MODE OF FORMING DISMANTLE CHAMBER IN MINING GENTLY-SLOPING COAL-BEDS

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ABSTRACT

The important issue of improving the effectiveness of installation and dismantling work in mining gently-sloping coal beds of big thickness, has been constantly increasing in relevance for many years due to the overall complication of the mining conditions. The paper describes the findings of reviewing the experience of installation and dismantling work in Russia’s mines, specifying the advantages and disadvantages of the main technologies of forming dismantle chambers. Such technologies include ahead sinking of an advance dismantle mine working and forming a chamber directly by means of the mining face. The paper demonstrates that in the practice of installation and dismantling work, long downtime periods of a longwall set of equipment might occur. Downtime periods of mining equipment which last up to several dozens of days, cause a substantial economic loss to a company. The main cause of the dismantle time increase is an unstable state of the roofing rocks above the dismantle chamber. Roofing weakening and the loss of its stability when the longwall set of equipment is installed into the dismantle working, occurs as a result of the protracted impact of the approaching longwall support pressure, with the longwall speed decreasing while approaching the dismantle spot, due to a number of the reasons of geotechnical nature. The authors of the paper suggest the mode of forming a dismantle chamber where roofing rocks above the future dismantle spot are preliminary extracted, and a man-made filling mass is constructed in their place, with specified parameters and characteristics. As a result of implementing the set of measures and engineering solutions, the man-made roofing in a dismantle chamber enables to hold and control this roofing more effectively, compared to natural roofing. This, in turn, enhances the work effectiveness and the safety of mine workers when conducting dismantle work.

INTRODUCTION

The coal industry in the Russian Federation has had a visible trend of increasing the load on mining faces equipped with longwall sets of equipment. In the recent 16 years, the average daily output from fully mechanized faces in Russia’s mines increased by a factor of 3.4 (Tarazanov, 2016). With the coal face equipment production rate growth, the losses caused by this equipment downtime periods, increase as well, amounting to tens of millions of roubles per day. Downtime periods of fully mechanized faces might have a number of causes: equipment malfunctioning; rectification of the consequences of roof dynamic settling; preventive measures on preventing the negative manifestations of rock pressure and gas-dynamic phenomena; breeding fires; face-to-face transfer of the longwall set of equipment; ineffective work organization in the company, and others. Among all the above-mentioned causes, downtime periods during face-to-face transfer are inevitable, and for this reason minimizing them is extremely important for improving mining effectiveness.

In long-term prospect, intensifying the underground production of coal will result in the increase of the number of working areas of limited dimensions, hence, the average annual installation and
The average duration of dismantling a longwall set of equipment, as the standard for mine operations in Russia, varies from 45 to 55 days. The actual average duration of work on dismantling a longwall set of equipment, is 25-30 days, with the mine face length of 190 m to 220 m, except for the cases of problems with roof support when the duration of dismantling extends up to 80 days and more, exceeding 150 days in some cases. For example, dismantling longwall set of equipment TAGOR 24/50 from chamber No. 1324 at the depth of 210 m to 290 m in mine named after November 7th, lasted more than 60 days because of the roof lowering by 1 m to 2.5 m along the entire longwall length (Kharitonov, 2016) during forming a dismantle chamber. In another case, dismantling longwall 6703 having 215 m in length, in Taldinskaya-Zapadnaya-1 mine was conducted at the average depth of 217.8 m, and lasted 65 days, and 39 of them were used for forming a chamber with strengthening roof rocks via polymer glue Shakhtizol-100. In Taldinskaya-Zapadnaya-2 mine, during mining extraction pillar 7006, with the longwall length of 250 m and the dismantle chamber stowage depth of 223 m to 306 m, the complete to dismantling of a longwall set of equipment lasted 154 days. The main cause of the dismantling duration increase was the occurrence of a roofing cavity which was not timely fixed, resulting in the large roof rocks collapse (Karpov, 2013).

Review of the experience of applying various technologies (Karpov, 2013) brings the conclusion that the main cause of extending the duration of dismantling is the strongly broken condition of the rocks of the immediate roof caused by the face support pressure impact on the immediate roof. At the same time, dismantling the shearer, face conveyor and other equipment, as a rule, does not cause long downtime periods, with the key problems arising when powered supports sections are extracted.

The experience of Zarechnaya mine is a positive example of fast face-to-face transfer, with the total downtime period of longwall set of equipment KM138/2 during its dismantling from longwall 1101 being as short as 16 days. In Kotinskaya mine, the total period for dismantling longwall 5204 with a longwall set of equipment, was 25 days, and the set was installed into the dismantle chamber in less than 24 hours.

