UTILIZAREA UNEI METODE INOVATIVE PENTRU ANALIZA STRUCTURALĂ A APARATULUI DE DISTRIBUTIE UTILIZAT LA MAŞINILE PNEUMATICE DE SEMĂNAT PLANTE PRĂŞITOARE / USE OF AN INNOVATIVE METHOD FOR STRUCTURAL ANALYSIS OF THE DISTRIBUTION DEVICE USED IN PNEUMATIC MACHINES FOR WEEDING PLANT SOWING

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Keywords: structural analysis, distribution device, weeding plant sowing

ABSTRACT

The topic addressed is a computer-aided design (CAD) method combined with computer-aided engineering (CAE) used in the analysis of choosing the optimal constructive variant of the distribution device used in pneumatic machines for weeding plant sowing. The CAD configurations, realized by the 3D parametric modeling using the SolidWorks program, were subjected to structural analysis (von Mises equivalent stress distribution, relative displacement field distribution and safety factor). Based on the resulting data, the mass/resistance coefficient for the 3 analyzed configurations were determined. The comparison of these indicators led to the choice of the optimal constructive variant, namely the most efficient one.

INTRODUCTION

At present, the engineering in the field of agriculture mechanization is so specialized, and the products so complex that more and more often the designers of agricultural technical equipment resort to some of the numerical methods used in the structural analysis, which are numerical approximation schemes, to facilitate the approximate solving of mathematical physics systems of equations for modeling the phenomena and processes that form the subject of structural analysis. The main methods used are: Runge - Kutta methods, finite difference schemes, finite element method, border element method.

Developments in power series or in trigonometric or other series (orthogonal function series) are widely used techniques, located somewhere between the analytical and numerical methods [2].

Computer-aided Design (CAD) defines those tools, applications, computer programs that can assist engineers, architects, geodesists in their design activity. Initially, these applications were created as a drawing tool with the computer, a tool intended to replace the drawing board. After that, the programs were developed to ease not only drawing, but also the entire design activity. Initially, these programs allowed only two-dimensional (2D) drawing, but at present, virtualization (computer representation) of a real object can be created, as well as spatial visualization (in 3D) of an assembly on a computer monitor [4]. Computer-aided engineering (CAE) is the use of computer software to simulate performance, improve product design, or help solve engineering problems for a wide range of industries. This includes the simulation, validation and optimization of products, processes and manufacturing tools [5].

For example, there is research conducted to use CAD / CAM / CAE / CIM / CAL (C5) technologies to identify performance criteria in the shipbuilding industry, which is a customised production process with a design that is traditionally difficult to manage [3]. Another example of the use of computer-aided engineering (CAE) is in numerical analysis of structural models for both microstructures and macrostructures in the field of technical equipment for agricultural mechanization [1].

The advantages of using CAD-CAE are:

- projects can be evaluated and improved prior to physical testing;
- provides performance prior to the manufacturing process;
- helps design teams manage risks and understand the implications for design performance. [6].

MATERIAL AND METHODS

Theoretical researches were carried out by 3D parametric modeling, in SolidWorks 2013 program, of the shaft driving the seed distribution disc of the distribution device used in pneumatic machines for weeding plant sowing designed within the project supported by a grant of the Romanian Research and Innovation Ministry, through Programme 1 – Development of the national research-development system, subprogramme 1.2 – Institutional performance – Projects for financing excellence in RDI, contract no. 16PFE.

Figure 2.1 shows the 3D geometric model of the distribution device used in pneumatic machines for weeding plant sowing, designed using the SolidWorks 2013 program, which was made by assembling previously defined parts, a method called *bottom-up* design. First, the 3D geometric model was made for each component, after which they were assembled using the *Assemblies* module. The SolidWorks 2013 program allowed both to assembly the components of the distribution device and to explode them, that is to detach each component in order to suggest the assembly.

