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DETERMINATION OF SOME MINING PARAMETERS OF THE LONG WALL FOR THE EFFECTIVE USE OF PLOUGH SYSTEMS IN THE WESTERN DONBAS MINES

[1]Oleksii Voloshyn, [2]Siarhei Onika, [1]Oleh Riabtsev, [1]Serhii Protsak, [3]Olena Nykyforuk

[1]Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine, [2]Belarusian National Technical University, [3]Institute for Economics and Forecasting on National Academy of Sciences of Ukraine

Abstract. Theoretical studies of stress strain state of rock under the extraction pillar working by mechanized complex with plough systems were conducted. As a result of studies the mining parameters of the wall face working are presented. The mining parameters include the width of coal shavings continuously removed before reaching the critical rock pressure in the face and duration of the technological pause between removal of coal shavings, that leads to "relaxation" of rock pressure in the bearing zone to a safe state for continued mining. The use of the values of these parameters during the extraction pillar working ensures efficient and no-failure operation of high-performance mechanized complexes equipped with plough systems as shown by the example of mining and geological conditions of one of the mines of the Western Donbas.

Intoduction. Analyzes of the past and current states of world coal production and consumption show that coal still remains one of the main resources with high role in the fuel and energy complex. The coal industry is important for Ukraine, which has large reserves of coal and incomparably small reserves of oil and gas. Providing comprehensively favorable conditions for the mines operations is a prospect of development of Ukrainian mining enterprises. The efficient use of high-performance equipment, with minimal losses, ensures no-failure, safe operation and careful use of the subsoil. In addition, the maximum satisfaction of demand determines the volume of coal production and, if necessary, its increase [1].

When coal is mined by high-performance plough mechanized complexes during their continuous operation with high speeds of daily advance and, more importantly, high speeds of coal shavings removal by the executive body, the parameters of the bearing pressure zone are redistributed [2]. The total length of the bearing zone is reduced, the location of the maximum value of the bearing pressure is shifted towards the rock face, while the value of the bearing pressure increases. In this case, the bearing zone "creeps" onto the wall face, which can cause various negative phenomena, such as destruction of rocks of the immediate roof in the wall face with the formation of destruction domes, delamination of the main roof rocks, the destruction of the coal seam, the extraction of the coal seam into the wall working space, the coal outburst, etc.

To prevent negative phenomena, it is necessary to combine the speed of movement of the face with the speed of movement of the bearing pressure zone. The duration of the movement of bearing pressure zone according to research [3] is in the range of 40 – 60 minutes and depends on geological and mining factors. Thus, the efficiency of plough systems is determined by its ability to provide the highest level of coal production during no-failure operation, using the rational mining parameters for specific mining and geological conditions. One of the main mining parameters in this case is the width of continuously removed coal shavings. The width consists of several coal mining cycles by executive body of plough system. After each coal mining cycle, the stress-strain state of the rocks in the long wall bearing zone changes. It is necessary to provide a technological pause when the stress-strain state reaches critical values (when the stress components exceed the corresponding limit values for this mining and geological conditions). This technological pause is another of the mining parameters that is defined in this work. The pause is necessary to provide "relaxation" of bearing pressure zone and prevent the negative phenomena described above.

Based on this, the purpose of the work is to determine the width of continuously removed coal shavings during the operation of plough system, as well as the duration of the technological pause between the removal process to ensure efficient and no-failure operation of high-performance mechanized plough systems in the mines of the Western Donbass.

Methods. Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine proposes a methodology for solving practical mining problems based on the modified Fuss-Winkler theory and implemented in the form of a software-technological complex "Technology for Planning Strategic Development of Mining Operation", which for the first time comprehensively takes into account the influence of mining, geological and working conditions, as well as the time factor (36 parameters in total) on the geomechanical state of the rocks surrounding the mine workings [4 – 6]. Using the Technology, changes in the stress-strain state of rocks are simulated and rational technological parameters are selected when solving a specific mining problem.

The indisputable advantage of the Technology, in comparison with existing methods [7], is a comprehensive account of the impact of the stress-strain state of rocks during mining of wall on the state of development workings, and account of the impact of mining operations on adjacent seams (underworking/overworking). This makes it possible to find the rational technological parameters of mining for the conditions of a particular production unit even at the design stage.

