An Establishment of Dependencies of Mutual Influence of Geological and Mining Factors on the Stress-Strain State of the Rock Mass

D N Shurygin¹, S V Vlasenko¹, I A Turbor¹
¹Department of mining, Platov South Russia State Polytechnic University (NPI), Prosveschcheniya St. 132, Rostov region, Novocherkassk, 346428, Russia

E-mail: shurygind@mail.ru

Abstract. The production activity of the coal mining industry is accompanied by the involvement in the development of deposits, which are characterized by a complication of mining and geological conditions at a depth of 1500 m. The increase in mountain pressure at great depths leads to a decrease in the efficiency of the use of complex mechanized technologies of coal mining. This is due to the imperfection of the technologies of fastening and control of mountain pressure. The existing schemes of movement of mechanized supports were developed for use at depths up to 800 m and do not take into account the features of geomechanical processes in the rock mass at depths of more than 800 m. In addition, the known technologies of fastening and management of the roof do not provide the necessary speed of fastening of the treatment face at high speeds of moving longwall, thereby causing the formation of large undefended areas of the direct roof and increasing the probability of dumping in the bottom-hole space of longwall.

1. Introduction
The analysis of modern trends in the development of tools and technologies for the extraction of thin and medium-sized coal seams in complex geological conditions at great depths showed that modern technologies of excavation and mechanized systems do not provide sufficient performance of the treatment face without reducing the level of safety [1-6]. Existing hydraulic mechanized supports provide satisfactory operation of the treatment face. However, we can note their common disadvantages: multi-element and bulky structures, high inertia in the movement, not high enough reliability to perform the process of fastening without the presence of people in the longwall. It is obvious that the search for promising technical solutions should focus not only on the modernization of existing hydraulic supports, but also on the creation of fundamentally new means of fixing treatment faces. The main indicators characterizing the interaction of the support with the roof are the absolute value and the nature of the convergence of the host rocks, the level of contact of the cover with the direct roof and the actual performance of the mechanized support [7-13].

The wrong choice of the type of mechanized support and its movement scheme in the treatment face for certain mining and geological conditions of the coal seam occurrence leads to an increase in the convergence of the host rocks with a reduced working resistance of the support. As a result, tensile stresses occur in the lower layers of the immediate roof, which lead to the crack opening and dump in the bottom space of longwall [14-19]. When high working resistance of the lining in the bottom layer
of the immediate roof arise compressive stresses that exceed the tensile strength of rocks in compression and result in dump in the longwall [20-23].

Analysis of the principle of operation of the powered roof supports and schemes of her relocation in a breakage face points to the fact that the formalization and identification of technological parameters in order to assess the reliability of the production process in a stable mode, it enables the parameter that takes into account physical-mechanical and strength properties of enclosing rocks to minimize the holding of ad hoc works when shifting sections of powered roof supports.

2. Problem’s statement and methods of its solution
To solve practical issues in the field of reliability of technological schemes of excavating coal of the necessary criteria with which to quantitatively assess the reliability of the mines equipped with coal-mining and transport machines and mechanisms, and hydraulic supports. The existing methods of research of reliability of mining technologies and production processes do not meet the requirements of practice and the level of mining technology. The reviews of the state of reliability studies in recent years have noted dissatisfaction with the existing methods of reliability studies, since the forecast estimates and the real values of reliability indicators have significant differences.

Unproductive time costs are caused by a set of factors, among which mining and geological conditions of the reservoir are dominant. Physical and mechanical properties of rocks cause the redistribution of stresses in the massif of host rocks during the development of coal seams. The establishment of dependencies of mutual influence of geological and mining factors on the stress-strain state of the massif allows to develop recommendations to reduce the time-consuming.

