FEM STRUCTURAL ANALYSIS OF A SHAPING CUTTER USING CATIA

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Abstract: *With the aid of the finite element analysis method, problems can be studied, the complexity of which is given by the complicated geometric configuration of the bodies, the material inhomogeneities, the anisotropy of the materials, the composite materials, etc. These problems occur frequently in practice at the various stages of development of a product, even when a product already exists, but the problem of improving its characteristics is raised.*

Key words: CATIA, shaping cutter, processing, forces.

1. Introduction

CATIA (Computer Aided Three Dimensional Interactive Applications) is a product of Dassault Systemes, one of the most advanced integrated CAD/CAM/CAE platforms based on the latest technologies in the informatic industry [1], [2], [3].

From a constructional point of view, the shaping cutters are similar to lathe ones. They are provided with a single blade and one or two secondary edges whose behavior to the action of the phenomena specific to the shaping process is specific to all metal processing tools. The shaping cutters are made entirely of high-speed steel,high-speed steel carbide tipped or sintered metal carbide tipped [4].

The construction of the cutting tools is also determined by the particularities of the roughing cut process by means of shaping, namely: contact of the active cutting edge with the chipped material; bending stress on the cutter body; repeating the transient process; the presence of the withdrawing stroke; large inertia forces. There are several types of shaping cutters; In this paper two types will be analyzed; right (figure 1, a) and bent (figure 1, b)

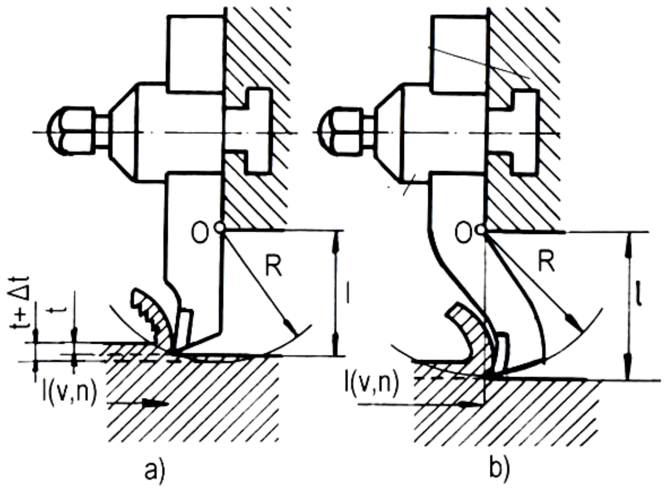


Fig.1 Shaping cutter
a- right; b- bent

2. Molding of the piece

In this stage, a right shaping cutter and a bent shaping cutter with the same construction geometry are considered [4]:

- attack angle $\chi = 45^{o}$;
- seat angle $\alpha = 6^{o}$- 14^{o};
- the angle of clearance $\gamma = 10^{o}$- 15^{o}.

The 3D modeling of the two cutters to be analyzed with the finite element is shown in Figures 2 and 3 [1], [2], [3].

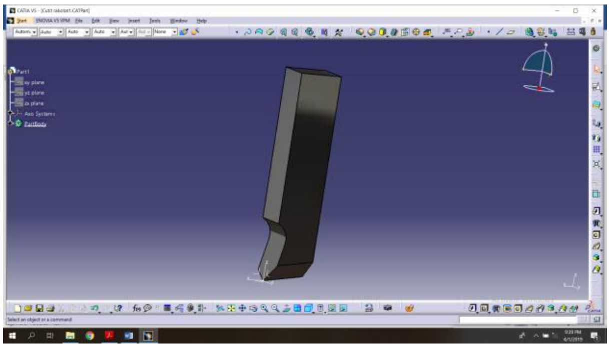


Fig. 2 Right shaping cutter

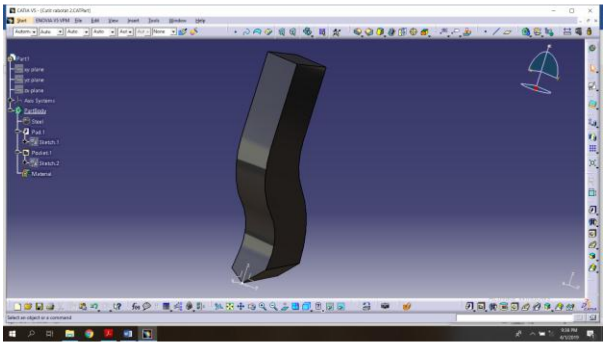


Fig. 3 Bent Shaping cutter

Shaping is a machining process used for the roughing and / or semi-machining of large horizontal or vertical planar or profiled surfaces situated on the outside of the prismatic pieces. Semi-finished products with large and non-uniform machining processes, semi-finished products obtained by casting, forging or flame cutting are processed through shaping. The method of clamping the shaping cutter for machining and processing itself is exemplified in Figures 4 and 5.