In addition, the determination of the stress-strain state patterns of a rock massif makes it possible to find the parameters of massif deformation. The main parameters are as follows: rock fault, upheaving of soils, convergence of working walls, horizontal movements of seams relative to each other by bedding, formation of delamination cavity and heir sizes. All these parameters as well as normal loads and stresses make it possible to solve complex mining problems.

Today technological and economic effectiveness of the Technology has been firmly proved in practical application in six greatest coal-producing enterprises of Ukraine [4, 7].

Results and discussion. The above complex scientific and practical problem has been solved by the example of one of the long wall geological and mining conditions in the mine of the Western Donbas, which has been equipped with a mechanized complex DBT and plough system GH 9-38ve. The mining parameters this long wall are as follows: the length of wall face is 300 m, the length of the extraction pillar of long wall is 3000 m, the rate of face advance is 13.7 m/day, the speed of removal of coal shavings by the executive body is 2.5 m/s, the working width of the executive body of the plough system is 0.07 m.

While researching, the excavation column has been conditionally divided into 6 sections, differing in geological conditions determined by exploration wells located on the field of the excavated mining column. The mining conditions of mining have been unchanged.

The use of high-performance mechanized complexes equipped with plough systems is most effective for coal cutting resistance ≤ 350 kN/m. Otherwise, without a significant increase in the driving power of plough systems, it is practically impossible to remove coal shavings, the executive body simply slips over the coal seam surface. In the coal mines of the Western Donbas, where the host rocks have less strength than the coal seam, there is a high probability of the plough leaving the seam to softer rocks of the roof or soil. In the studied conditions, the uniaxial compression strength of a coal seam is 35 MPa, and uniaxial compression strengths of the roof and soil rocks are 23 MPa and 22 MPa, respectively.

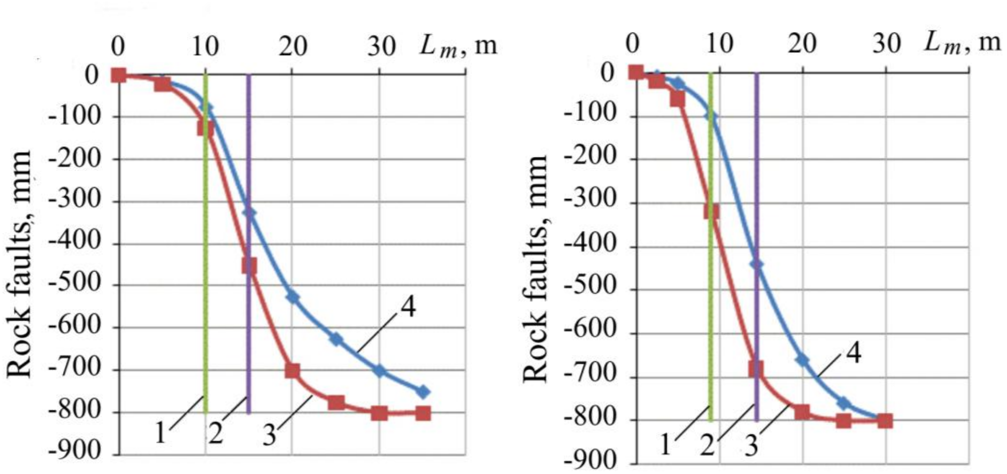
The simulation of changes in the stress-strain state of the rocks of the immediate roof performed by Technology [3] has showed the following. The immediate roof collapses due to a critical increase of all stress components when coal shaving reaches the total width higher then 0.3 – 0.6 m for different geological conditions under the continuous removal of coal shavings by plough system. According to the simulation results, the angle of the plane of destruction is directed from the rock face in the lower part of the immediate roof to the working space in the upper part of the immediate roof and the value of the angle is about 45°.

The simulation of changes in the stress-strain state of the rocks of immediate roof after its destruction shows that the values of all stress components exceed the corresponding limit values. Perhaps this is due to the delamination of immediate roof. This occurs at the moment of destruction of the immediate roof, and leads to a very rapid increase in rock faults over the space supported by powered roof support. The simulation results show that in this case, the loads on the powered roof support are increased by 1.3 - 2.7 MPa while increasing in the rock faults to the level of powered roof support back part by 280 - 420 mm relative to the rock faults that have taken place before the destruction of the immediate roof and delamination of the main roof.

