FINITE ELEMENT METHOD USED IN STRAIN AND STRESSES STUDY FROM ACTIVE PLATE OF PUNCHING USED FOR CUTTING OF MEDICAL DEVICES

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Abstract: *Permanent innovations in medical devices manufacturing technologies has as purpose to low their prices and improve the quality and efficiency of medical care. Shaped knives used for cut medical devices as polyurethane compresses are active elements in various forms and are part of automatic and semiautomatic punches. These stamps have a high price because of non-conventional processes used to manufacture them, and limited lifetime due to active wear of the edges is mainly due to uneven distortions arising from the application of these active elements. This paper work presents some theoretical and experimental research on deformation and stresses calculation of active plate of stamps 100 × 100 mm, for a set of loading and border conditions.*

Keywords: medical devices, shaped knives, active plate punching.

1. INTRODUCTION

Polyurethane dressing with adhesive borders (Figure 1) is a composite material consisting of a cellular polyurethane PAD thickness of 3 mm (position 2), applied at the center of a polyurethane film support (position 1) coated with acrylic adhesive. The contact surface of the dressing to the wound is covered with protection silicone paper (position 3) to facilitate the use.
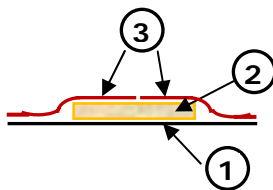

Fig. 1
1. Adhesive polyurethane film
2. PAD from polyurethane
3. Protect sheets from silicon paper

Using polyurethane dressing has some significant advantages including:
- it is an antibacterial barrier
- exudate absorbtion is vertical and does not adhere to the wound
 - have a good retention
- are very economical
- polyurethane adhesive dressings allows high comfort for patient, being very flexible and adhesive.
Polyurethane dressings are available on the international market are non-adhesive and adhesive dressings with different shapes (heel, elbow, sacrum, cavity, rectangular, etc.) and different sizes (5 x 5 cm, 10 x 10 cm, 10 x 20 cm, 12,5 x 12,5 cm, 15 x 15 cm, 15 x 20 cm, 20 x 20 cm, etc) .

2. STAMPING EQUIPMENT DESCRIPTION

Figure 2 shows an original semiautomatic equipment use for manufacturer at Velfina SA Campulung Muscel company of cellular polyurethane dressing with adhesive borders.

This equipment includes the following parts:

A. The recovery system of the protection paper made of a gear motor, paper voltage control system, d roller and limit switch type ELECTROZEP. (*Figure*

B. Cutting system of the protection paper made of ripping device, paper voltage control system, drive roller and gear motor (*Figure 2*).

C. The transfer system of the PAD on polyurethane film is made of a mechanical-vacumatic manipulator, sliding rail, the vacumatic hook of the PAD limit switch type Camozzi (*Figure 3*).

D. The feeding system of polyurethane film is made of tension control system of polyurethane film, drive roller and gear motor (*Figure 4*).