A paper (World mining equipment, 1991) reports that the fast transfer of the longwall set of equipment to a new working area, conducted in 1991 in Plato mine (Utah, USA), lasted only 105 hours, and at that period, the fastest time of face-to-face transfer in the USA was 52 hours. It should be noted that the paper does not describe the equipment parameters and mining technologies in sufficient detail. Nevertheless, such results can be considered as outstanding even for the current level of technological development of installation and dismantling work. No similar cases were reported in the open literature during the mining of medium and thin beds in Russia’s mines.

Despite the strong interest being expressed by scholars and production specialists to the issues of intensifying the work on dismantling longwall sets of equipment of mining faces, this area still has a significant potential for reducing downtime periods and improving the work safety of mine workers. The authors of the paper strongly believe that the success in dismantling a longwall set of equipment is related to competent selection of a dismantle chamber forming, alongside with work organization and planning.

METHODS

The applied technologies of forming dismantle chambers can be conditionally divided into two groups, basing on the results of reviewing more than 40 cases of the face-to-face transfer of longwall sets of equipment in mines in Russia and other countries. The technologies of the first group include ahead sinking of an advance dismantle mine working (crosscut or through-cut) with subsequent installation of a longwall set of equipment into it. The second group includes the technologies based on forming dismantle chambers directly by means of mining faces with subsequent construction of overlapping in the longwall face space. Also, there is a mode of forming a dismantle chamber by means of coal face heading set of equipment, with its application
in Raspadskaya-Koksovaya mine described in a paper (Grechishkin, 2014), but because of a number of reasons related to high labor intensity and the peculiarities of mining in the longwall support pressure zone, this mode has not been widely used in the mines of Russia’s major coal basins.

The key advantages of the technologies of the first type include the capacity of ahead strengthening the roof rocks above the dismantle spot prior to the longwall approach and the roof rocks’ entering the support pressure zone. A number of papers describe cases of successful application of the technologies of this type (Artemiev, et al., 2010; Stankus, 2014; Bauer, 1988; Tadolini, 2002). The major flaw of such technologies is the presence of a decreasing pillar between the mining face and the advance dismantle mine working. The destruction of the pillar resulting from the effects of the increased pressure before the entrance to the chamber, creates significant difficulties in several aspects. Big amounts of rocks fall into the longwall face working space, preventing the further movement of the longwall before rock burst are removed. The formation of a non-strengthened cavity in the roofing in front of the longwall face complicates controlling the powered supports’ sections in installing them for thrust. As a result, the load on the roofing, as well as the duration of the load, significantly increase, along with the probability of the hazard of the support resting upon the frame of the longwall set of equipment (Kharitonov, 2016; Peng 2006; Tadolini, 2003).

The technologies of the second group enable to eliminate the above-mentioned defects. Currently, the leading coal mines having high production rate of mining faces and maximum spatial concentration of works, predominantly apply the technologies of the second type. At the same time, because of the face advance speed reduction caused by the need to form protective overlapping and to install dismantle chamber roofing, the intensity of inrushes increases, as well as the duration of the longwall support pressure affecting the roof rocks above the dismantle spot (Zubov, et al., 2014). This reduces the stability of the roof rocks and significantly increases the likelihood of inrushes into the working area.

Thus, in both the technology groups, the main cause of the downtime periods increase during dismantling, is the unsatisfactory state of the immediate roof rocks above the dismantle chamber.

RESULTS AND DISCUSSION

The authors of the paper suggest the mode of forming a dismantle chamber enabling to eliminate the presence of unstable rocks in the chamber roofing. No similar mode has been reported, according to the review of the open literature conducted by the authors.

The suggested mode is illustrated by Fig. 1-3. The dismantle spot of the longwall set of equipment is prepared in advance by constructing a man-made roofing of a dismantle chamber. For this purpose, a working filled with solidifying stowage materials, is sunk directly above the dismantle spot.

Sinking a stowed working starts from making stable-hole 1 in one of site development workings 2

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**Fig. 1.** Layout of sinking a development working into the roofing of the future dismantle chamber: 1-stable-hole; 2-development working; 3-pass; 4-stowed working; β-pass inclination angle
(Fig. 1), the stable-hole is required for the heading machine U-turn. Depending on the geomechanical and geoengineering conditions, the stable-hole can be constructed both in the protective pillar and in the coal massif. If the working width is sufficient for performing a U-turn, constructing a stable-hole is not required. Then pass 3 into stowed working 4 is constructed. Maximum pass inclination angle $\beta$ should be adopted, according to the equipment technical capacity.