The rock mass with the coal seam under development is an anisotropic elastic-plastic medium. Consider the initial stage of development of coal seam before the closure of the roof and soil rocks. The x-axis of the Cartesian coordinate system is directed along the formation perpendicular to the treatment face line, the y-axis perpendicular to the formation in the direction of the surface. The origin is taken to be the middle of the developed space. Near the bottom of the coal seam is in an inelastic state. Part of the developed space on the site is fixed.

After a part of the coal seam has been removed, there is a redistribution of stresses in the coal seam and the host rocks. An additional stress field is found from the boundary conditions. The coal seam under development is in the ultimate stress state in the reference pressure zone. To formulate boundary conditions, it is necessary to solve the problem of determining the stresses in the boundary of the coal seam. The numerical method allows to solve the initial characteristic problem. The zone is limited by four lines, two of which are already known voltage. The coordinates at the nodal points are determined by solving difference equations. The method allows you to find the coordinates of points and stresses in them with any accuracy in the entire area.

The mixed problem is formulated as follows. The zone is limited to two characteristics and the contact line, which is not a characteristic line. Divide the segments into equal parts, and draw characteristic lines from them. The coordinates of the grid nodes and the value of the parameters at the node points are found from the difference relations. On the contact parameters are determined from the boundary conditions. Thus, the stress state is determined in this zone. Acting in a similar way, in all areas of the formation, moving along the sliding lines, we determine the stresses.

3. Discussion
Analysis of the obtained numerical results showed that the stresses in the bottom formation zone to increase in absolute value as the distance from the face into the depths of the array and can exceed the tensile strength of the rock.

It is established that in the area of free hanging of the roof rocks are unloaded. At a distance of 5-10 m from the face, a zone of tensile horizontal stresses is formed. The stronger the anisotropy of rocks, the greater the magnitude of the tensile horizontal stresses. With increasing anisotropy of the host rocks, the horizontal tensile stresses are 5 times higher than the vertical tensile stresses. The presence
of support leads to a decrease in the deflection of rocks. The effect of the support extends to a distance of 3-4 m.

The development of the coal mining industry has shown that the previously developed standard schemes for the movement of sections of the mechanized support are a limiting factor for increasing the load on the treatment face. The vast majority of mines of Donbass, under the control roof complete collapse applied a consistent scheme of shifting sections of powered roof supports. With this method of management of the roof, there is often a situation when the cleaning combine is removed from the place of movement of sections at a distance of more than 4-5 m due to the lag of the fastening process. In most cases, this causes the destruction of the immediate roof of the formation and rock falls in the bottom space.

To assess the dependencies, in December 2012 was carried out by the timing of the observation in the 8th Western lava formation l4 of the mine "Trudovskaya". During December 2012, 11 time-lapse observation cycles were carried out. Over the observation period occurred on the 7th of dumped rocks of the direct roof of coal in the bottom space of longwall. A fall in the vast majority due to delays in the process of fixing. The maximum fixed fastening gap from the lower screw section 4, which is 6 m. The area of exposure, taking into account the length of the combine is 8 m. Calculations using the new mathematical apparatus allowed to establish that for the conditions of the mine "Trudovskaya".

Allowable area of exposure of the roof in the lava is 6 m, which is much less than the recorded values of exposure in the longwall.

4. Conclusions

It was found that with the increase of the anisotropy of the host rocks, when the young modulus value in the horizontal direction is twice more than in the vertical direction, the horizontal tensile stresses are five times greater than the vertical tensile stresses. Improved elastic-plastic model of the interaction of powered roof supports stope rock mass with an array, allowing, depending on the properties of host rocks to develop a scheme of shifting sections of powered roof support for mining and geological conditions of mining of coal seams at great depths.

Recommendations for improving the efficiency of complex-mechanized coal mining in complex geological conditions at great depths have been developed. The implementation of the developed recommendations in the 8th Western lava layer l4 of the mine "Trudovskaya" allowed to increase the speed of moving the treatment face to 94.5 m/month (20%), increase the load on longwall to 1453 tons per day (25%).

5. References
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