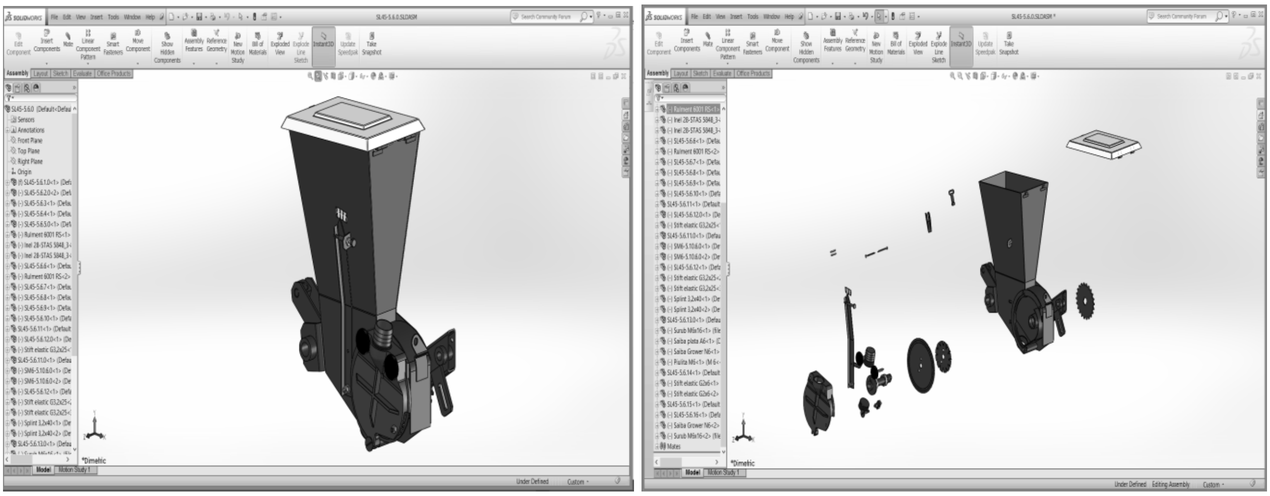

Figure 2.1 - 3D geometric model of the distribution device used in pneumatic machines for weeding plant sowing

RESEARCH RESULTS

After the stage of shaping the drive shaft configurations which is the main component part of the distribution device used in pneumatic machines for weeding plant sowing, we passed to the structural analysis stage with the help of the structural simulation application SOLIDWORKS SIMULATION 2013, which involved importing the geometry of the model created using the computer-aided engineering application (SolidWorks 2013), defining the material, defining the restrictions appropriate to meshes, running the program to calculate the Von Mises stress analysis, displacement, relative elongation, safety factor and visualizing the results in the form of diagrams.

Structural analysis using the CAD-CAE method involved the following operations:

- ❖ selecting option static as analysis type, solid for mesh type and FFEPlus solver (fig. 3.1);
- ❖ selecting materials from the SolidWorks 2013 library and automatically assigning these properties to each component part (as shown in Table 1);
- ❖ applying the appropriate stress. In accordance with the actual operating mode (during exploitation) of the drive shaft, the simulation scenario was adapted accordingly. The stress was applied in the points corresponding to the operating mode shown in figure 3.2;

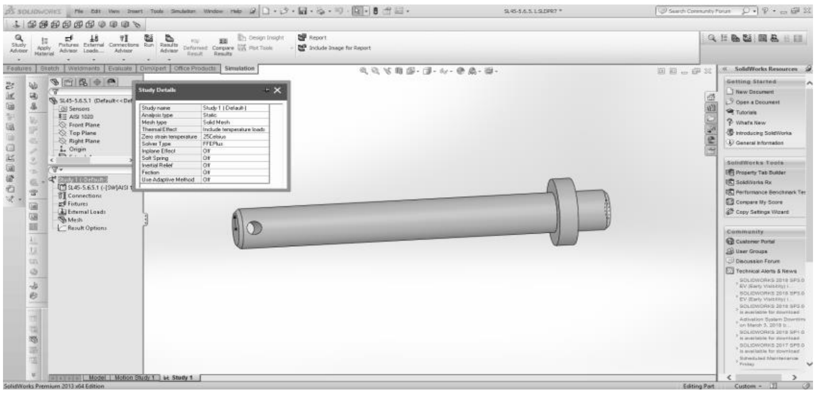

Figure 3.1 Option static as analysis type,
solid for mesh type and FFEPlus solver

Properties of selected materials

Table 1

Material	Yield strength (σ_c) (N/mm^2)	Traction limit (σ_r) (N/mm^2)	Poisson's ratio	Traction / compression elastic modulus (E) (N/mm^2)	Traction / shear elastic modulus (G) (N/mm^2)
M1: S235JR	235	360	0,28	210000	79000
M2: E335	275	550	0,28	210000	79000
M3: C45	580	750	0,28	210000	79000

- applying the appropriate stress. In accordance with the actual operating mode (during exploitation) of the drive shaft, the simulation scenario was adapted accordingly. The stress was applied in the points corresponding to the operating mode shown in figure 3.2;
- using the *meshing procedure*, to decompose the model into discrete elements (fig. 3.3). In general, a finite element model is defined by a network, which is completely realized from a geometric arrangement of elements and knots. Knots represent points, where features are calculated, such as displacements;

