Development of a technique for surface treatment of a rotary machine

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Abstract : *Analytical solve to obtain an accurate surface of the rotor and stator, we calculated the formula of the crank-rocker mechanism and Determination of the angle of exit of the cutter beyond the work surface In order to ensure a surface with a complex shape with a high and accurate surface finish in order to get wear resistance and good lubrication then this gives long time life working. A comparative analysis of traditional methods of restorative treatment of the support surface is carried out, drawbacks are revealed, the main ones of which are unstable quality, low productivity and high cost. Considerable attention is paid to the problem of technological assurance of product quality, efficiency improvement and optimization of technological processes in mechanical engineering technology.*

Keywords — *Surface treatment, rotary machine*

I. INTRODUCTION

The disadvantages of traditional methods of blade processing are the constant contact reactions of the working surfaces of the tool blade with the material processing the work piece in the form of slip. Also the lack of a lubrication system for the friction zone of the radial seal and the stator, the need to inject oil into the working fluid, the complexity of the pneumatic clamping system

As a result, the heat and power loads are determined in a small size of the tool, which affects its cutting ability, and also reduces the quality of surface treatment of machine parts [1]. In this regard, it is desirable to develop progressive methods of processing the quality of surface treatment. One such method is the rotation technique using a multi-blade tool that is forcibly rotated. The formation kinematics of this method is characterized by rolling without sliding the center point of the tool in a circle along the center point of the part in the form of a straight line [2], while the generation line is reproduced by the bending method, and the helical guide line is reproduced by the kinematic patterning method. In rotational rotation, two principles of the processing process are implemented: conventional cutting due to the sliding of the cutting wedge of the tool on the formed surface and the cross cutting during rolling due to rotation of the tool. Actual rotor profiles. This paper presents methods for replacing the side surface of an outer rotor with circular arcs, methods for calculating the coordinates of the missing rotor profile of the inner rotor, a description of the technological equipment and a method for determining the backlash and the deflection of the driven rotor angle from the nominal angle. Efficiency of the device (internal combustion engine, pump, etc.) as a whole.

The disadvantage of the two considered devices is that the opposite faces of the sealing elements periodically find themselves in zones of alternating pressure drop, which makes it impossible to provide an oil wedge for sealing and lubrication. The situation is aggravated by the fact that the sealing element is constantly at an alternating angle to the normal to the stator surface. This requires a symmetrical rounding of the face in contact with the stator, which also does not contribute to the creation of hydraulic sealing effects [3].

The indicated issue is partially resolved in the device. Here, profiled sealing elements swinging in a cylindrical recess are used as contact elements, located in the blades moving along the cam mechanism along a trajectory equidistant to the stator contour. The contact elements are pressed against the stator by air pressure, which also provides a pneumatic cushion between the blade and the contact element.

The disadvantage of this device is also the absence of a lubrication system for the friction zone of the radial seal and the stator, the need to inject oil into the working fluid, the complexity of the pneumatic clamping system, as well as the fact that the problem of coupling the stator with the radial seal element is partially solved: the device compensates for the alternating contact angles of the sealing element with stator, but is not able to compensate for the variable curvature of the stator surface, as a result of which the sealing element is in linear contact with the stator. In addition, the inclined oscillatory movements of the sealing elements do not contribute to the improvement of the dynamics of the rotor machine as a whole, imposing restrictions on its rotation frequency and acting loads. and also the fact that the problem of mating the stator with the radial seal element is partially solved: the device compensates for the alternating contact angles of the sealing element with the stator, but is unable to compensate for the variable curvature of the stator surface, as a result of which the sealing element has linear contact with the stator. In addition, the inclined oscillatory movements of the sealing elements do not contribute to the improvement of the dynamics of the rotor machine as a whole, imposing restrictions on its rotation frequency and acting loads.

The closest technical solution in its essence is a device that includes one triangular sealing element, and the radial seal is made in the form of an asymmetric trapezium, simultaneously adjacent to the end cover and stator [4].