E. The shape cutting system is made of pneumatic cushions, cutting dies, motherboard and mobile sliding plate (*Figure 5*).
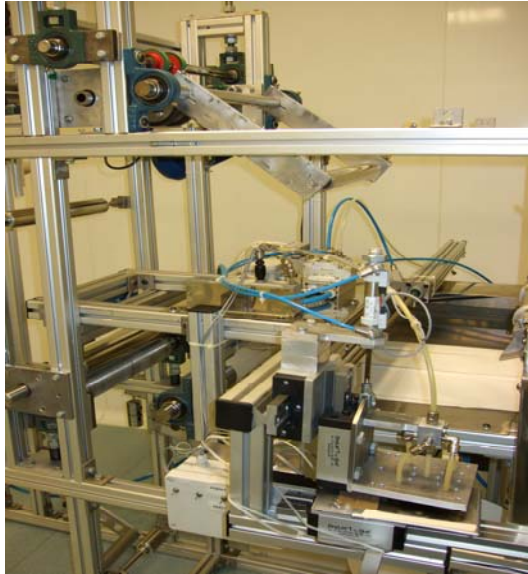
F. Equipment control system (*Figure 7*).
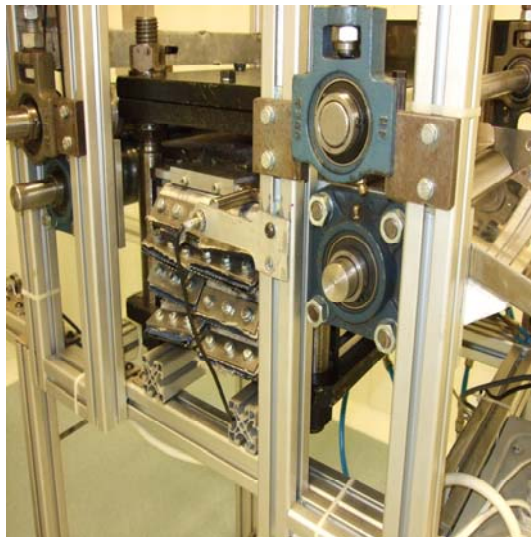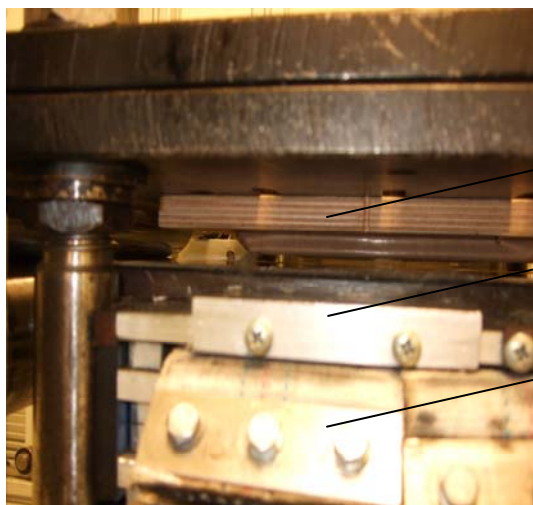

Fig. 2

181

Fig.3

Fig. 4

Fig.5

3. MODELING OF ACTIVE PLATE SUBSET AND CUTTING DIE SET

Punching subset or active plate (position 1, figure 6) is made of two components: a metal (steel rod shaped knife) and a non metal laminated wood in which is embedded the shaped knife. Figures 5,6,7 presents geometric shapes are rates of these elements of the active plate modeling using SOLID WORKS 2008 program.
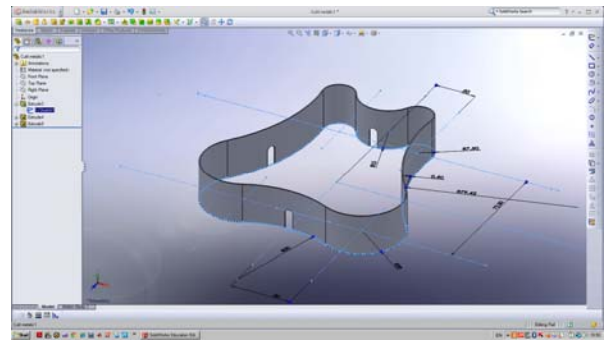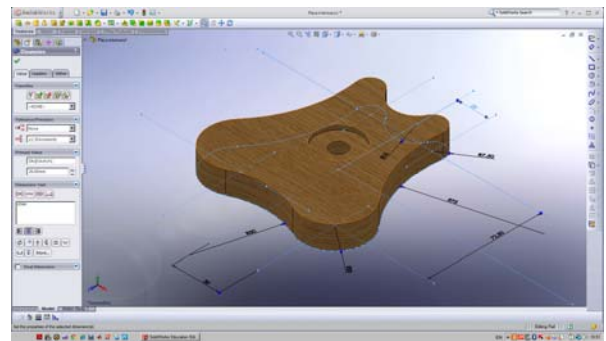