Stowing along the length of the working is conducted in blocks separated with shuttering. Pass 3 into working 4 is stowed as well.

Depending on the dimensions of the longwall set of equipment and the size of the maximally stable bay, the working may be sunk in one or several stopes with their stowing one by one. The soil of the working is located at the height of the designed dismantle chamber roofing. If the working is sunk in several stopes, their contact area $AB$ should be located above the overlapping of the powered supports' sections (Fig. 2).

The width of the stowed working is established by the equation:

$$b = x_1 + x_2 + x_3$$

where $x_1$ is the length of the supporting part of the powered supports, $m$; $x_2$ is the width of the dismantle lane required by the technology, being a factor of the grip width of cutter-loader $r$ (as a rule, 1.6 m to 2.4 m), $m$; $x_3$ is the width of the forward part of the filling mass (adopted as exceeding the width of the sloughing zone $z$), $m$.

It is recommended to adopt the minimally possible height of working $h$ because of the technological requirements.

The parameters of the lining of a working should ensure the working stability before the complete solidification of the filling mass, as well as the maximum speed of sinking the working. The requirements to the strength and deformation characteristics of the filling mass are identified basing on specific mining engineering and geological conditions. The filling mass should completely

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**Fig. 2.** Cross-section of the dismantle chamber after turning off the longwall set of equipment: $b_1$—the width of the 1st stope; $b_2$—the width of the 2nd stope; $b$—the finite width of the stowed working; $x_1$—the length of the supporting part of the powered supports overlapping; $x_2$—the dismantle lane width required by the technology; $x_3$—the length of the forward part of the filling mass; $z$—the width of the sloughing zone; $h$—the height of the stowed working.
solidify prior to its entering the support pressure zone of the approaching longwall.

The application of this mode results in forming a stable filling massif of separate monolith blocks in the dismantle chamber roofing. The layout of lining and controlling the dismantle chamber roofing when the powered supports’ sections are extracted, is demonstrated in Fig. 3.

The suggested technology stipulates the application of two or three pilot sections 1 of the powered supports unfolded towards the dismantle direction, for roof support in the zone of extracting the linear sections of set 2. Along the entire length of the dismantle chamber, on the boundary with the worked-out area, along the face flange and along the longitudinal contact line of the filling mass blocks CD, auxiliary support is installed. Auxiliary support can have different type and parameters, depending on the mining geological and engineering conditions, these parameters should be established according to the dismantle data sheet. In this example, on the boundary with rock burst 7 and along flange 6, installation of wooden bars of individual support 3, is stipulated. Wooden chock 4 is installed under the contact areas of the filling mass blocks.

When filling mass is formed for enhancing the control effectiveness, during the sections dismantle it is possible to divide the filling mass into blocks 5 of required length \( L_{\text{block}} \) by lowering the roofing. For this purpose, the stowage of the workings sunk in the roofing, should be conducted in stages, with blocks separated by shuttering installed at the distance equal to block length \( L_{\text{block}} \). Dividing filling mass into blocks, both down the dip and along the strike, will eliminate bracket hanging during roof dismantling, preventing resulting high loads on pilot and end sections.

Wooden roofing, due to its pliability, enables

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**Fig. 3.** Process of extracting power supports’ sections and roof control in a dismantle chamber according to the proposed technology: a-view of sections’ dismantle spot from above (the image is turned); b-the dismantle chamber cross-section (in parallel with the face flange); 1-pilot sections; 2-dismantled section; 3-wooden supports of individual roofing; 4-chock; 5-filling mass blocks; 6-mining face final position (face flange); 7-worked out space (rock burst); \( L_{\text{block}} \)-stowage block length.
smooth lowering of filling mass. At the same time, the sufficient section of the dismantle chamber is preserved for its airing due to the overall mine depression throughout the entire dismantle duration.

CONCLUSION

Testing the above-mentioned mode of forming a dismantle chamber will become the next stage of the study. According to preliminary estimates, the anticipated economic effect from implementing this mode of forming a dismantle chamber, will include:

- Improving work safety of mine workers during dismantling a longwall set of equipment;
- Improving work conditions in a dismantle chamber by means of sustainable airing and reducing the amount of manual labor related to rectification of the consequences of roof rocks' caving into the working area;
- Reducing the downtime periods of expensive high-capacity longwall equipment;
- Increasing the average yearly coal production output from mining face;
- Increasing the labor productivity in a company.

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