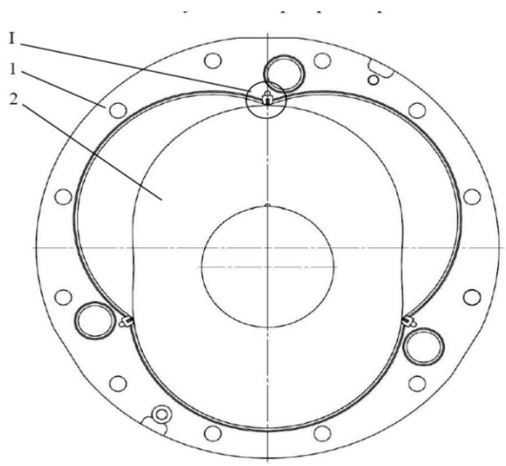


Figure 1: Shows the location of radial seals and their structural elements in a rotary machine

On the opposite side, the triangular element is pressed by a leaf spring against the opposite end cover and against the stator surface, pressing the trapezoidal asymmetric plate. Structurally, this solution provides pressing of the sealing elements to the two covers and the stator, the leakage section is halved compared to the device, however, there is an inevitable gap between the triangular element and the stator. In addition, it is characterized by all of the above disadvantages of the previously described devices associated with the lack of lubrication.

The problem to be solved by the proposed invention is to increase the tightness of the stator of the rotary machine, the resource of the radial seals and simultaneously reduce the concentration of oil and its combustion products in the working fluid leaving the rotary machine.

The technical result achieved using the proposed device consists in reducing the amount of leakage through the radial Sealing, ensuring lubrication of the radial seal using the hydraulic effect, increasing the life of the seal and the mating part, as well as reducing emissions of oil combustion products into the atmosphere when using the device in a rotary internal combustion engine [5].

To achieve this result, in the proposed device containing the stator 1 and the rotor 2, at the points of separation of the stator in its grooves 7, radial seals are installed, consisting of two pairs of main plates 3 and side compensator plates 4, mating without a gap along an angular bevel at the border contact with each other. Pairs of the main plates 3 and side compensator plates 4 are rotated in the stator groove 7 by 180 degrees so that the side compensator plates 4 are located on opposite sides of the groove. Two springs are located under two pairs of main plates 3 and side compensator plates: a lower spring 5 and an upper spring 6. The ends of both springs are split. The lower spring 5 is located in the stator groove 7, rests with its central part in the bottom of the stator groove 7, and its edges are pressed against the ends of the main plates and side compensator plates in such a way that each of the four elements of the spring 5 is in contact independently with each of the plates. The upper spring 6 is also located in the stator groove 7, resting with its central part on the lower spring 5, and its edges contact independently with each of the main plates 3. In the main plates 3, channels are formed for supplying lubricant 10 from the stator to the contact zone with the rotor 2, distributed evenly along the length of the base plate [6].

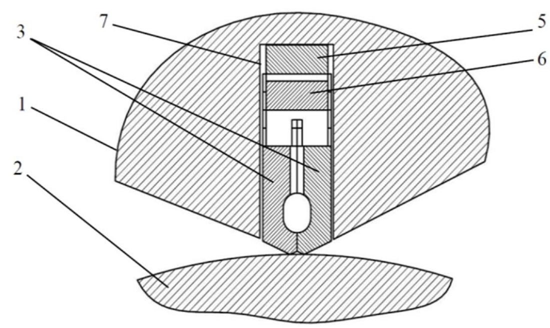


Figure 2: Shows the elements of the radial seal

II. DEVELOPMENT OF A MATHEMATICAL MODEL OF PARTS PROCESSING EXPERIMENTAL SETUP

The product includes several key parts, geometry which obeys a parametric description using equations. The work area includes the following parts: shaft, rotor and base. The main purpose of the shaft is to transmit torque to the rotor, which moves inside the base. At the base there is a working space in which the rotor moves on the shaft. To construct the rotor geometry in the experimental engine, the parametric hypotrochoid equation is used - the equation of the plane curve formed by a fixed point, which is located on a fixed radial straight line of a circle rolling along the inner side of the other circle (Figure 2).