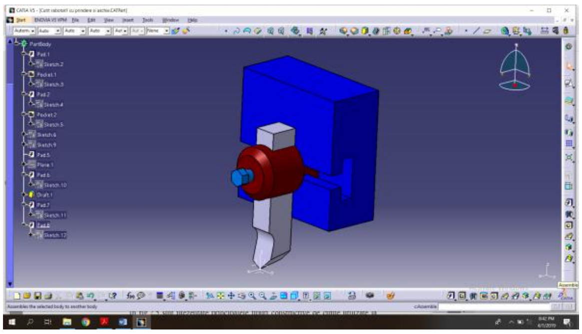


Fig. 4 Clamping of the shaping cutter

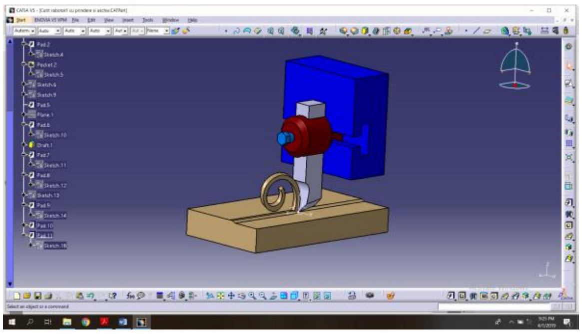


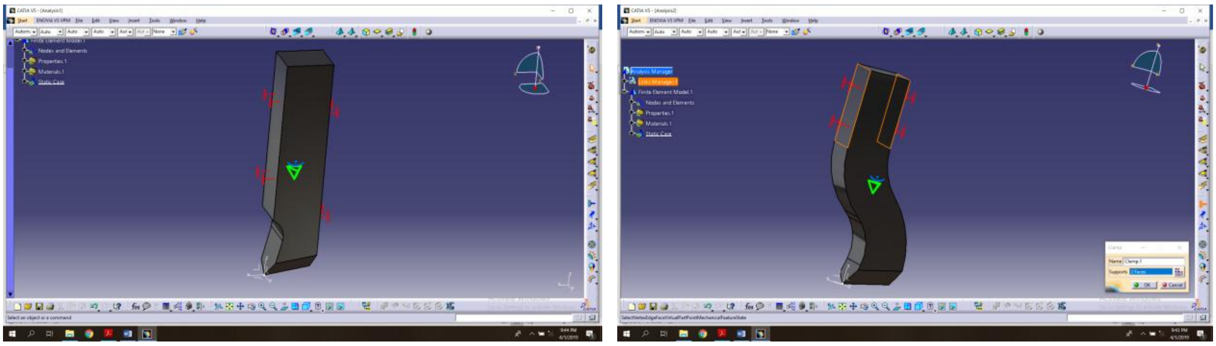
Fig. 5 Processing with the shaping cutter

3. Analiza FEM

After solid modelling in the CATIA Part Design module, the piece is considered to be made of a material (steel) having the following physical and mechanical properties, important during analysis: Young's module ($2x10^{11}$N/mm^{2}), Poisson's coefficient (0.266) , density (7860 kg/m^{3}), coefficient of thermal expansion ($1,17x10^{-5}$ ^{o}K), permissible strength ($2,5x10^{8}$ N/m^{2}).

The CATIA Generative Structural Analysis module is accessed from the Start - Analysis & Simulation menu and the Static Case type is determined , the specification shaft simultaneously displaying the element bearing the same name . Although the CATIA program defines the network of nodes and elements(discretization), it is recommended to edit this and determine the size of the finite element, the maximum tolerance between the discretized model and the real model used in the analysis (Absolute sag), the type of element (Element type), and so on [5].

