

MANUFACTURING TECHNOLOGY FOR A NEW TYPE OF PROFILED ROTOR

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Abstract:

The paper presents the sketch and the functioning principle of a new type of volumetric rotating pump using two identical profiled rotors.

Achieving such a pump involves, in a first phase, the building of a functional model defined by the dimensions previously established. A computation method was elaborated for the outline of the rotor profile, as well as the manufacturing technology.

The advantages of the new type of volumetric rotating pump are also presented.

Key words: rotating piston, rotating motion, half-cylinders, hole.

1. INTRODUCTION

A new type of working machine was conceived in order to deal with compressible, non-compressible and viscous fluids, as well as with some poliphase fluids.

The new type of the working machine is based on a pattern [1] and can be used as pump, fan or blowing engine.

The motor torque transmitted to the machine shaft is almost fully transmitted to the fluid, increasing both its kinetic energy and its pressure potential energy.

The advantages of the new rotary working machine compared with other solutions, for instance the Roots compressor, were presented in [2].

Alternate constructive solutions of the working machine were presented in [3] and [4]. Consequently, this paper presents only a constructive solution adequate for a new type of rotating volumetric pump with two profiled rotors.

In order to build a functional model of the pump, some geometric dimensions were chosen and manufacturing technology for CNC machining centers was elaborated.

2. CONSTRUCTIVE SOLUTION OF THE MODEL OF ROTARY VOLUMETRIC PUMP

Figure 1 presents a transversal section of the volumetric pump. The two rotors (1) and (2) rotate with the same angular speed inside the half-cylinder casings (3) and (4). The rotors are fixed on the shafts (5) and (6). On each shaft, outside the casing, an identical gear wheel is mounted, the two gear wheels meshing one with another. The

fluid enters the intake chamber (7) and is transported to the discharge chamber (8) by the four rotating pistons (9) (10) and the opposite ones.

The following dimensions were chosen in order to build the functional model, as shown in Fig. 1:

- Radius of the rotor $R_r = 25$ mm;
- Height of rotating piston: $z = 15$ mm;
- Radius of casing: $R_c = 40$ mm;
- Rotor length (perpendicular to the plane of the drawing): $l = 20$ mm.

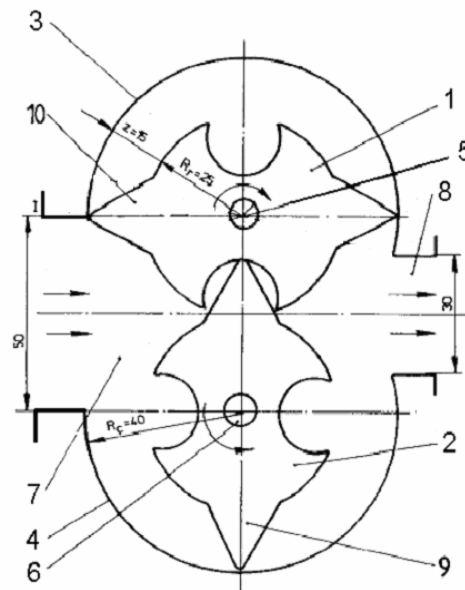


Fig. 1 Transversal section in the volumetric pump

1- upper rotor; 2 – lower rotor; 3 – upper casing; 4 – lower casing; 5 – upper shaft;
6 – lower shaft; 7 – intake chamber; 8 – discharge chamber; 9,10 – rotating pistons

If a series of geometric (R_r , z , l) and functional (rotating speed n , pressure increasing between intake and discharge Δp) parameters are imposed, the amount of the volumetric flow rate ($\dot{V}$) can be deduced, as well as the theoretical driving power of the pump. The reference [4] presents the way of establishing the original computing relations for flow rate and for power:

$$\dot{V} = \pi \cdot z \cdot l (2 \cdot R_c - z) \frac{n}{30} \quad [\text{m}^3/\text{s}] \quad (1)$$

$$P_t = \dot{V} (\Delta p) = \pi z l (2 R_c - z) \frac{n}{30} (\Delta p) \quad [\text{W}] \quad (2)$$

Relation (1) shows that the flow rate is proportional to the geometric elements of the pump z , l , R_c and to the rotating speed. The power needed to the driving of the pump increases proportionally to the flow rate and to the pressure increasing produced by the pump. The reference [5] presents the way of calculating the outline of the rotor profile, as well as the numeric values of the coordinates obtained for $R_r = 25$ mm, $z = 15$ mm and $l = 20$ mm.