Fig. 6. Shaped knife made in SOLID WORKS

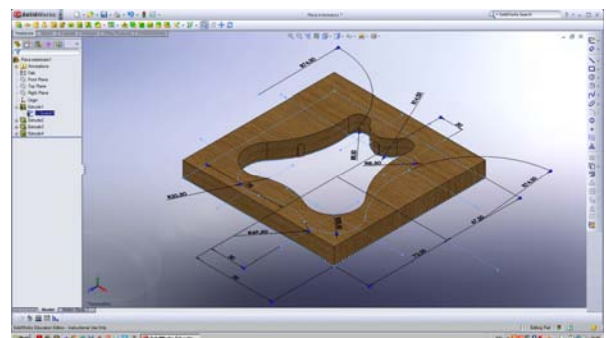**Fig. 7. Inner plate from laminated wood**

Fig. 8. Outer plate made of laminated wood

Inner plate (Figure 7) and the outer plate (Figure 8) of laminated wood with are set up by adhesion with shaped knife (figure 6) through some protuberant elongated shape as is shown in Figure 8.

The shaped knife is made from steel alloyed with chromium and vanadium, resistant to wear.

Figure 9 presents the overview of punch with a detailed of the active part which is mounted on a square board of laminated wood.
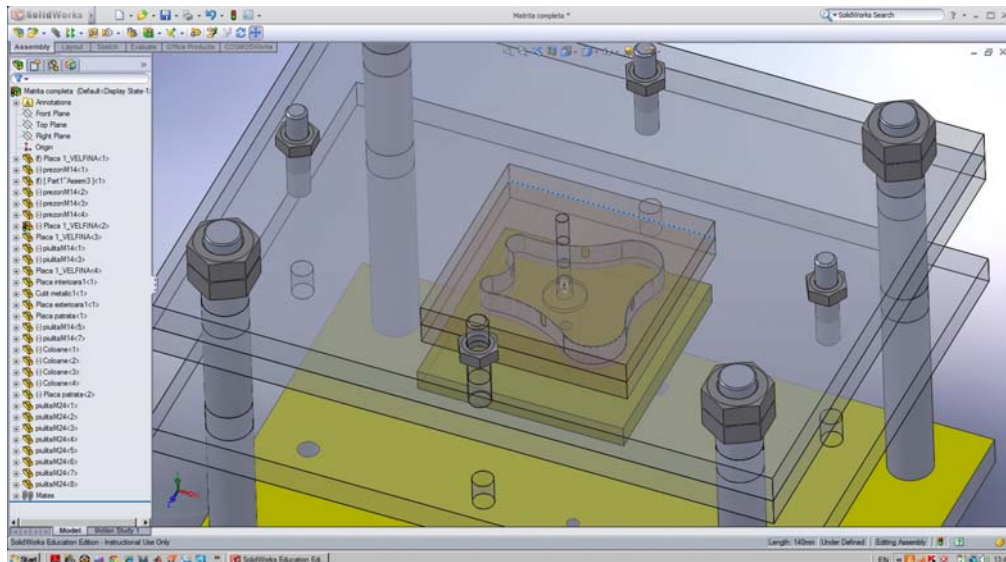
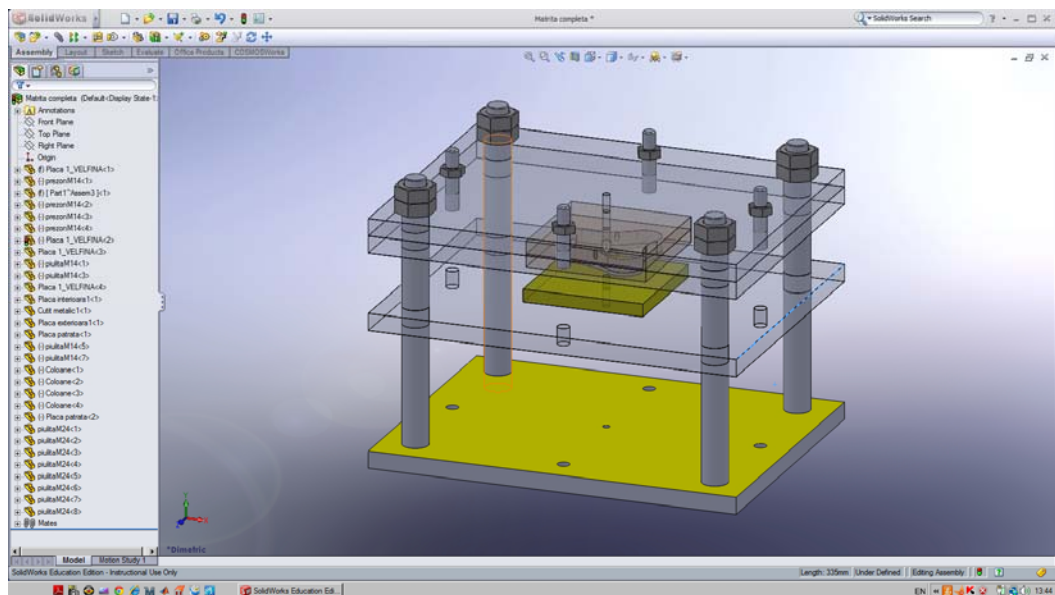**Fig. 9. View of active plate subset designed in SOLID WORKS**

