Nicusor BAROIU, Elena-Felicia BEZNEA, George BASALIC

CONSTRUCTIONAL-FUNCTIONAL ANALYSIS AND GRAPHIC DESIGN OF ELECTRO-HYDRAULIC VALVE DISTRIBUTOR

Abstract: *Among the machines which distribute fluid discharge in hydrostatic installations, valve distributors are the most important and differ in terms of a series of criteria related to the number of grooves, the distribution sketch, the nature of the switchboard etc. A valve distributor is comprised of a fixed part (the valve body), a mobile part (valve) and actuator elements. The operation of this type of distributors is based on the translation and shut down of the valve in the body in certain positions. These positions are fixed and the correspondence with certain paths from the body is specific for each type of distributor. This correspondence determines the transfer of the fluid according to the distribution sketch. The work presents the construction-functional analysis and CAD design in the CATIA graphic design environment of a basic distributor component – the valve, CAE analysis, with its finite element, as well as CAM simulation with the help of Sinumerik 840D software and system control of machining operations and phases by cutting the valve.*

Key words*:hydrostatic actuator, distributor, valve, pressure, CATIA, CAD, CAE, CAM.*

1. INTRODUCTION

Valve distributors are part of the distributor equipment of a hydrostatic installation, equipment intended for conducting the motor agent through pipes on different traces of a hydraulic installation [1]. The valve distributors are one of the most vast in hydrostatic actuator systems and the main advantage of these distributors is the simple constructive and technological shape, very good balance of pressure on pivotal and circumferential direction, high cut-in speed, actuator speed for reduced switching etc. [2], [3].

The distributor valves, also known as piston distributors are generally made of a plunger (arm piston), the valve body and the switchboard [4].

2. CONSTRUCTIONAL-FUNCTIONAL ANALYSIS OF VALVE DISTRIBUTOR

In terms of the number of inside chambers, there can be three chamber distributors and five chamber distributorsFigures 1 and 2.

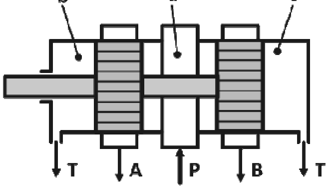


Fig. 1 Three chamber valve distributor (a, b, c).

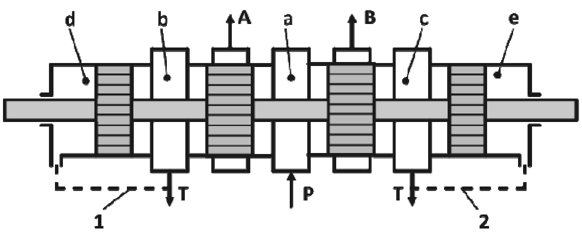


Fig. 2 Five chamber valve distributor (a, b, c, d, e).

The cast body Fcx300machines a circular, longitudinal alloy, discontinued by circular grooves made by casting. The valve is a cylindrical part made of steel18Mc10,it slips in the body which has many arms. The valve is kept in stable position by the compression arch or arches made of wire.

For example, in the 5 chamber valve distributor, pump *P* can repress the oil from chamber *A or B,* in terms of the left or right position of the valve distributor. The inactive chamber is connected to collector*T*.

At the sides of the plunger, chambers *d and e* are not under pressure.

They are connected through pipes *1*and *2* to the pipe of the collector in order to provide drainage. The drainage represents the flow in the collector of the oil from the leaks of the plunger sides from chambers*d*and *e*. If not drained, the oil could prevent the switch and the movement of the plunger.

The nature of the switchboard represents one the most significant differentiation criteria of the valve distributors, Figure 3.

It can be: manual, mechanical, electrical (with continuous or alternative current electromagnet), hydraulic, electrohydraulic and pneumatic [5].

