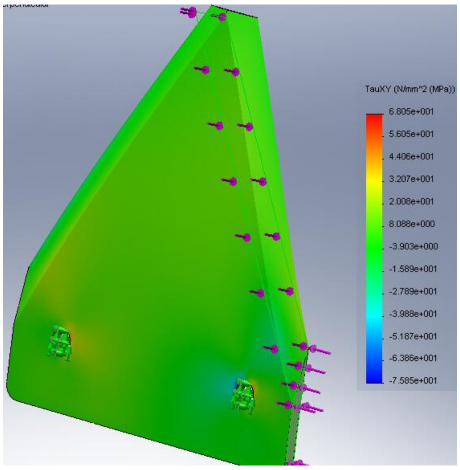

Fig. 6 – Stress distribution τ_{xy}.

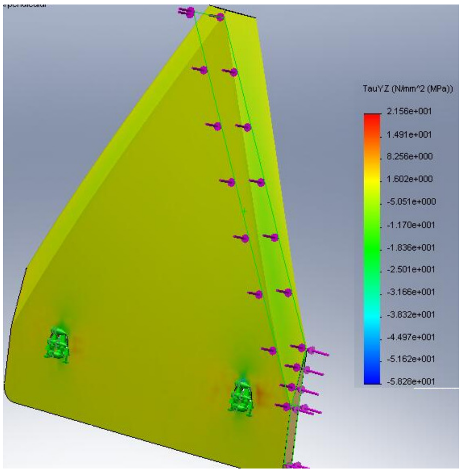

Fig. 7 – Stress distribution τ_{yz}.

The same software enabled us to obtain τ stress on plane xy (Fig. 6), xz and yz (Fig. 7), total deformation of the blade (Fig. 8) and equivalent stress (σ_{ech}) von Mises (Fig. 9).

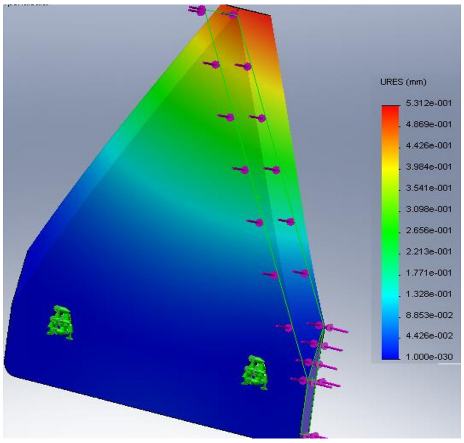

Fig. 8 – Total deformation of the blade.

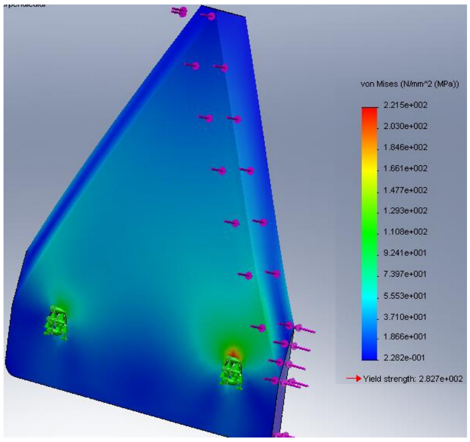

Fig. 9 – Equivalent stress (σ_{ech}) von Mises.

We can observe that the maximum deflection is recorded at the tip of the blade, has low values and the tensions do not exceed the admissible limit.

The program can be used for other values of cutting force, depending on crop type, and further on will be viewed stress and strain state of the blade for each case.

4. Conclusions

Finite element method allows the study of strains and tensions that arise in cutting machines blades used in forage harvesting.

Using FEM, it has been observed that efforts mainly focus on fixing holes of the blade on the support bar, while the blades strains are minor.

Using finite element analysis, an optimization of the constructed shape of the blade can be done, depending on the angle of sharpening, cutting edge angle, blade thickness, material used in its execution, or covering the active surface with wear resistant materials, etc.

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STUDIUL TENSIUNILOR DIN LAMELE CUŢIT DE LA APARATELE DE TĂIERE A TULPINILOR VEGETALE FOLOSIND METODA ELEMENTELOR FINITE

(Rezumat)

Lucrarea prezintă o aplicaţie a metodei cu elemente finite pentru studiul tensiunilor care iau naştere în lamele tăietoare de la vindrovere (secerători), ce au în construcţia lor aparate de tăiere de tip cuţit-deget. Pe baza construcţiei lamei tăietoare s-a realizat un model solid, apoi modelul discretizat şi cu ajutorul programului COSMOS WORKS s-au pus condiţiile limită şi constrângerile asupra modelului finit.

După aplicarea unei forţe de tăiere, obţinută practic prin tăierea unei tulpini de lucernă în momentul optim de recoltare, s-a rulat programul pe calculator şi au fost obţinute distribuţia deformaţiilor după cele trei axe de coordonate, a eforturilor unitare după axe şi plane de referinţă şi a efortului echivalent von Mises, distribuţii pe marginea cărora se pot trage unele concluzii.

Metoda permite ulterior o analiză a distribuţiei tensiunilor din lamele de cuţit din construcţia oricărui tip de maşină de recoltat, prin modificarea parametrilor constructivi ai lamei, până la obţinerea unei variante optime.