Determining the interaction surface parameters of the geokhod knife operating body with the face rock

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Abstract. One of the main devices of the geokhod having a direct impact on the force characteristics of the underground apparatus is the operating body. During the work of the operating body, the interaction surface of the geokhod operating body with the face rock is formed. The purpose of the research is to determine the parameters of the surface of interaction of the geokhod knife operating body with the face rock. As a result, it was revealed that the interaction surface parameters of the geokhod knife operating body with the face rock can be divided into two groups: general, which are characteristic for each variant of operating body, and variable, which are characteristic for each variant.

1. Introduction
Throughout the world, the construction of underground facilities for various purposes has become one of the priority areas. Their number in developed countries doubles every 10 years, and in the future we should expect a further increase in the rate of development of the underground space [1–6].

One of the directions for the formation of a cavity in the underground space is geokhod technology, where the basic element is a geokhod [7–11].

When developing technical and constructive solutions for devices and elements of geokhods, it is necessary to take into account the complex, helical movement of the machine to the bottom of the mine. In addition, the developed methods for determining the force parameters of devices and elements of the geokhod, which interact with the environment and among themselves, must take into account the complex nature of the movement of the geokhod [12–16].
One of the main devices of the geokhod that has a direct impact on the force characteristics of the underground apparatus is the operating body [17–21]. During the work of the operating body, the interaction surface of geokhod operating body (hereinafter – OB) with the face rock is formed. The interaction surface of the operating body with the face rock is a secondary factor and is not taken into account when designing the operating body.

Therefore, the research work aimed at substantiating the parameters of the interaction surface of geokhod operating body with the face rock is relevant.

2. Research methods

When cutting with one straight knife of the geokhod OB, all the power of blocked cutting can be represented as the sum of the three constituent forces (figure 1).

1. Forces to overcome the frontal resistance of the soil by the front edge of the knife $P_{cv}$, proportional to the cross-sectional area of the slot in front of the front edge of the knife and depending on the cutting angle and soil strength;

2. Forces to overcome the resistance of the soil to fracture in the lateral extensions of the slot $P_{side}$, proportional to the area of these parts of the slot, which depends on the strength of the soil and does not depend on the cutting angle and cut width;

3. Forces to overcome the resistance of the soil to the cut with side edges of the knife at the bottom of the slot $P_{side.mid}$, proportional to the thickness of the cut, depending on the strength of the soil and not depending on the width of the cut and the angle of cutting.

Figure 1. The area of action of the cutting force constituents with a straight sharp knife.

The interaction surfaces (hereinafter – IS) of the knife OB of the geokhod were constructed taking into account the three constituent forces shown in figure 1.

Figure 2 shows the helicoid conical surface of the interaction between the OB of the geokhod and the face rock.

From figure 2 it follows that the parameters of the helicoid conical IS of the geokhod knife OB are the radius of the geokhod $r_g$, which consists of the cutting width $b$ and the generatrix radius $r_0$, the cutting depth $h$, as well as the angle of inclination of the radial knife to a plane perpendicular to the axis of geokhod rotation $\gamma_{OB}$.

The parameters of the helicoid convex IS of the geokhod knife OB with the face rock (figure 3) include the geokhod radius $r_g$, which consists of the cutting width $b$ and the generatrix radius $r_0$, the cutting depth $h$, as well as the radius of curvature of the cutting edge of the knife $r_{ep.0}$, which center is located on the axis of mine. Another parameter will be the segment angle $\Omega$. 
Figure 2. The parameters of the helicoid conical IS of the geokhod knife OB with the face rock.

Figure 3. The parameters of the helicoid convex IS of the geokhod knife OB with the face rock.

If the curvature center of the knife cutting edge does not coincide with the axis of mine, the shape of IS of the geokhod knife OB with the face rock will have a convex torus shape (figure 4).

Figure 4. Parameters of helicoid IS with a convex torus shape.
From figure 4 it follows that the parameters of a helicoid IS with a convex torus shape are the geokhod radius $r_g$, which consists of the cutting width $b$ and the generatrix radius $r_0$, the cutting depth $h$, as well as the radius of curvature of the knife edge $r_{cp}$ with a center located at a distance $b/2$ from the mine contour. Another parameter will be the segment angle $\Omega$.

Another chosen variant of the IS of the geokhod knife OB is helicoid with the shape of a concave torus (figure 5). The difference from the helicoid IS with the shape of a convex torus will be the direction of concavity from the face rock.

Consequently, the parameters of a helicoid IS with a concave torus shape will be similar to the parameters of a helicoid IS with a convex torus shape; the only difference will be the location of the curvature center of the knife cutting edge. For a helicoid IS with a convex torus shape, the curvature center is located on the worked out space, and for a helicoid IS with a concave torus shape it is located on the side of the rock mass.

3. Conclusion
It should be noted that the parameters of IS of the geokhod knife OB with the face rock can be divided into two groups: general, which are characteristic for each variant of IS, and variable, which are characteristic of each variant.

The general parameters of IS include the geokhod radius $r_g$, cutting width $b$, generatrix radius $r_0$, and cutting depth $h$. The remaining parameters are variable and characterize each variant of IS separately.

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