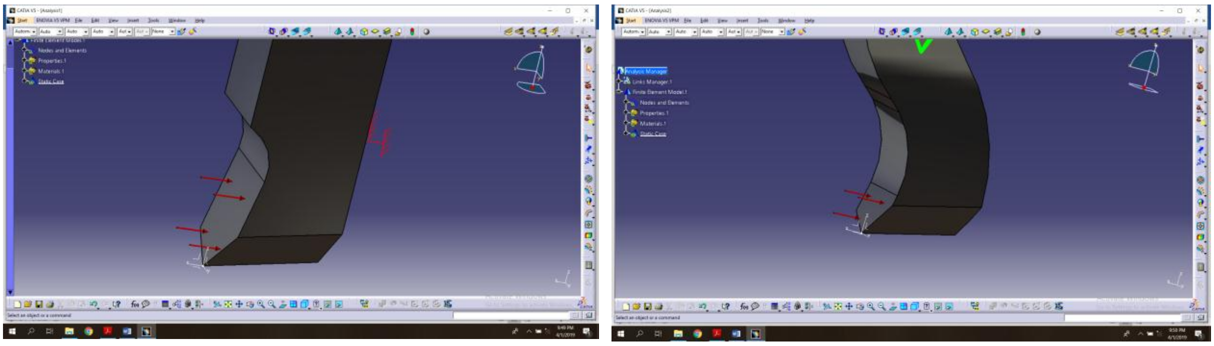
Next, a Clamp-type restriction (Figure 6a for the right shaping cutter and Figure 6b for the bent shaping cutter) is applied to the clamping surfaces[1], [2], [3].



a b

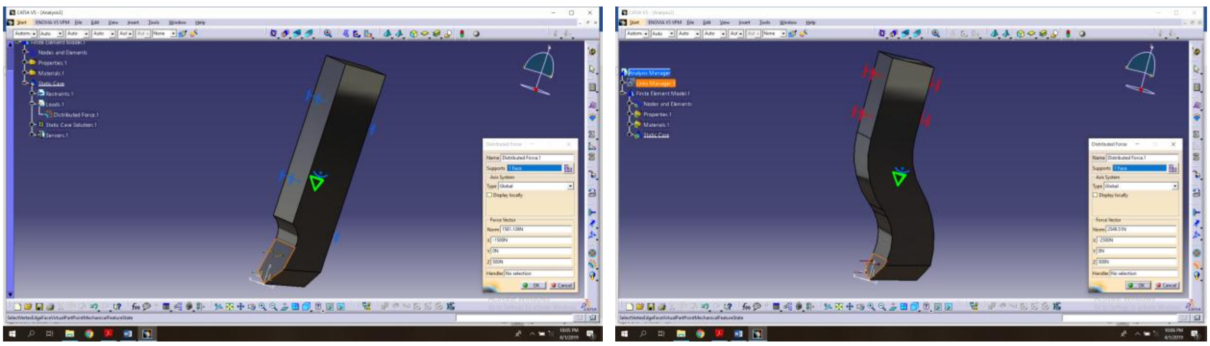
Fig. 6. Applying the supports: straight shaping cutter; b – bent shaping cutter

The cutting forces resulting from the machining process (Figure 7 a, b) with the F_{as} = 1581,139 N in the case of the right shaping blade (Figure 8a) and F_{as} = 2549,51 N in the case of the right shaping knife (Figure 8b). As a result, the Distributed Force 1 element becomes available in the specification tree, the force being specified by the arrows on the surface.



a b

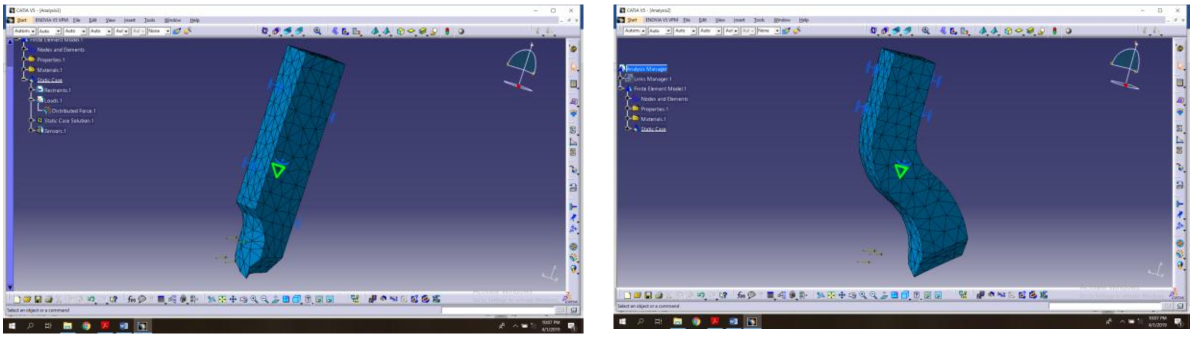
Fig.7. Applying the cutting forces: a straight shaping cutter; b – bent shaping cutter