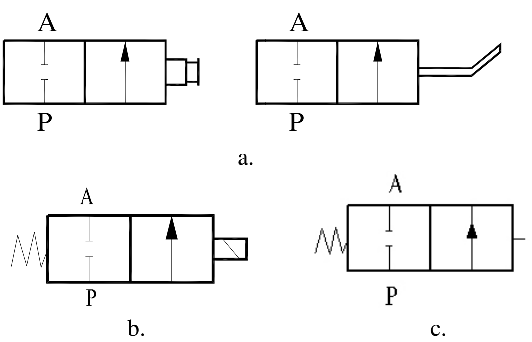


Fig. 3 Distributor switch: manual (a); with electromagnet (b) hydraulic/pneumatic (c).

Among the parameters of the distribution hydraulic machine the most important are [6]: *themain parameters*: *p* [bar] –the nominal operating pressure; *NO*[mm] – nominal opening (diameter), conventional size which defines the nominal section of flow through the machine; *secondary parameters:* Q_{max}[cm^3 / s] –the maximum flow which crosses the machine, limited in terms of the functional sketch, the actual operating pressurep_{ef} , the approved pressure drop$\Delta p$and the switch speed; Δp[bar] – the pressure drop when the flow crosses the machineQ_{ef}; ΔQ –the flow loss at operating pressure$p_{ef.}$

3. GRAPHIC DESIGN OF THE VALVE DISTRIBUTOR IN CATIA

When creating solid bodies in CATIA V5R20 the sketchesare concluded in *Sketcher*module and module*Part Design*is used for volume figures, with the final 3D shape beginning with the size of the component. The soft package CATIA has different design and editing tools which can be used for drawing sketches and especially for creating the volumes of the bodies.

3.1 Design of valve distributor plunger

In order to make the valve distributor in*Sketcher* module with the help of *Line*and*Circle*, the sketch from Figure 4 is made also highlighting its levels. In *Part Design* module,the sketch made is transferred in 3D pattern with the help of *Shaft,*by specifying the axis in terms of which the 360^0 rotation is made, Figures 5-6.

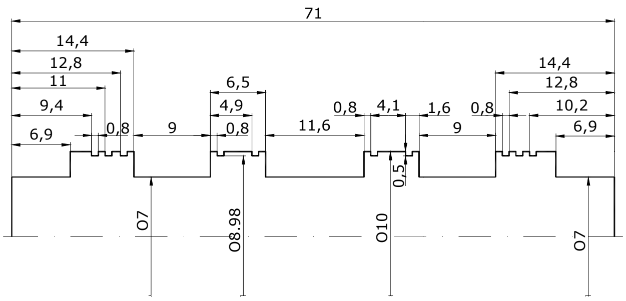
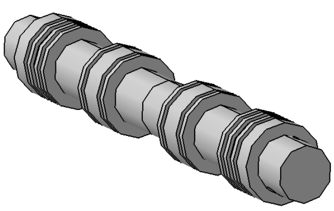


Fig. 4 Basic sketch of valve.



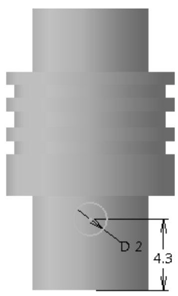


Fig. 5 Valve extruded section.**Fig. 6**Circle sketch Ø2.

Moreover, in*Sketcher*module,with the help of*Circle,*the sections of the two circles from a given distance from one end where they are extruded by eliminating the material using *Pocket*from module*Part Design*, thus acquiring the penetrated holes, Figure 7.

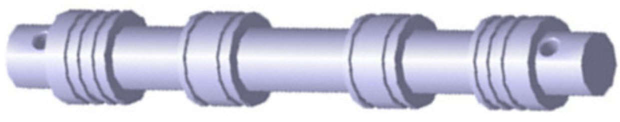
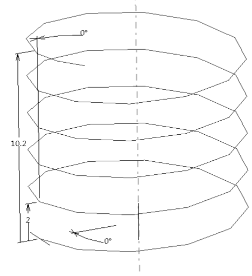


Fig. 7 Valve distibutor.

3.2 Design of distributor compression arch

In order to execute the arch, in module*Part Design*a point from a given distance on axis Y is created in module*Wireframe Design,*the spire is made, specifying the step and height. In module*Part Design,*at the base of the spire, a circle with known diameter is built. With *Rib*material is added, resulting the 3D shape of the compression arch, Figures8÷10.