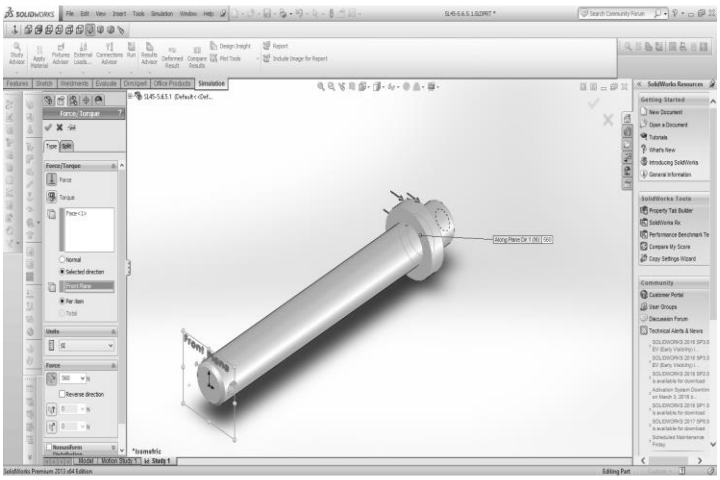

Figure 3.2 - Application of the stress corresponding to the resultant force

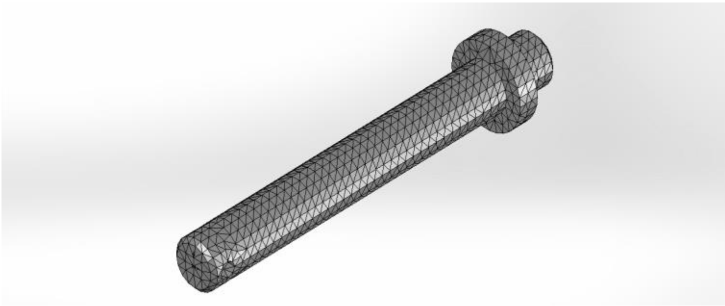

Figure 3.3 - 3D model discretized in a finite element network

- running the analysis study to calculate the strain, safety factor and displacement, which is based on geometry, material, stress, restriction types and meshing type. After running the analysis studies, the results can be visualized for comparison (fig. 3.4)

The results of the analysis based on technical-economic criteria in choosing the metal material from which the drive shaft is manufactured are presented in table 2.

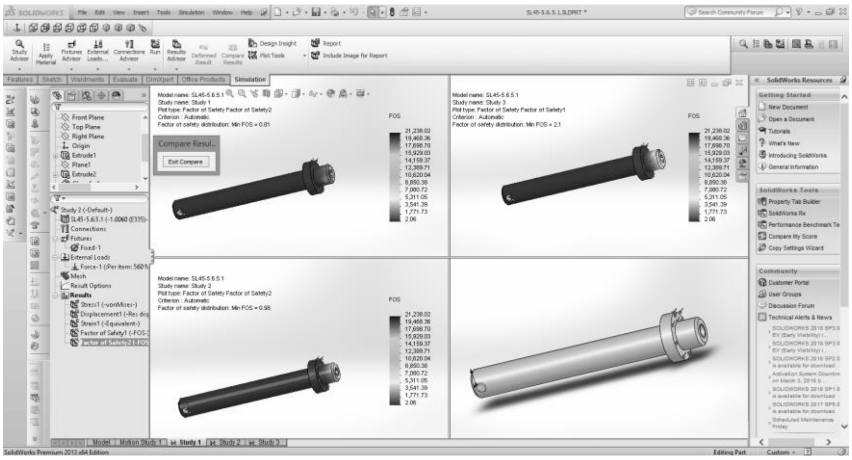

Fig. 3.4 - Sequence during the comparison of the studies and the results that appear on the screen in the form of the safety factor

Results of the analysis based on technical-economic criteria

Table 2

Name	Unit of measurement	Value		
		Material 1 S235JR	**Material 2 E335**	**Material 2 C45**
Safety factor	-	0.81	0.98	2.1
Mass	kg	0.9	0.9	0.9
Ratio: mass / safety factor	-	1.1	0.91	0.42

Comparison of these indicators led to the choice of the optimum variant (material C45 with the lowest mass/safety factor ratio: 0.42 was chosen).

CONCLUSIONS

The technical-economic indicator (material consumption per safety factor unit) proposed by the authors for analyzing the choice of the optimum variant, which is represented by the mass/safety factor ratio, contributes to reducing the design validation time.

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ACKNOWLEDGEMENTS

This work was supported by a grant of the Romanian Research and Innovation Ministry, through Programme 1 – Development of the national research-development system, subprogramme 1.2 – Institutional performance – Projects for financing excellence in RDI, contract no. 16PFE.