a b

Fig. 8 Values of applied forces: knife-sharpened straight; b - chopping knife

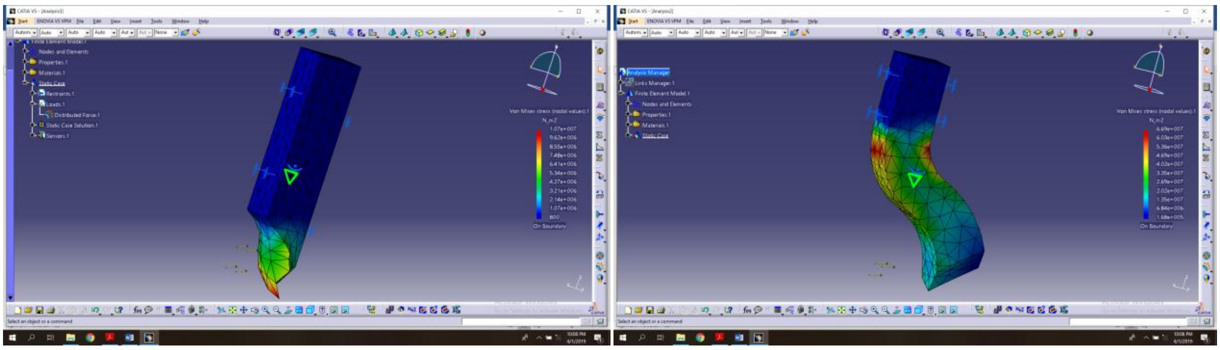
Once the restrictions and loading have been established, the actual step of the calculation (analysis) follows. By clicking the Compute icon on the toolbar All option is selected , the first effect of the action being to update the Static Case Solution (figura 9 a,b) [1], [2], [3], [5].



a b

Fig. 9 Optimization of the analysis process: straight shaping cutter; b – bent shaping cutter

Once the calculation is complete, the user has the Image bar tools available to view the results. The specifications tree is completed according to the inserted images. Figure 10 a,b shows the image (using Von Mises Stress, Deformation, Principal Stress and Precision) corresponding to the calculation of the piece model and load considered, specifying that the deformations are graphically presented slightly overstated in order to ease the stage of determining the conclusions of the analysis.



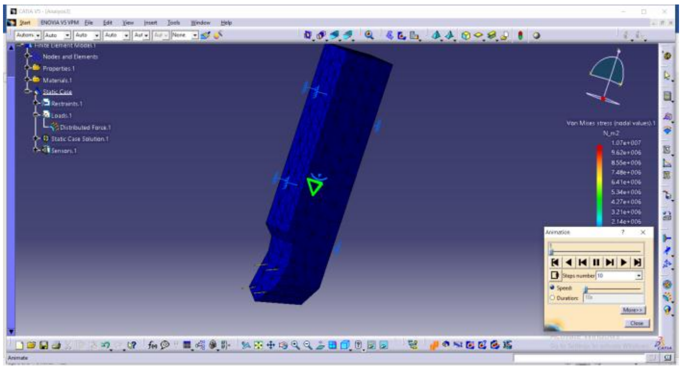
a b

Fig. 10 Deformed piece: straight shaping cutter; b – bent shaping cutter

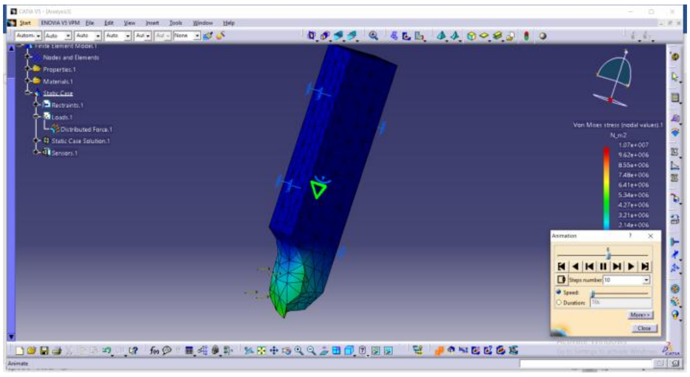
In this window is also presented the color palette accompanying the result - Von Mises image. The lowest values of the stresses are at the bottom of the palette and the maximum at the top of the palette. The dialog box also contains explicit values in the Extreme Values area. The blue and light blue colors indicate low stresses, and the yellow to red colors indicate high ones.

Considering that the admissible material strength is 2.5 x 10^8 N/ m^2, it can be concluded that the piece model will withstand the applied forces.

