Classifications of schematic solutions of the geokhod knife operating body and the interaction surface of the geokhod operating body with bottom rock

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Abstract. When developing geokhods, it is necessary to take into account the helical movement of the machine in the rock mass. In this regard, the substantiation of the technical and structural elements of the geokhod is relevant. The purpose of the work is to classify the schematic solutions of the geokhod knife operating body and the surface of interaction of the geokhod operating body with the bottom rock. As a result, schematic solutions were developed for the knife operating body of the geokhod and the surface of interaction of the geokhod operating body with the bottom rock, their classification is proposed.

1. Introduction

The development of civilization is accompanied by the expansion of infrastructure and the growth of both the population and the number of vehicles, which leads to a reduction in undeveloped territories on the planet’s surface and the search for new places to solve modern urban problems – territorial, transport, environmental, energy [1–3].

At the present stage of development of our society, the greatest interest is the underground space [4–7].

For the formation of cavities in the underground space there are many machines, one of them is a geokhod [8–12].

When developing geokhods, it is necessary to take into account the helical movement of the machine in the rock mass [13–16]. In this regard, the substantiation of the technical and structural elements of the geokhod is relevant.
2. Research Methods

The operating body (hereinafter – OB) is one of the main elements of the geokhod, affecting the power parameters of the underground apparatus [17, 18]. For destruction of soft rocks with geokhods, the knife-type OB was selected [19, 20].

Given the structural possibility of changing the geometry of the knife, it becomes possible to obtain a number of options for schematic solutions of geokhod knife OB for the destruction of soft rocks, some of which are shown in figures 1 and 2.

![Figure 1. Schematic versions of a four-shaft geokhod knife OB with different knife geometry: a) flat shape; b) inverse cone shape; c) convex cone shape; d) convex ball shape.](image)

Figure 1 shows the options for a four-beam geokhod knife OB, which make various forms of faces. So, the option that forms the flat shape of the face (figure 1, a) is a traditional form when tunneling with the shield method. With this scheme, the knives are perpendicular to the axis of rotation of the geokhod. When the knives are tilted at an angle $\gamma_{OB}$, the OB forms a conical shape face. The cone can be either convex (figure 1, b) or concave (inverse) (figure 1, c) relative to the geokhod. These schemes allow keeping the direction relative to the axis of the geokhod, but at the same time reducing the maneuverability of the machine. The geokhod OB, which forms a convex ball face (figure 1, d), in contrast, increases maneuverability.

The geokhod OB can have a different number of shafts. Figure 2 shows the schematic versions of a three-shaft geokhod knife OB for destruction of soft rocks. Schematic versions of the geokhod OB (figure 2, a, b) form the bottom of the conical shape. The geokhod knife OB forming the torus shape face (figure 2, c, d) differ from the spherical shape OB in that they form a spherical shape on the periphery and a cone in the center. The OB with a convex torus shape (figure 2, c) as well as the geokhod OB of a convex ball shape increases the maneuverability of the machine, but closer to the axis of the mine, a rational form of the generatrix appears [21], which leads to a shift of the main stresses in the direction of tension.
Based on the proposed schematic options for a geokhod knife OB (figure 1, 2), a classification of geokhod knife OB is proposed.

Figure 2. Schematic versions of a three-shaft geokhod knife OB with different knife geometry:

a) convex cone shape; b) inverse cone shape; c) convex torus shape; d) concave torus shape.

Features of classification of geokhod knife OB:

1. Location relative to the face surface:
   - convex into mass (figure 1, c, d; figure 2, a, c)
   - direct (figure 1, a)
   - concave (figure 1, b; figure 2, b, d).

2. The shape of the knife:
   - straight (figure 1, a);
   - inclined (figure 1, b, c; figure 2, a, b);
   - radial cone;
   - concave (ball shape) (figure 1, d);
   - circumferential (torus shape) (figure 2, c, d).

3. Number of shafts:
   - two-shaft;
   - three-shaft (figure 2);
   - four-shaft (figure 1);
   - multi-shaft.

4. Presence of helicoidity:
   - straight;
   - helicoid (figure 1, 2).
When the operating body is working, the interaction surface (hereinafter – IS) of the geokhod OB with the bottom rock is formed.

One of the signs of IS is the shape of the face. Taking into account the schematic solutions of the geokhod knife OB, schematic solutions of various forms of the face were developed (figure 3) with various forms of the generatrix.

![Figure 3](image)

**Figure 3.** Schematic options for the face shape: a) flat; b) conical; c) with a convex radial-conical generatrix; g) concave; d) with a concave radial-conical generatrix; e) with a circumferential generatrix.

Another sign of interaction surface between the operating body and the face rock is the presence (figure 4, a) or the absence of a bench (figure 4, b).

OB forming a bench include knife, bar, screw, drum OB. Destruction of the face without the formation of a bench is carried out by such OB as faceplate, rotary, planetary, drum.

V.Yu. Beglyakov [21] found out that in the presence of a bench, the total stresses from the action of the operating body lead to a shift in the value of the main stresses in the local zones of action of individual cutters in the direction of tension relative to the same effect with a flat face; the presence of a bench creates the prerequisites for a decrease in the specific energy intensity of fracture in comparison with the energy intensity of fracture in a flat face; the advantages of destruction of the face with a bench are manifested to one degree or another in any direction of cutting forces.

![Figure 4](image)

**Figure 4.** Schematic versions of the interaction surface of geokhod OB with the face rock: a) with a bench formation; b) without a bench formation.
Also the visible sign of IS is the number of the geokhod OB shafts, it is also the number of face benches (figure 5).

![Figure 5](image)

**Figure 5.** Schematic versions of the interaction surface of the geokhod OB with the face rock with a different number of benches: a) two-bench; b) three-bench; c) four-bench.

Based on the material presented above, one can classify the surface of the face by visible signs, i.e. signs that give a general characteristic of the interaction surface at a qualitative level, determine the type of face being formed by the presence or absence of certain signs.

**Features of face surface classification:**
1. Location relative to the face surface:
   - convex into a mass (figure 3, c, f);
   - direct (figure 3, a);
   - concave (figure 3, b, d, e).

2. Generatrix shape:
   - straight (figure 3, a);
   - inclined (figure 3, b);
   - radial cone (figure 3, c, d);
   - concave (ball shape) (figure 3, d);
   - circumferential (torus form) (figure 3, f).

3. Number of benches:
   - two-bench (figure 5, a);
   - three-bench (figure 5, b);
   - four-bench (figure 5, c);
   - multi-bench.

4. Presence of bench:
   - with a bench (figure 4, a);
   - without a bench (figure 4, b).

**3. Conclusion**
A classification of geokhod knife OB for the destruction of soft rocks is proposed. Based on the schematic solutions of the geokhod knife OB, the schematic solutions of the surface of the interaction of the geokhod operating body with the face rock are developed, and a classification of the schematic solutions of the interaction surface of the geokhod OB with the face of the rock is proposed.
For further research, it is necessary to evaluate each schematic solution of a geokhod knife OB for the destruction of soft rocks for compliance with their requirements.

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