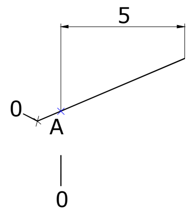


Fig.8 Design of point. **Fig.9** Spire section.

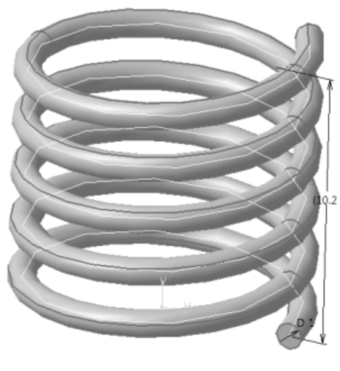
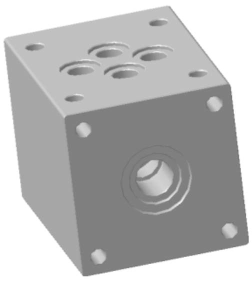


Fig.10 Result of*Rib*.

By similar actions and techniques a series of components are presented which are generally part of the valve distributor: central body, Figure 11, lid, Figure 12, tube flange, connector carcass, connector body, Figure 13, exterior chamber, Figure 14, guide bushing, Figure 15, base plate of distributor body, Figure 16etc.



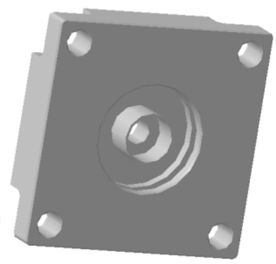


Fig.11 Central body.**Fig.12** Lid.

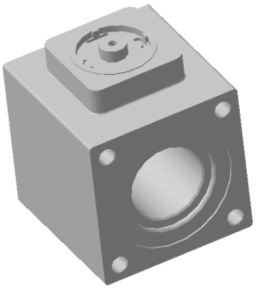



Fig.13 Connector body.**Fig.14**Exterior chamber.

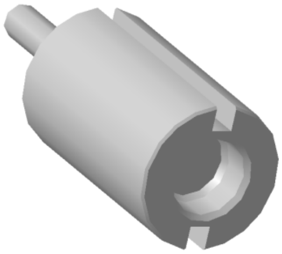
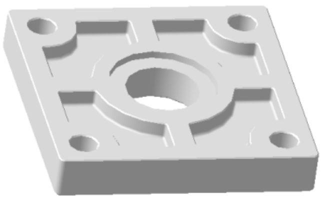



Fig.15 Guide bushing.**Fig.16**Base plate.

3.3 Graphic design for assembly of electrohydraulic distributor

From the*START*menu, in section*Mechanical Design*you must choose module*Assembly Design*. When selecting the active button you click right on the*Components*tab and then on the*Existing component*field*,*where the window for inserting components in the assembly module opens, the action is made on each*part*.

The first component is the central body in which the components are fixed and the *Fix Constraint* is applied, because it is the only component for this action.As for the rest, all the other components are assembled with the coincidence, distance, contact etc. constraints. The actual assembly of components by applying their constraints is made with the help of*Update All*.

The following component is the valve which by*Coincidence Constraint*and*Offset Constraint*, is jointly assembled with the first components already assembled.

Applying the same assembly actions and techniques to the other components, we acquire: the fixing of the main body, assembly of valve in the main body, valve bushing, Figure17, fixing the compression arches, Figure18, fixing the base plates of the main body, assembly of tube flanges,guiding the bushings in flange, Figure19, fixing the switch chambers, Figure20, fixing the side lids with screws, Figure 21 etc.

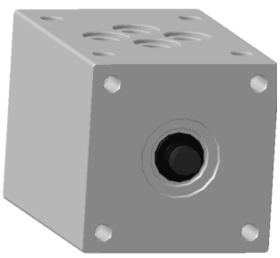
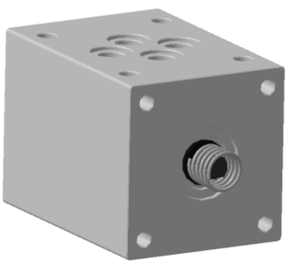



Fig. 17 Valve bushings.**Fig. 18**Arch fixing.