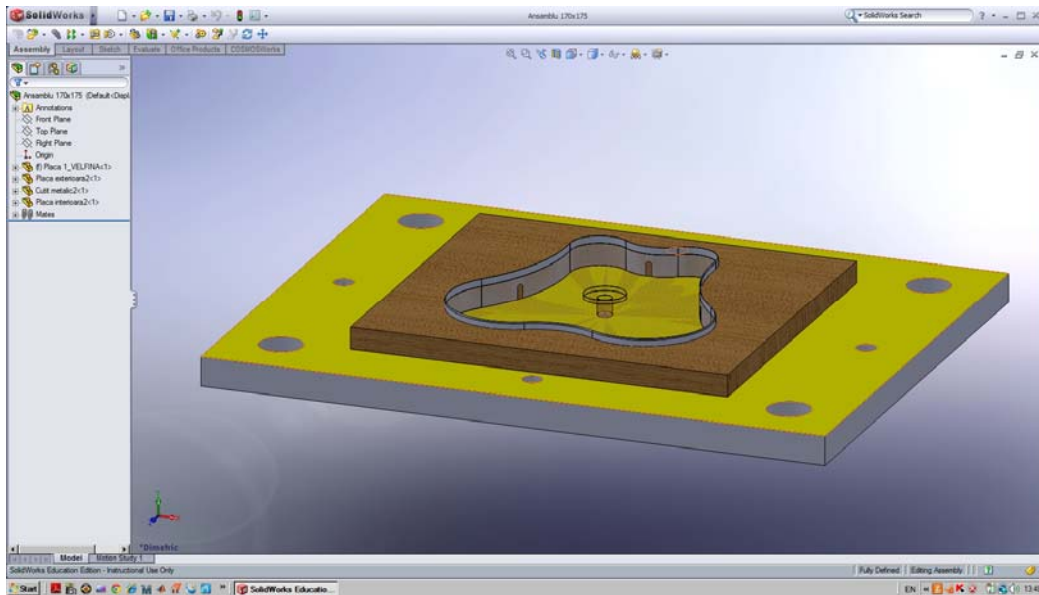**Fig. 10. Isometric view of cutting die design in SOLID WORKS**