3. MANUFACTURING TECHNOLOGY FOR THE NEW TYPE OF PROFILED ROTOR

The industrial experience shows that integrating various applications in the field of design (CAD – Computer Aided Design), analysis (CAE – Computer Aided Engineering), manufacturing (CAM – Computer Aided Manufacturing) and PDM (Product Data Management) results in an extremely efficient solution when solving all the problems connected with the product, starting with conceiving, product planning, and manufacturing. The system CAD/CAM/CAE proves itself this way to be a powerful tool in engineering.

The manufacturing solutions allow the programming of the main operations of turning, milling, boring, using up to five axes controlled simultaneously. The programmer of the numerical control equipment obtains relevant data from a technological database including information regarding the manufacturing process involved and other manufacturing parameters. Parts are designed directly in three dimensions, operating with volumes, restrictions and constraints among the various component surfaces [6].

The paper presents the design and the manufacturing of the rotor using a CNC machining center. The modeling of the rotor was done using the option SKETCHER (Fig. 2) from the Part Design Menu. Because CATIA is a parametric software, all the elements of a sketch can be connected among themselves using dimensional constraints (diameters, lengths etc.) or geometric constraints (parallelism, contact etc.). Thus, if a modification of a certain element is required, all the other elements connected will be modified consequently.

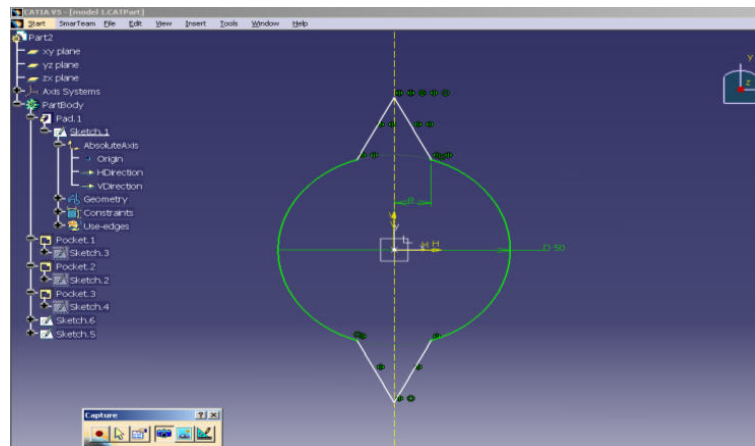


Fig. 2 The sketch of a two-piston rotor

The sketch obtained using the SKETCHER module will establish the shape of the profile, by selecting the Pad icon, introducing the required value (for instance, a length of 20 mm) and validating it (Fig. 3).

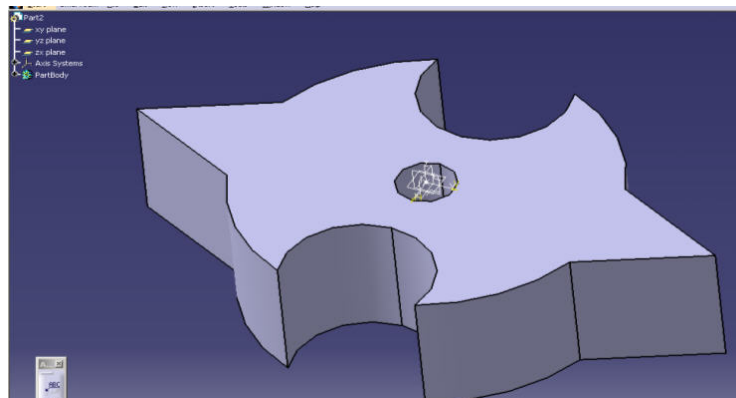


Fig. 3. Determining the shape of the profile by using the Pad icon

CATIA is endowed with a powerful CAM module, in order to define and organize CNC programs dedicated to the manufacturing of parts whose geometry is represented by 3D models of type wireframe (only edges) or solid, using machining procedures of machines-tools with 2.5...5 axes. The manufacturing module is endowed also with a post/processing engine that covers the entire manufacturing process, starting with the generation of the tool trajectory and arriving to the NC program.