The studies and the results of these studies, as well as their comparison with the technical characteristics of powered roof support, indicate the possibility of fitting the powered roof support on a "hard base" in the case of continuous coal mining after removing shavings with a total width of 0.3 – 0.6 m.

Based on the simulation results (Fig. 1) using the example of sections of the excavation pillar located in the ranges of 1500 – 1900 m (Fig. 1, a) and 1900 – 2200 m (Fig. 1, b), the dependences of rock faults of the main roof in the section along wall face *L*, before and after delamination of the roof rocks.

The pattern of rock faults of main roof, shown in Figure 1, retains a similar trend in all six studied sections of the extraction pillars. Thus, when the rocks of the immediate roof are destroyed, the rocks of the main roof stratify, which leads to a rapid increase in rock faults by 280 – 420 mm and fitting the powered roof support on a "hard base". In this case, an emergency in the long wall may occur.



(a) (b)

Figure 1 – Rock faults of main roof before (4) and after (3) the rock delamination in the area of wall face (1) and border of powered roof support (2) along the wall face L: a) – for the long wall section 1500 – 1900 m, b) – for the long wall section 1900 – 2200 m

To prevent the negative consequences of destruction of rocks of immediate roof in wall face and the subsequent delamination of main roof, it is necessary to perform the following. It is suggested to make a technological pause after removal of coal shaving of a certain width under continuous operation of plough system. Because of that the stress-strain state of rock in bearing zone returns to the initial state that corresponds to the beginning of mining operations.

The duration of the technological pause between the process of continuous removals of coal shavings is calculated on the based on the methodology for calculating the duration of technological processes during mining [8]. According to this methodology, the time for removal of coal shavings by a plough system with a width of b_c = 1 m is t_1 = 30 minutes, and the recovery time of bearing zone, as mentioned above, is on average t_r = 50 minutes. Thus, for a "relaxation" of bearing zone to its initial state under the continuous removal of coal shavings 1 m width, a necessary technological pause is:

$$t_p = t_r - t_1 = 50 - 30 = 20 \text{ minutes}.$$

When simulating the geomechanical state of rocks during mining, it has been found that the width of continuously removed coal shavings depending on changes in geological conditions along the extraction pillar is 0.3 – 0.6 m. Based on this and estimated time for a technological pause between the process of continuous removals of coal shavings of 1 m width, we determine the duration of the technological pause for the specified range of width of continuously removed coal shavings by the expression:

$$t_{pi} = b_{ci}\, t_p / b_c,$$

where b_{ci} is a width of continuously removed coal shavings on different sections of the extraction pillar, m.

Table 1 shows the calculated values of continuously removed coal shavings width and duration of the technological pauses for studied mining and geological conditions.

Table 1 – Calculated values of continuously removed coal shavings widths and duration of the technological pauses for studied mining and geological conditions

Range of the long wall section, m	Width of continuously removed coal shaving, m	Duration of the technological pause, min
200-550	0.6	12
550-950	0.4	8
950-1500	0.5	10
1500-1900	0.4	8
1900-2200	0.3	6
2200-2400	0.5	10

Conclusions.

1. Under the continuous removal of coal shavings by a plough system during the entire operating shift, dynamic manifestations in the wall face from the side of roof rocks are possible, which are caused by the destruction of the rocks of the immediate roof. It leads to instantaneous increasing of normal loads and all stress components in the rock seam of the main roof, which causes its delamination and leads to a sharp increase in rock faults above the powered support by 280 – 420 mm and an increase in the support load by 1.3 – 2.7 MPa. The load can exceed the load-bearing capacity of the powered roof support, which leads to the destruction of its structural elements and the fitting the powered roof support on a "hard base".

2. According to the results of studies performed for these conditions, the destruction of the rocks of the immediate roof in wall face does not occur if widths of continuously removed coal shavings are less than 0.3 – 0.6 m, depending on the geological conditions, and duration of technological pause is 6 – 12 minutes. That leads to "relaxation" of rock pressure in the bearing zone to a safe state for continued mining.

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