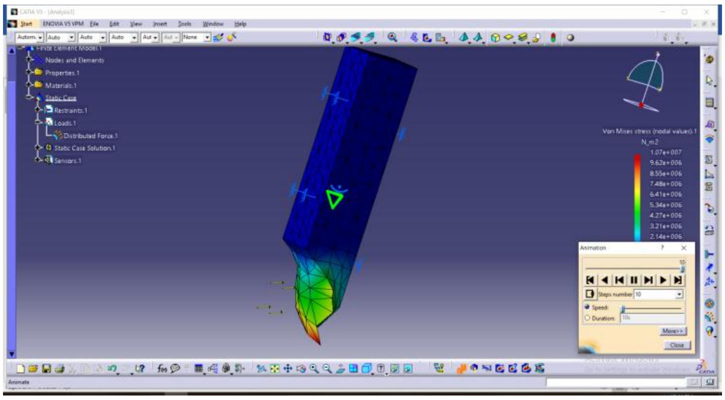
By means of an animation command, the deformations of the two cutters can be viewed clearly, in Figures 11 a, b, c and 12 a, b, c being presented the starting, middle and final moments of the deformations.



a

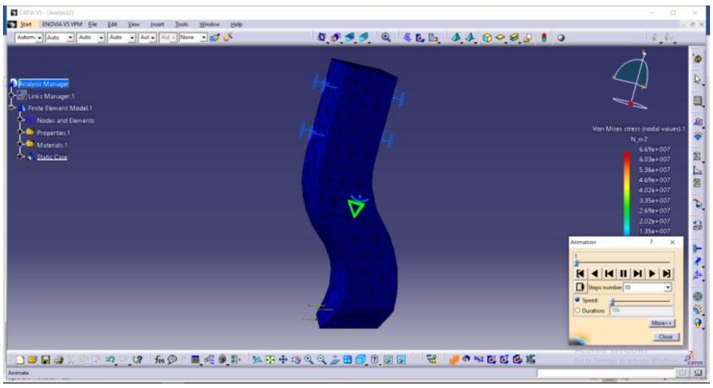


b

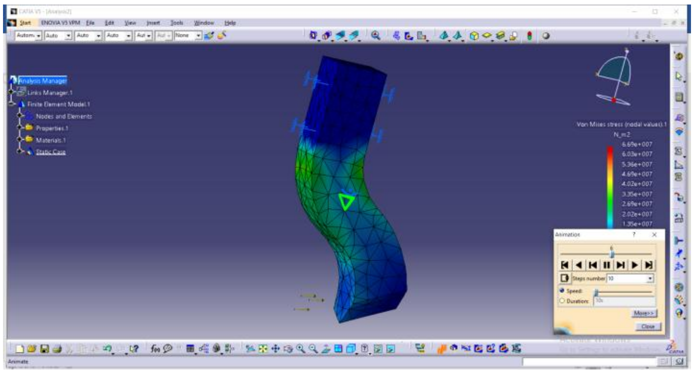


c

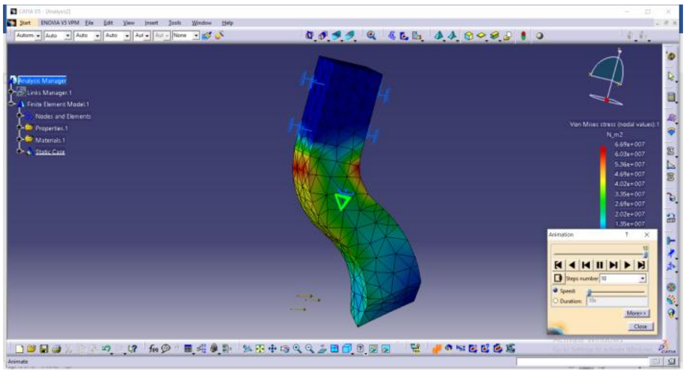
Fig. 11 Steps of deformation of the straight shaping cutter



a



b



c

Fig. 12 Stages of deformation of bent shaping cutter

4.Conclusions

Finite element analysis using the CATIA program is a modern method for studying different contacts, allowing the determination of important parameters for the study of different contacts. In the case of hertz contacts, accurate information on the state of stresses at the contact level is obtained. The point contact analysis using the classical method (Hertz theory) did not allow such accurate results to be obtained. Von Mises stress determination allows a stress state analysis thus allowing for a correct quantification of this state and the possibility of identifying the deterioration that occurs.

It can be concluded that a straight shaping cutter is first deformed in the active part while a bent shaping cutter has its largest deformation at the bent side.

References

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