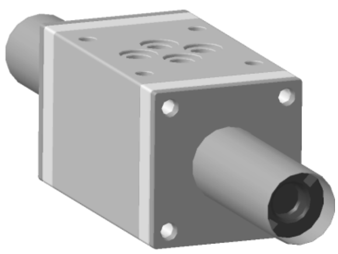



Fig. 19 Bushing guide in flange.**Fig. 20**Chamber fixing.

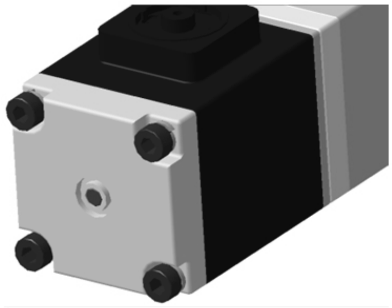


Fig. 21 Lid fixing with screws.

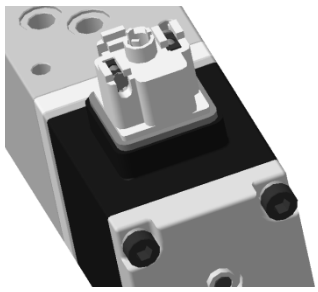
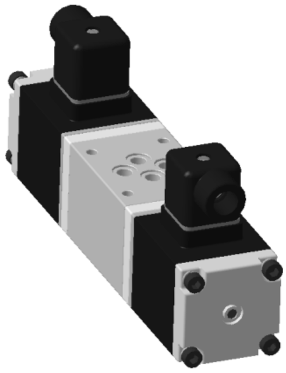



Fig. 22 Circuits. **Fig. 23**Valve distributor.

Figure23presents the general drawing of the electrohydraulic valve distributor and Figure24 presents the same drawing, but with the components in exploded position.

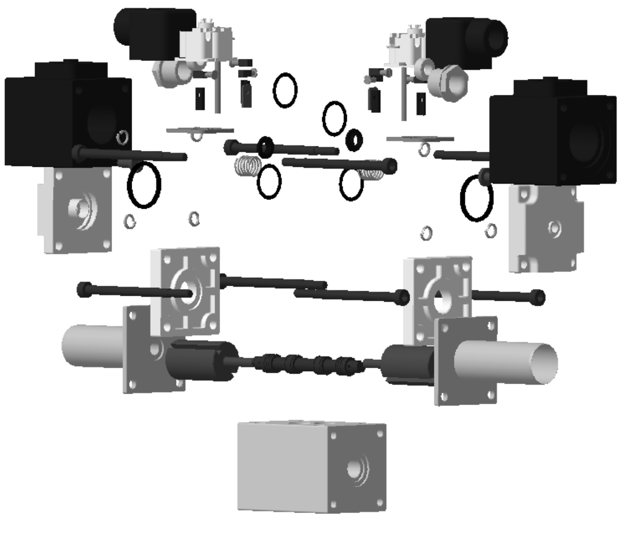


Fig. 24 Exploded view of electrohydraulic valve distributor.

4. CAM SIMULATIONIN SINUMERIK 840D SL CONTROL SYSTEM OF VALVE

When implementing the CAM simulation in*Sinumerik 840D* and*control system* the technological stages must be set and programmed beginning withthe sizes of theblank, with the execution drawing in order to reach the desired end product.For this, must open the application on the*Desktop*and then create a new virtual machine.By clicking on*Program Manager,*you perform the direction to certain already existing folders, Figure25.