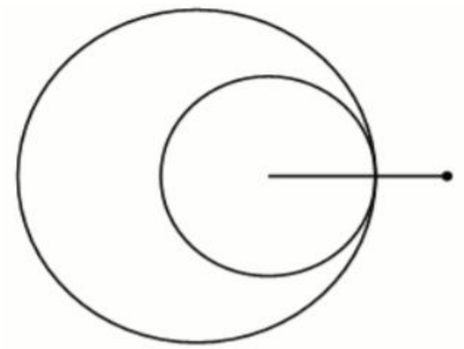


Figure 3: General view of the hypotrochoid in the initial position

$$F(x) = (R - r) \times \cos(\varphi) + h \times \cos\left(\frac{R - r}{r}\varphi\right) \quad (1)$$

$$F(y) = (R - r) \times \sin(\varphi) - h \times \sin\left(\frac{R - r}{r}\varphi\right) \quad (2)$$

Where m is the ratio of small and large radii r and R, R is the radius fixed circle, r - radius of the moving circle, φ – angular position of the circle, h - distance from the center of the rolling circle to fixed point (1,2). The rotor equation consists of several variables (parameters), defining its geometry. In particular, the value eccentricity e - variable denoting the position offset relative to the main axis of rotation of the drive shaft. Angular position rotor during rotation of the shaft is determined by the angle of rotation α, while α is in the range $0 \le \alpha \le 2\pi$.

Due to the peculiarities of the rotor geometry, the original equations 1 and 2 are transformed into a parametric hypotrochoid equation describing rotor geometry:

$$F(x) = e * \cos[\alpha] - (R - r) * \cos[\varphi + \pi/2] + h * \cos[\left(\frac{R - r}{R}\right) * \varphi + \alpha/3] \quad (3)$$

$$F(y) = e * \sin[\alpha] + (R - r) * \sin[\varphi + \pi/2] - h * \sin[\left(\frac{R - r}{R}\right) \quad (4)$$

To calculate the dimensions of the rotor, the dependences of all key parameters on the magnitude of the eccentricity are introduced: the radius of the moving circle is taken equal to two times the value of the eccentricity, the radius of the stationary threefold; the distance from the center of the rolling circle to the point is taken equal to seven times the value of the eccentricity. As a result, by varying only the value of the eccentricity, all the key parameters of the rotor can be obtained.

Taking the eccentricity index equal to one and setting the position angle α within the above limits, we obtain a graph of the rotor geometry with its position at angle α (Figure 4).