Fig. 11. Isometric view of subset active plate designed in SOLID WORKS
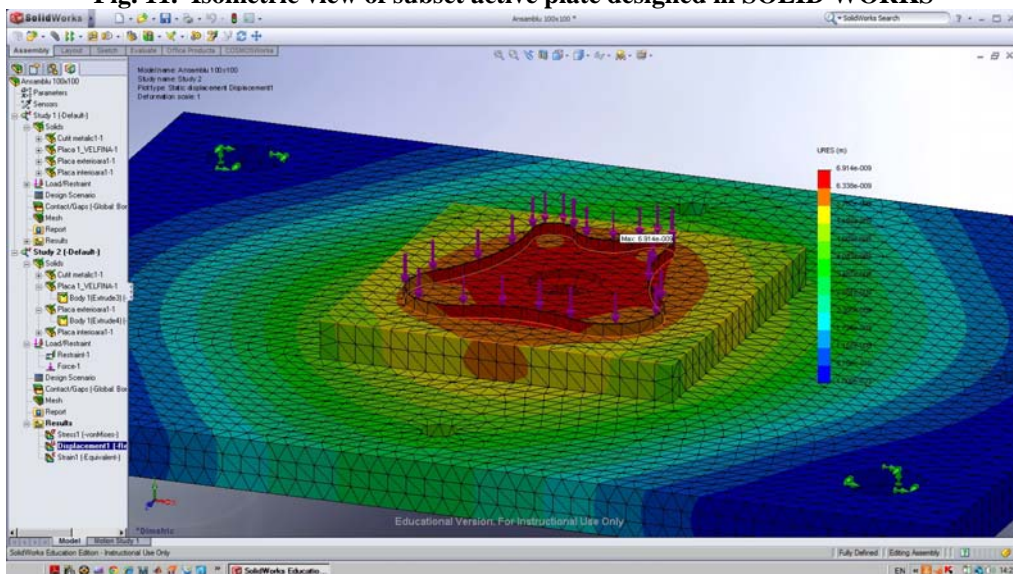

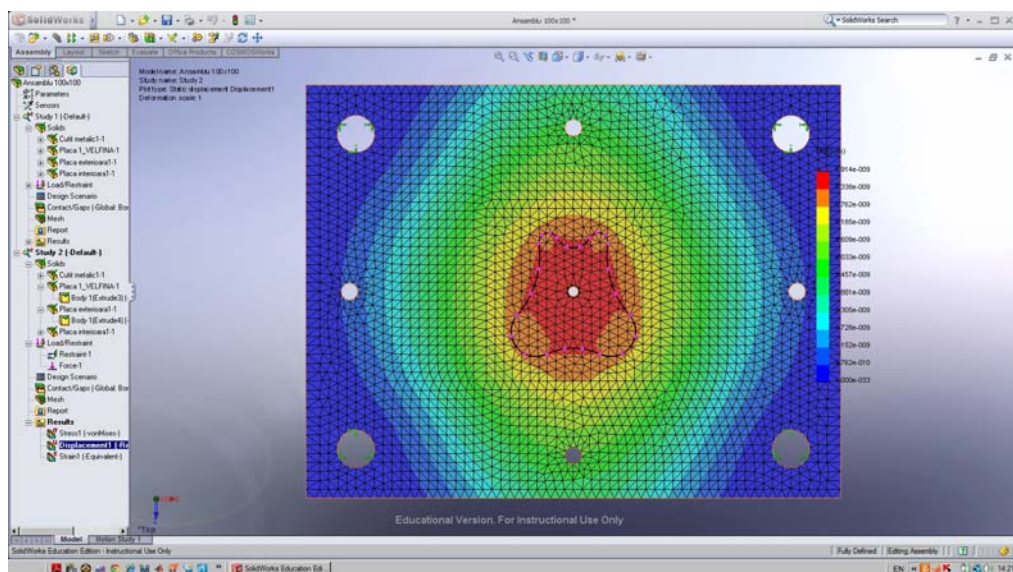**Fig. 12. Movement chart of correspondent active plate simulated in COSMOS WORKS (isometric view)**