The first step after creating a new file consists in defining the operation (Part Operation) and its parameters (machine, blank, safety plan). This operation (Fig. 4) involves tools and options proposed by the software, so the processing geometry must be specified by selecting the Profile Contouring icon. This icon contains some sensitive areas, as well as text helping to select the processing geometry. Tool parameters are introduced (a mill type D10R0 will be used), as well as contour offset. All other required parameters are also established. The Reply option allows visual checking of the tool trajectory.

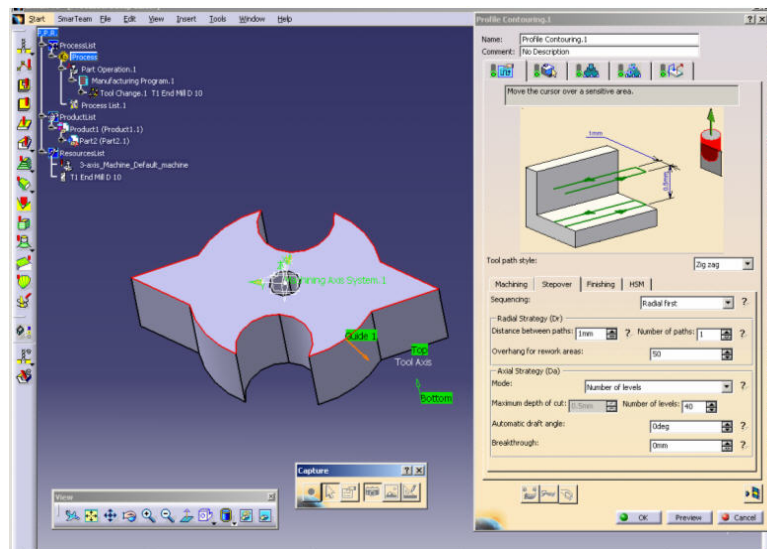


Fig. 4. Defining the processing

If a collision analysis is required or the programmer suspects other problems, pressing the sequence of buttons Photo / Analyze Photo shows the potential collisions between the tool and the part.

Analysis of the processing accuracy variation for three-dimensional surfaces is a very useful step in order to validate the CNC programs, generated automatically by a post-processor.

Such an analysis is important also for the estimation of the deviations from the imposed values appeared in the manufacturing process.

The analysis offers information about the volume and the disposition of the exceeding material which has to be removed, guiding thus the operator in choosing the right procedures for processing different areas of the part.

The software CATIA V5 uses the coloring in a very suggestive way, according to the tolerance levels, in order to quickly evaluate the manufacturing accuracy of the part. Pressing the button "Generate NC code in Batch Mode", followed by the selection of the post-processor, the name and the type of the output file (NC code) leads to the generation of the control program.

The rotors were manufactured on the CNC machining center type FVMC 610, making part of the endowment of the Precision Engineering and Mechatronics Chair from the "POLITEHNICA" University of Bucharest. The CNC machining center type FVMC 610 ACRA is a vertical machining center including a tool storage room with 24 tool holder devices (Fig. 5), the axis of the tool storage room being perpendicular on the rotation axis of the spindle of the center.

Due to the layout of the tool storage room, the mechanic gripper is pneumatically actuated, being of type "double mechanical gripper". The chucking and the extracting of a tool holder from the tool storage room (Fig. 5), respectively from the main spindle require a pliers-type device with double jaws, system that ensures also the transfer of the tool between the two subassemblies of the machining center, as shown in Figure 6. The fastening of the tool holder bracket in the spindle of the machining center involves a cone ISO BT 40, guaranteeing an accurate and quick centering.



