OPEN-PIT AND UNDERGROUND MINING OPERATIONS

SCHEMES FOR THE SHIFTING OF SHIELD SUPPORTS

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A selection procedure is presented for the control of shield supports using experimental relationships between the forces exerted by jacks and the pressure of the caved rocks.

The selection of schemes for the shifting of shield supports, which ensure the safe and effective getting of coal, is an urgent problem in the development of such supports. A detailed investigation has appeared in Pomortsev's works [1] regarding these problems associated with flat shields. Use of an enclosing type of supports for the mining of coal seams over a broad range of mining-geologic conditions, including those where the dip angle varies from 37 to 90°, has led to their structural changes; this has been reflected on schemes where the supports shift in the seam.

For a self-shifting support, which can be used for seam dip angles of 45–55° and represents a rigid triangle in cross section, the "throw" is the basic scheme of shifting. In this case, the shield support is frontally displaced simultaneously along the floor and roof of the seam after breaking of coal support pillars [2, 3]. For a similar means of shifting, slots through which the ingress of caved rock is possible beneath the support arise due to the unevenness of the line of the breakage face between the lip of the shield ceiling and the coal pillar.

In a shield support with separate shifting (SSSS), which can be used for dip angles of 37–60°, a hinged coupling and jack, which connects the ceiling with the base, is applied in the rigid triangle [4]. Separate movement of the bases and ceilings along the floor and roof of the seam, respectively, can be used for this support; this makes it possible to expand the range of application of the support and to improve the safety of mining operations in the breakage face. Let us note, among other things, that, for coal seams with dip angles ranging from 37 to 45°, drill-and-blast breaking of coal support pillars will not affect the state of the support and movement will be initiated only by the jacks. Both schemes — "throw" and separate shifting — are used jointly when seams are mined with 45–60° with SSSS. Shifting with a "throw," which is initiated by drill-and-blast breaking of support pillars with subsequent forced separate shifting of the ceilings or bases up to contact with the coal mass, is carried out initially. The combined scheme is the basic scheme used in mining seams with dip angles in the range from 45 to 60° with the SSSS type of supports.

In the support of the ShchK6 shield complex [5, 6] for working seams with a dip angle of 40–90°, the jack is connected to the base and ceiling via a sliding-friction element, which under certain conditions, excludes the jack from the operation, making it possible to shift freely the ceiling along a given path due to its own weight and the pressure of the overlying rocks. The sliding-friction element eliminates the rigid coupling between the ceiling and base and performs a self-regulation function for the positioning of the ceiling. This excludes tipping of the support onto the face, and also ensures immediate shutoff of roof outcappings; this tends to improve the safety of mining operations and the efficiency of coal getting. Consequently, the new structural element makes it possible to control the ShchK type of supports in accordance with the new scheme: shifting with the "throw" and subsequent additional movement of the ceiling up to contact with the coal mass without the participation of jacks, i.e., in a regime of self-regulation of the mutual positioning of the bases and ceilings. This scheme is possible only in supports with an independent shifting of the ceiling.
The possibility of shifting a support in accordance with any of the above-enumerated schemes will depend on the pressure of the caved rock on the support and the value of forces of the jacks. The loading conditions of the shield support vary continuously as the pillar is mined. The load is determined initially by an artificially created coal cushion, and then by the caved rocks moving behind the shield from the upper horizon and by caving roof rocks after failure of the interhorizon pillar. As mine observations have indicated, the most active layer formation of caved rocks occurs in working the first 15–20 m of the pillar being mined; this is equal to three seam thicknesses (for a seam thickness of 5–6 m). A subsequent increase in this layer will not lead to a significant rise in the pressure of the caved rock onto the support. Study of the effect of the varying load by caved rock on the processes of separate shifting of shield supports is of scientific and practical interest.

The purpose of the study is to substantiate and select schemes for the shifting of shield supports of the type of ShchK6.

Let us examine the design scheme of the “support—caved rocks” system in the position of static equilibrium (Fig. 1). In that case, the pressure \( P \) of the caved rocks on the support, which contributes to the latter’s movement, is in equilibrium with frictional forces \( T_1, T_2, \) and \( T_3 \). The force \( F_1 \) of the jacks reduces to the initiation of movement, i.e., to overcoming of the resistance forces and the disturbance of the equilibrium state. The force parameters for which separate shifting of the bases and ceilings is possible can be estimated from the forces in the jacks, which are measured at the moment when the support is displaced. The problem was solved by modeling the coal getting process using a movable support equipped with hydraulic props.

**MODELING OPERATION OF SHIELD SUPPORT WITH SEPARATE SHIFTING**

Separate shifting processes were modeled on a flat rotary bench with a diameter of 200 and width of 40 cm. The experiment was performed at a bench incline of 70°. The coal mass and wall rocks were simulated by an equivalent material, which was selected in accordance with the known procedure [7]. The modeling was carried out at 1:20 scales. The space above the support was filled with fine crushed stone with a lump size of from 5 to 20 mm to a fixed height \( h_s \).

The model of the support corresponded to the analogue (Fig. 1), and consisted of two sections, the bases of which were rigidly connected in the plane of the seam and hinge-connected (across the strike), while the ceilings were joined by flexible couplings. The support was shifted with a hydraulic system consisting of a manual plunger pump, valves, a manometer, double-action jacks with a one-sided rod outlet, and a main hydraulic line. Shifting was accomplished separately along the roof or floor of the seam. For this purpose, we mined the appropriate support pillar and delivered pressure to the piston or rod chamber of the jacks. The manometer readings were recorded at the start of motion of the shield ceiling.