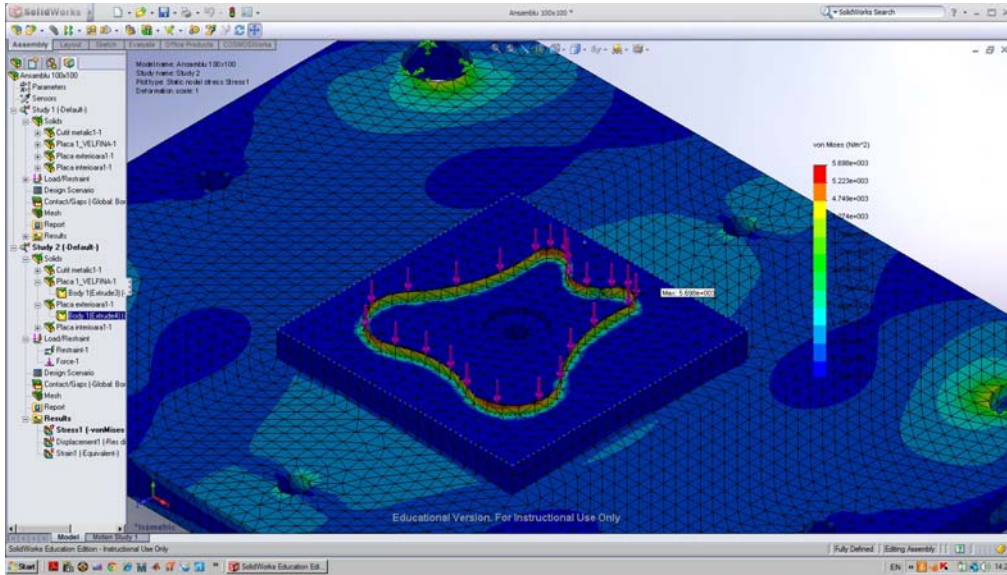**Fig. 13. Movement chart of correspondent active plate simulated in COSMOS WORKS (top view)**

**Fig. 14. Von Misses Tensions chart from active plate
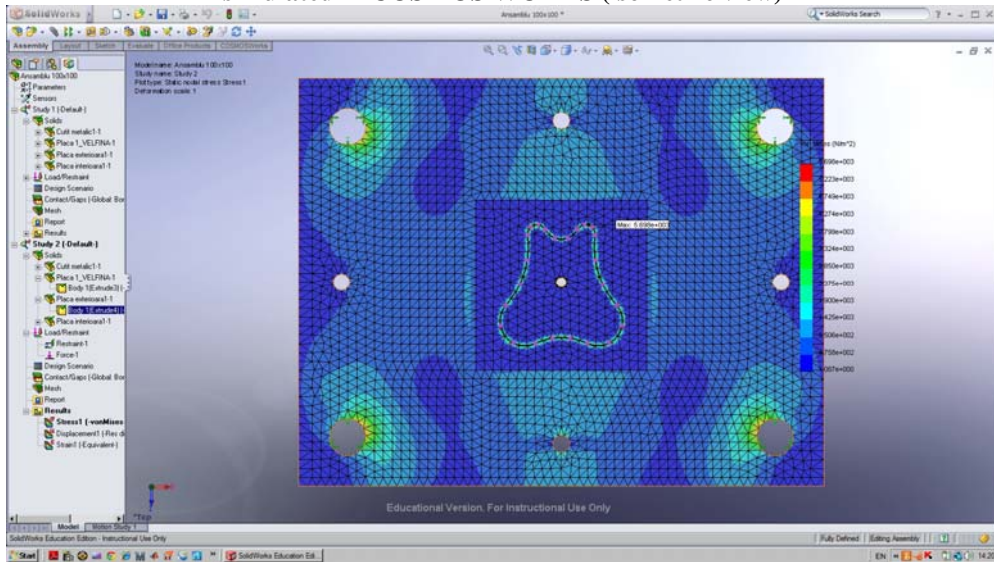simulated in COSMOS WORKS (isometric view)**