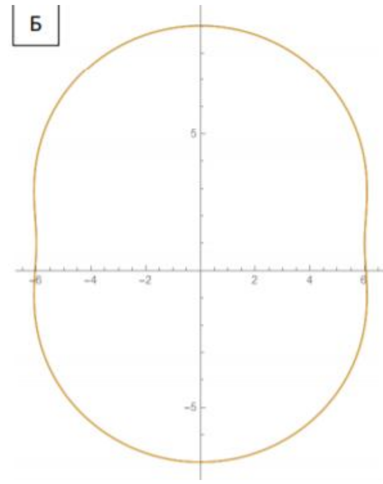


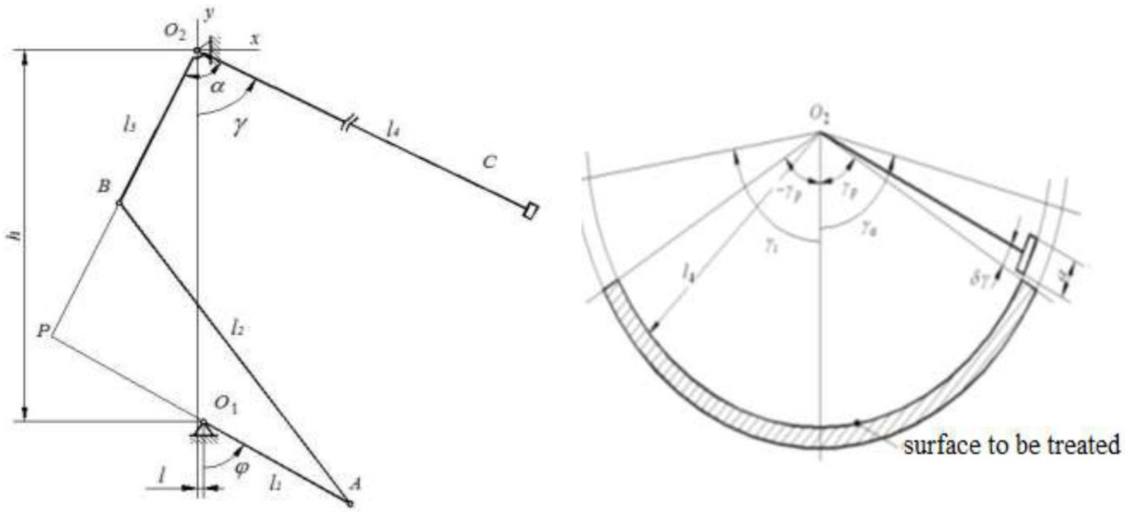
Figure 4: The geometry of the rotor at α = 0

As can be seen from Figure 1, the eccentricity value shifted the graph relative to the initial point of coordinates, thereby simulating the position of the rotor on the shaft with an offset from the main axis. Smoothly changing the value of α in within the limits $0 \le \alpha \le 2\pi$, you can get the rotor position at any time at any value of the eccentricity. As mentioned above, h is a parameter of the distance from the center of the rolling circle to a fixed point.

From a mathematical point of view, this distance is equal to the product of the eccentricity value by a certain proportional factor (in the case described above, equal to seven). If you add a correction factor equal to the radius of the cutting tool to this factor, you get a trajectory described around the rotor geometry with a tool correction. The result is a cutter trajectory that moves around the rotor and reproduces its original geometry. In addition to the cutting tool, it is possible to use abrasive nozzles (also taking into account the correction for their radius), a finishing and debugging tool. (A B) This mathematical model allows you to describe the trajectory of the tool from the point of view of the hypotrochoid, that is, the movement of a small circle within a larger one. This makes it possible to process the rotor contour of the experimental engine by repeating its geometric shape with high accuracy.

III. ANALYTICAL SOLVE TO OBTAIN AN ACCURATE SURFACE OF THE ROTOR AND STATOR

The implementation of the supporting elements in the form of special grooves corresponding to the grooves of the plain bearing allows you to combine the axis of the plain bearing sector and the axis of rotation of the swinging frame, which ensures processing accuracy. To ensure the required technological process conditions milling, a structural and kinematic analysis of the executive crank-rocker mechanism was carried out, the design diagram of which is shown in (Fig. 5, a). The minimization of the dimensions of the links of the actuator is carried out, provided that it is operable in extreme working positions crank in order to ($\gamma = 0°, \gamma = 180°$) enable it use in the processing of bearings of various diameters.