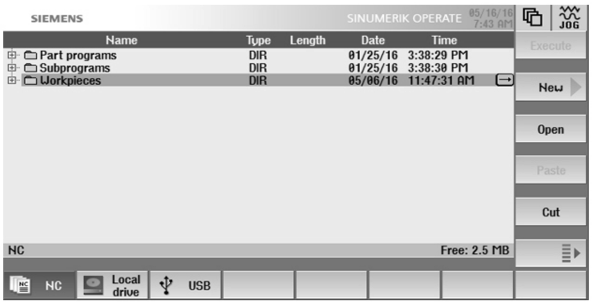


Fig. 25 File with existing folders.

Creating the program for *Valve* is made in the*Workpieces* folder.A new folder is created with the name of the valve which is to be machined, Figure26.

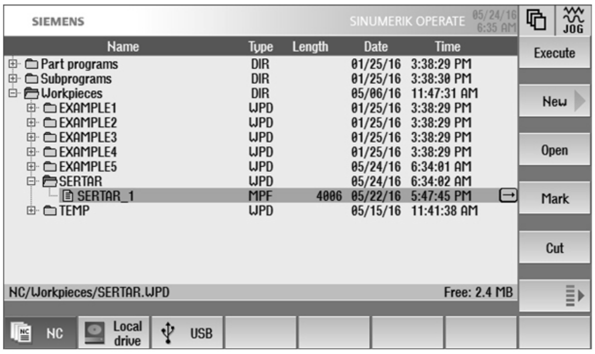


Fig. 26“Valve F1” program.

The technological process set is programmed only for machining on face I, Figure 27.

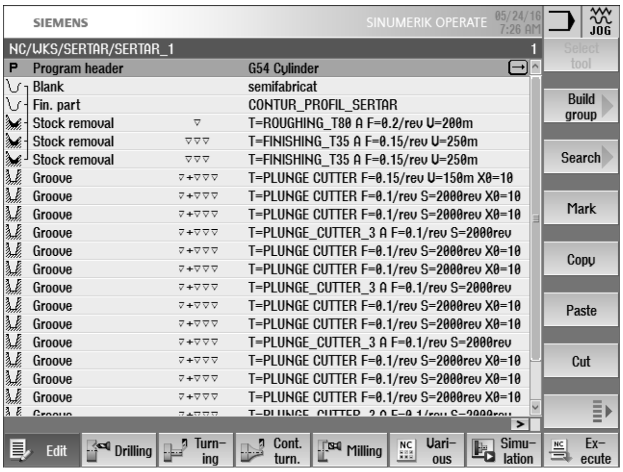


Fig. 27 Structure of ValveF1 program.

Setting the technological process of the *Valve* and with the execution drawing you introduce the data of the blank from the measurements made and in*Program header* you introduce the values of its size, Figure28.

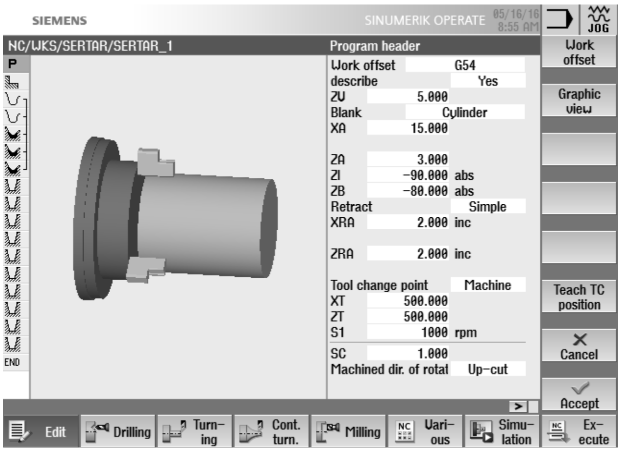


Fig. 28 Program header.

The data of the blank is again declared, introducing the values which start from zero on the direction of the tool cutting, meaning in negative direction.CAM machining cycles and rough turning and exterior finishing, turning grooves and cutoff are set by the cutting regimes and tools-T with which the operation is made, meaning:

-*feedrate* (F), expressed in mm/rev;

- *cutting speed* (V), expressed in m/min;

-*machining*type;

-*roughing*, ▽ or *finishing*, ▽▽▽ or combined, ▽+▽▽▽ .

