Development of a methodology for modeling complex shaped geokhod operating body in SolidWorks

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Abstract. Modeling complex, curved surfaces of manufactured parts is an elaborate design task. The article discusses the development of a methodology for modeling a knife with a complex helicoid surface and a geokhod knife operating body in SolidWorks. The development of the modeling methodology presented in the article allows making constructive solutions not only for the knife-type operating body of any size, but for other types of geokhod operating bodies. In addition, the solid model of the operating body knife allows assessing the stress-strain state of the operating body elements.

1. Introduction

Geokhods represent the new class of mining machines, combining the performance of technological mining cycle operations on a single platform [1–5]. The technology of cavity formation in the underground space using a geokhod is called a geokhod technology [6–8].

The main operation for the formation of a cavity in a rock mass is the destruction of the rock mass in the bottom of the mine. The destruction operation is carried out by the operating body [9–12].

At shallow depths of cavity formation in the rock mass, rocks have low physical and mechanical properties [3] and belong to the category of soft rocks according to the scale developed by M.M. Protodyakonov. In geokhod technology, knife-type operating bodies are used to destroy such rocks [13]. One of the technical solutions of the knife operating body of the geokhod is shown in figure 1.
Operating bodies of geokhods have structural and technological features [14, 15], the main of which is the dependence of the geometrical parameters of the knife operating body on the diameter of the head section and the geometrical parameters of the external mover of the geokhod [16].

To develop options for constructive solutions of a knife operating body, as well as to assess the stress-strain state of the knife and the elements of the operating module pairing with each other and with the head section of the geokhod, it is necessary to develop a method for constructing a solid model of a helicoid operating body used for face destruction [17].

Purpose of work is to develop a methodology for creating a solid model of a knife operating body for face destruction.

2. Methodology

Any point of the knife located at a distance $x$ (figure 1) from the axis of rotation of the geokhod moves to the bottom at an angle of [18]

$$\beta_x = \arctg \frac{h_B}{2\pi x}$$

(1)

For one revolution of the geokhod each point of the knife of geokhod operating body must move to the bottom of the mine by an amount equal to the step of the external mover of the geokhod $h_{e,d}$. Moreover, the length of the path for each point in the process of moving will depend on the radius of the location on the knife of the operating body. Knife points located closer to the axis of rotation of the geokhod move to the bottom at a larger angle (point $B$ at an angle $\beta_B$) than points located on the periphery of the knife (point $A$ at an angle $\beta_A$) (figure 2). The size of the cut-off layer for each point of the knife of the geokhod operating organ will depend on the angle of movement of the point to the bottom of the mine.

The point located on the periphery of the knife moves to the bottom at an angle $\beta_A$ that should be equal to the angle of inclination of the external mover of the geokhod.

We will carry out the development of a method for constructing a solid model of a knife operating body for a geokhod diameter of 1.8 m. The values of angles $\beta_x$, calculated by expression (1), depending on the location on the radius of the knife, are presented in table 1.

| No | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----|---|---|---|---|---|---|---|---|---|---|----|
| $\beta_x$, degrees | 90 | 37.36 | 23.41 | 16.81 | 13.06 | 10.67 | 9.01 | 7.79 | 6.65 | 5.54 | 5.05 |
| $r_x$, mm | 0 | 90 | 180 | 270 | 360 | 450 | 540 | 630 | 720 | 810 | 900 |
1. We select the plane in front in which the cross section of the knife of the operating body will be built (figure 3). In the selected plane, we construct the cross section of the knife (figure 4).

2. Perpendicular to the constructed sketch, we build 10 additional planes parallel to each other at a distance of 90 mm (as a component for the plane we select the plane in front and the points on the segment) (figure 5).

3. In each of the additional planes constructed, we build exactly the same sketch of the knife cross section (figure 6) as in the first construction plane (the center of the sketches will be the segment characterizing the length of the knife). After constructing the sketches in additional planes, we turn each sketch by the calculated angle (table 1) relative to the first sketch.
4. Using the boss arrangement method, we build a solid model of the knife of geokhod operating body on the base (figure 7).

![Figure 7. Solid model of the knife.](image)

5. We make a circular array 90 degrees to the previously constructed solid model of the knife (figure 8). The operating body may have a number of knife shafts. We will construct a four-shaft model of the geokhod knife operating body.

![Figure 8. Four shafts of operating body.](image)

![Figure 9. Simulating central part.](image)

6. We build a circle in the center of the connection of the four knives on top and squeeze in both directions. Then, in the constructed cylinder, we cut out the cavity of a given radius (figure 9).

7. From the center of the part we build up the center line of a given length. We add a new plane parallel to the plane at the top and the end point of the additional centerline. We build two circles in this plane and make a cutout to the side of the part (figure 10).

![Figure 10. Aperture simulation.](image)
8. We draw the center line from the center of coordinates at a given distance. We build a rectangle, positioning it so that the auxiliary line that we built is located in the center of the rectangle and extrude it to a given distance (figure 10, a). We make a circular array relative to the origin.

9. Using the tool “Arc Center” from the center of coordinates we build two circles of a given radius. In the center of the rectangle (point 8) we connect both ends of the arcs. We extrude out for a given distance. We make a circular array of this part (figure 10, b).

10. We add a circle with a radius equal to the length of the knife. The solid model of the knife operating body of the geokhod is ready (figure 11).

![Figure 11. Model of the helicoid geokhod operating body.](image)

3. Conclusion

The developed technique for constructing a solid model of the helicoid shape of a knife of geokhod operating body allows

- simulating the stress-strain state of the elements of geokhod knife operating body, as well as the fastening elements of the operating body to the geokhod bulk;
- substantiating the design parameters of both the elements of geokhod knife operating body and the elements of their fastening to each other and to the head section of the geokhod;
- developing new constructive solutions for various types of operating bodies that meet the requirements for geokhod operating bodies.

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