Fig.5. The tool storage room

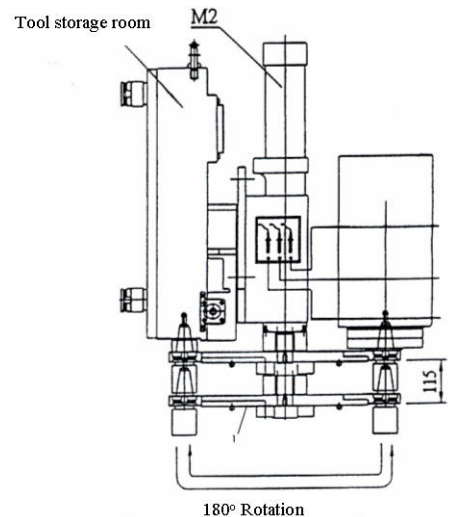


Fig. 6. The mechanic gripper

The machining center is endowed with facilities of numerical control of the X, Y and Z axes, having also a rotary table controlled numerically on the A axis. This table allows obtaining continuous rotary movements or angular indexing of the parts to a range of programmed values, thus increasing the CNC machining possibilities. Due to the high rotating speed of the spindle (up to 10,000 rpm), the machining center includes a cooling system with special oil, which is permanently cooled and maintained to the temperature imposed by the manufacturer. The rotors were manufactured from aluminium. The blank was fastened on the machine table using an accurate vice. The tool used for roughing and finishing milling was a 10 mm cylinder-front mill (Fig. 7).

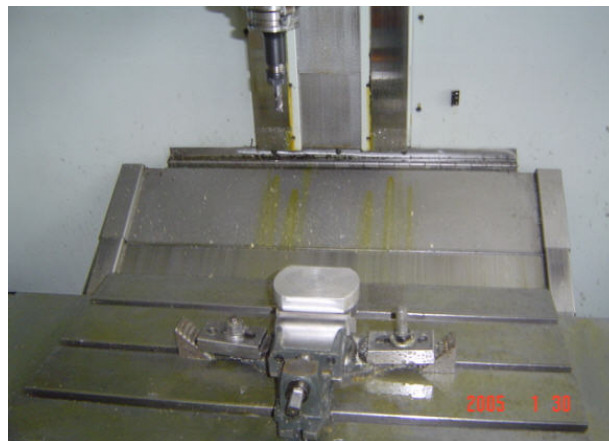


Fig. 7 .The fastening of the blank on the machine table

Tool trajectory and correlation between the processing speed and the working feed were permanently monitored during the part processing.

After concluding the roughing and finishing milling, holes were drilled in the rotors using a 8 mm drill. The finite parts obtained are presented in Figure 8.



Fig.8 The finite parts

Designing of the rotor, as well as of the other constructive elements of the working machine, generating the numerical control program for the manufacturing of the proposed parts as well as computer aided inspection offer the advantage of integrating the computer in all the design, manufacturing and control activities.

4. CONCLUSIONS

- The presented constructive solution eliminates the disadvantages of other types of volumetric rotating pumps (with gear wheels, with blades), where the transported fluid has to be free of solid contaminants; this type of volumetric rotating pump, without valves, can be used for the transport of contaminated, viscous or polyphase fluids.
- The specialists in the fields of chemistry, energetics and metallurgy are the potential users of this type of pump, able to transport any kind of liquid, viscous or polyphase substance.
- The software CATIA V5R7 allows designing and analyzing of the engineering systems in a tri-dimensional, dynamic and interactive conception; continuous editing and preserving product data is possible by commuting among different applications, without loss of information.
- A prototype of the original architecture volumetric rotating pump will be built after the manufacturing of the model.

5. REFERENCES

- [1] Baran N. , Baran, Gh., *Patent*, no.111296/1996, emitted by the State Office for Inventions and Trademarks, Bucharest.
- [2] Baran N., Baran, Gh., *Comparative study between the Roots compressor and a new type of compressor* (in Romanian), The Romanian Review of Chemistry, vol. 54, no. 11, 2003, pp. 919-922.
- [3] Baran N., Marinescu M., a.s.o., *Technical thermodynamics*, MATRIXROM Publishing House, Bucharest, 1998.
- [4] Baran N., *Working rotating thermic machines*, MATRIXROM Publishing House, Bucharest, 2003.
- [5] Baran N., Dontu O., a.s.o.- *Constructive elements and technological procedures used in the construction of a new type of rotating compressor*, Romanian Review Precision Mechanics, Optics & Mechatronics no. 25/2004, pp. 265-268.
- [6] O. Dontu, *Manufacturing technologies and systems used in mechatronics* (in Romanian), Printech Publishing House, Bucharest, 2003.