Other cutting parameters such as the *maximum infeed depth* (D), the machining direction given by the machining type meaning *longitudinal* or for face turning, on the inside (alloys) or outside (shafts) are defined in Figures29÷35.

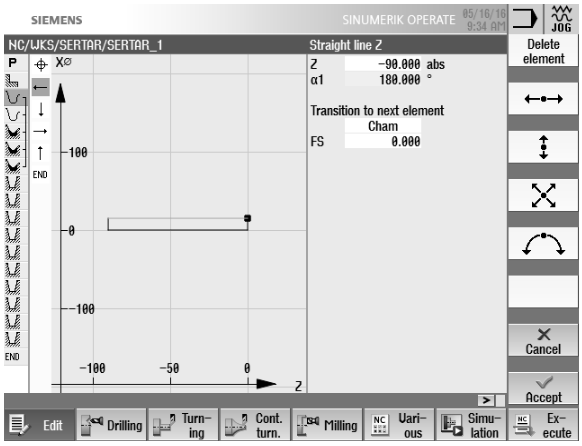


Fig. 29 Creating the contour of the blank.

In order to built the contour of the end productthe end quotas from the drawing are introduced on diameter and on length, all are unconditioned, Figure30.

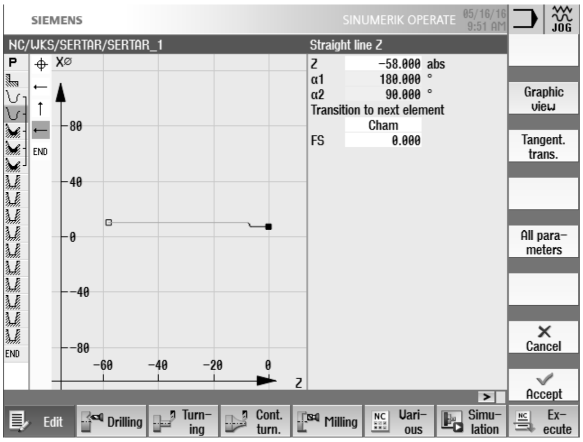


Fig. 30 Creating the contour of the finite product.

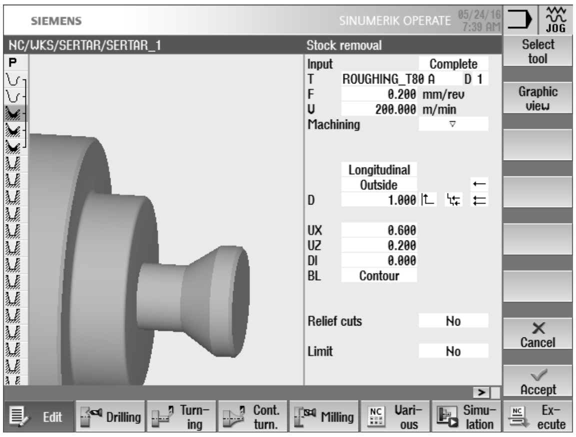


Fig. 31 The exterior rough turning cycle.

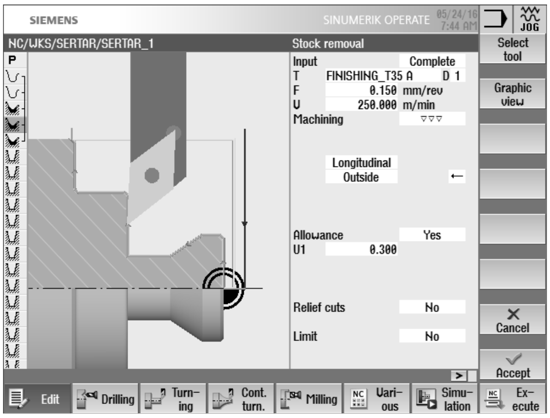


Fig. 32 The exterior turning finish cycle.