(a) (b)

Figure 5: a). Calculation diagram of the crank-rocker mechanism b). Determination of the angle of exit of the cutter beyond the work surface

In order to ensure the required overhang of the cutting tool beyond the limits of the machined surface, the angle α at the top of the rocker arm was determined, the value of which determines the swing angle of the link l_4 with the cutting tool (calculation scheme Fig. 5, b):

$$\delta\gamma = \frac{a}{2l_4}, \quad \gamma_m = \gamma_p + \delta\gamma \qquad (5)$$
$$\gamma_a, \qquad \gamma_i > \gamma_m$$

The analysis of Surface roughness when milling aluminum (D16T)

The micro relief of the sliding surface of the bearing forms friction conditions, having a significant effect on the wear processes, therefore, experimental studies were carried out in order to identify the influence of technological processing modes (feed per tooth sz, speed v and depth of cut t) on the formation of roughness of the machined surface. Based on the results of using the central compositional plan of the second order, the following dependencies were obtained (Fig. 6):

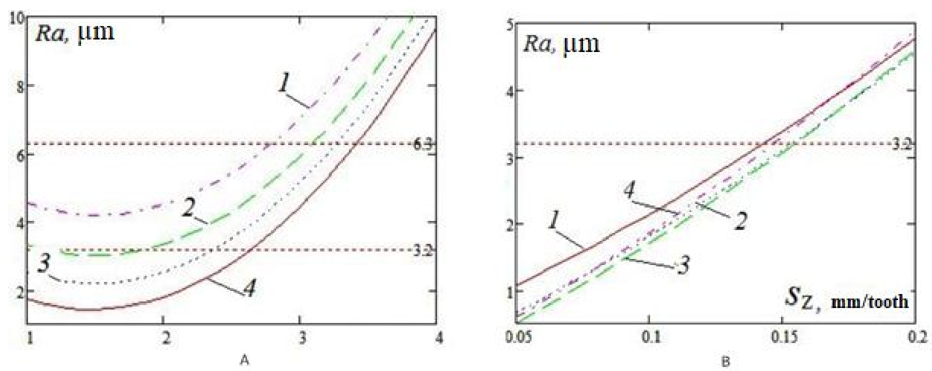


Figure 6: Surface roughness when milling aluminum D16T: a - v = 105 m / min, 1 - sz = 0.2 mm / tooth; 2 - sz = 0.16 mm / tooth; 3 - sz = 0.13 mm / tooth; 4 - sz = 0.1 mm / tooth; b - t = 1 mm,

1 - v = 75 m / min; 2 - v = 95 m / min; 3 - sz = v = 115 m / min; 4 - v = 135 m / min

The feed and the depth of cut have the greatest influence on the surface roughness: the effect of feed is close to a linear form, the effect of the depth of cut has a pronounced extremum, and the cutting speed does not have a significant effect. The nature of the roughness formation, depending on the technological conditions for tin and lead aluminum, does not differ significantly, the roughness values for D16T are slightly higher compared to D16T. An optimization model has been developed that provides an increase in productivity and a decrease in the cost of processing the supporting surface of large-sized bearings with a stable quality assurance of the processed surface by optimizing the technological parameters of a special machine module.

Figure 4 shows a diagram of the structural elements of the optimization model. Parameters to be optimized are feed per tooth and cutting speed, expressed in terms of cutter speed, which have the greatest influence on machining performance. The feed significantly affects the surface roughness and cutting power, while the cutting speed determines the tool life. The input parameters are the cutting conditions (cutter diameter, number of teeth, milling width, cutting depth) and design parameters of the bearing segment being machined (diameter and width). Technical limitations: allowable cutting temperature, specified roughness provided at the transition being performed, drive power of the main movement, specified tool life. Outputs machining time, effective cutting power, actual cutting temperature.

IV. CONCLUSION

In this paper tried to an economically viable way to obtain an accurate rotor and stator surface and studied the parameter effect on the surface finish of metal of the rotary part and stator like Surface roughness, the new model of technologies shape. The angle of cutting of the surface work and the grinding. All this led to get results like wear resistance and good lubrication. The accuracy of the surface shape is ensured due to the guaranteed straightness of the generating line and the accuracy of the guide.

ACKNOWLEDGMENTS

The work was financially supported by a program of the ministry of education and science of the Russian Federation for higher education establishments, project No. 05.608.21.0280 (RFMEFI60819X0280).

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