**Fig. 15. Von Misses Tensions chart from active plate
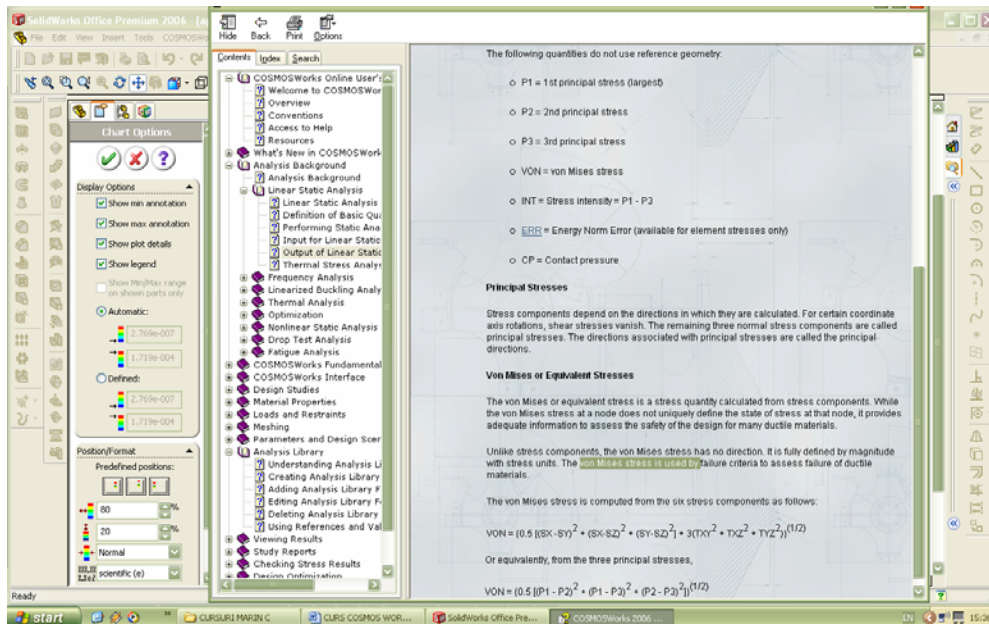simulated in COSMOS WORKS (top view)**

Fig. 16. Definition of correspondent Von Misses tensions

5. SIMULATION OF DEFORMATION AND TENSIONS IN ACTIVE PLATE

Simulation of deformations and tensions of active plate was made with COSMOS WORKS program under SOLID WORKS 2008 for the following *load and border conditions*:

- Border conditions are zero displacement of inner cylindrical surfaces points of the columns guides (figure 12)
- Load Conditions with external forces: *3200* N normally applied on contact surface of shaped knife (active edge)
- Link conditions between the parts: the finite element nodes for the attached adjacent parts.
- Digitization in finite element (mesh creation) was achieved with the minimum size recommended by the program, due to the existence of very small thickness elements (steel knife shaped of 0.5 mm).
- Materials: alloy steel with Cr and Va for shaped knife; for interior and exterior piece laminated wood having similar characteristics to wood material from the program; for the main plate quality steel.

- Following the finite element analysis using COSMOS WORKS program were obtained *results for the deformation and tensions,* in the form of maps showed in figures 12 ... 15:
- figures 12 and 13 represents charts of total distortions $URES = \sqrt{UX^2 + UY^2 + UZ^2}$; in figure 12 it can be seen that the maximum distortion corresponds to a point located inside the shaped knife and has the value: *6,091 ·10⁻⁹ m.*
- figures 14 and 15 are charts of equivalent tensions Von Misses according to the variation energy theory of the shape count with the known formula and shown in Figure 16. Note that the maximum

tension corresponds to a shaped knife point and has the value of 5,698 ·10³ Pa. This value is much lower to the allowed tension of shaped knife material (350 ·10⁶ Pa)

6. CONCLUSIONS

- The equipment is designed and functional and endures the universality of anatomical shape required on the medical devices market, ensuring very high dimensions accuracy to micrometer level.
- Finite element analysis carried out in the theoretical research presented in this paper was the base of for punching opposite solution (by moving the active part of the bottom up) and how to achieve the cutting force (pneumatic device) applied under active plate.
- Very small distortions show a sufficiently high rigidity of the active sliding plate, is not necessary other system for stiffening strengthening by fining.

7. ACKNOWLEDGMENTS

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