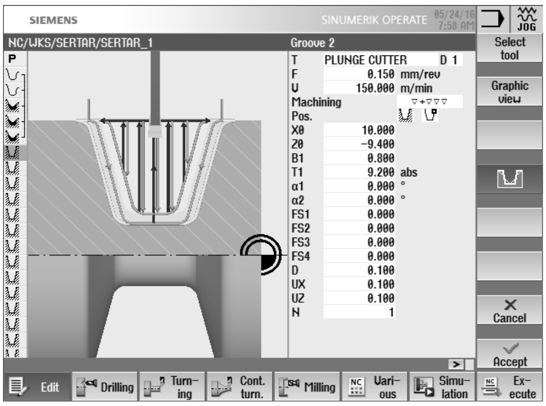


Fig. 33 Groove turning program.

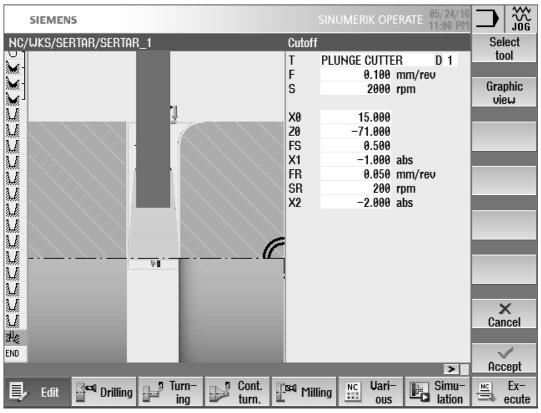


Fig. 34“Cutoff”.

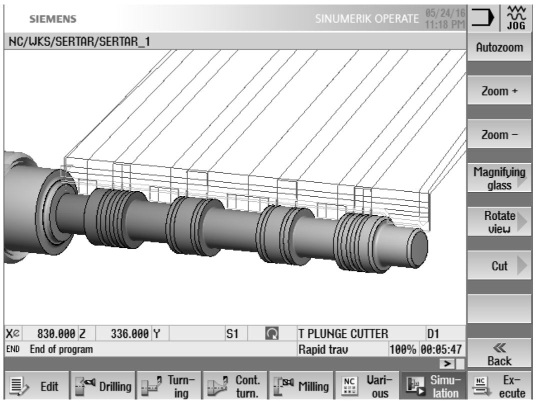


Fig. 35CAM simulation of machining by cutting.

5. FEM ANALYSIS OF *VALVE* IN *ANSYS*

FEM analysis of solid pattern *Valve* is made in the analysis and simulation program with finite element, *ANSYS 14.5,* the graphic design is made in the drawing and design program Autodesk Inventor Professional 2013 and especially in*ANSYS 14.5.ipt,* Figure36.The material of the tool is18Mc10,alloy steel for cementation and it is an iron alloy with chromium molybdenum for the manufacturing of parts submitted to moderate effort [7].

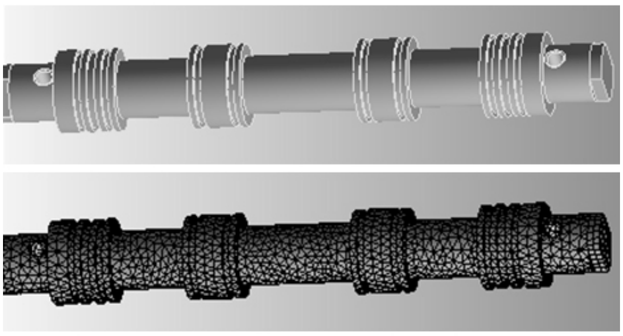
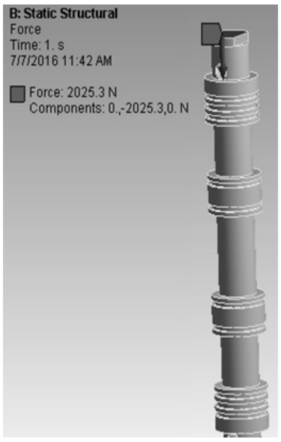


Fig. 36 Solid pattern in Ansys and quantizing of “Valve” solid.

A pivotal force F=2025.3[N] is applied to the valve and the effect is its movement or translation equal to the switch movement in the central body of the distributor in different positions of the valve performed when crossing the motor agent through the distributor, Figures 37-38.



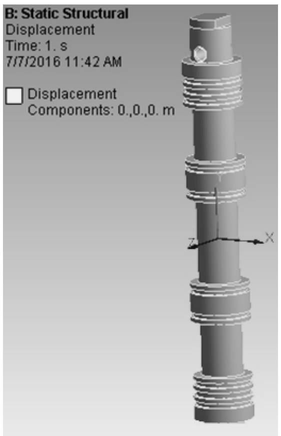


Fig. 37 Applying the pivotal force. **Fig. 38** The structural-static movement of the solid.

In order to perform a correct simulation of the operation conditions of the valve in the central body of the distributor, when switching from a position to another, the pivotal force applied on one of the faces of the valve is considered when supporting and contacting the arms of the valve in the body of the distributor.

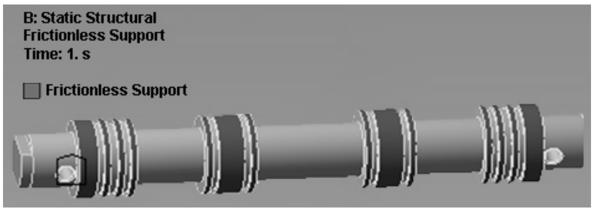
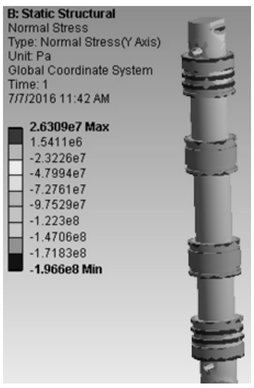


Fig. 39 Contact conditions of the distributor valve.



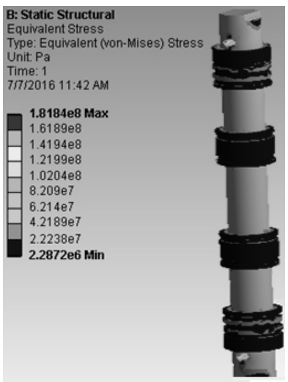


Fig. 40 Normal tension. **Fig. 41** Equivalent tension.

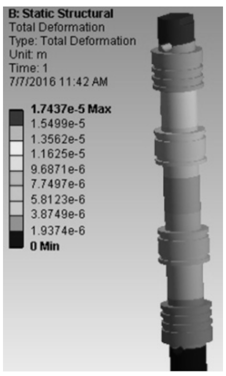


Fig. 42 Map of total deformation.

The results of the elastic deformation of the material are given in table 1.

Table 1

Results of elastic deformation of material.

	Normal Stress	*Equivalent Stress*	*Total Deformation*
Min	-0.966 MPa	0.0022872 MPa	0 mm
Max	0.026309 MPa	0.18184 MPa	1.7437×10^{-2} mm

6. CONCLUSIONS

The distribution equipment must provide simplicity and safety in operation, minimum local resistances and losses for friction, reduced flow losses, easy control without much effort and shifting, high sensitivity to changing the run, inverting without shocks the movement as quickly as possible.This leads to the hydraulic distributor equipment to be considered superior to the electrical or mechanical distribution or inversion equipment, its superiority represents the high frequency of inversions without affecting the functionality in the actuator sketch.

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Authors:

Assist. Prof., PhD. Nicusor BAROIU, Department of Manufacturing Engineering, "Dunărea de Jos" University of Galaţi, România, E-mail: Nicusor.Baroiu@ugal.ro, tel.0040721771000.

Assoc. Prof., PhD. Elena Felicia BEZNEA, Mechanical Engineering Department, "Dunărea de Jos" University of Galaţi, România, E-mail: Elena.Beznea@ugal.ro, tel.0040743605440.

Eng. George BASALIC, Department of Manufacturing Engineering, "Dunărea de Jos" University of Galaţi, România, E-mail: georgebasalic3@gmail.com, tel.0040753683369.