Geomechanical feasibility of underground coal mining technology using control systems of electro-hydraulic shield supports for longwall mining

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Geomechanical feasibility of underground coal mining technology using control systems of electro-hydraulic shield supports for longwall mining

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Abstract. The main objective of the research is to assess the possibility of using control systems of electro-hydraulic shield supports for researching geomechanical processes in the rock massif. The research aims to increase the efficiency of longwall mining technology. As a result of the research, changes of pressure distribution in the hydraulic powered shield supports along the width and length of the longwall panel are established. Pressure changes at various speeds of a longwall advance have been established. Recommendations about an increase in efficiency of underground mining of coal seams are made. The paper novelty consists in establishment of dependences of the maximum loads upon a shield on the speed of the longwall advance.

1. Introduction

Use of the modern reliable and powerfull equipment in longwall faces provides growth of intensity of flat coal seams and improves technical and economic indicators of underground mining. However, underground coal mining is characterized by the high level of accident rate that defines the need for studying mining operations conditions to enhance safety of underground mining [1-12]. Besides, the work of present-day longwalls is characterized by equipment downtimes, considerable duration, which happen both during mining of longwall panels and during removal of equipment [13-14]. Experience of the flat coal seams mining in mines of the Kuznetsk coal basin shows that the actual time and cost of removal of equipment significantly exceed the planned duration, which leads to work cost increase and economic disbenefit because of downtimes of the high-productive equipment. The economic losses caused by equipment downtimes in up-to-date mines can reach 50 thousand US dollars per day, and the actual costs of equipment removal can exceed planned costs twice.

One of the major factors defining cost efficiency and safety of conducting removal of equpment is recovery room stability. Violation of the recovery room stability leads to sharp deterioration in the equpment removal conditions, increase in the time and cost of longwall equipment removal. One of the main reasons for decrease in stability of the recovery room formed by a longwall is the effect of the main roof caving.

It should be noted that caving of the main roof have significant effect on mining operations safety, leads to the increased gas emission from the undermined coal-rock massif in the goaf [15-19], and to methane emission from goaf in a longwall face during the collapse of the main roof [20]. Thus, an important problem is definition of the influence of a roof which can be studied using control systems of modern electro-hydraulic shield supports.

2. Materials and methods

When carrying out research, the data of control systems of MARCO electro-hydraulic shield supports obtained during mining of longwall panel No 17-47 on the Breevsky seam in the conditions of the Polysayevskaya mine of JSC SUEK Kuzbass was analysed. Within considered longwall panel No 17-47 the seam height changes from 1.56 m to 1.63 m, the seam inclination is 12-17°. The host rocks: the immediate roof of the seam with a height of 4-8 m consists of average stability aleurolite; the main roof - aleurolite and 8-10 m sandstone. The immediate floor is presented by 3-8 m aleurolite with a strength of 35-40 MPa.

Mining of the longwall panel was carried out using the face equipment: shearer SL 300, shield support Glinik 12/25, face conveyor FFC-9. The length of the longwall panel was 300 m. The data analysis of the Marco system was carried out since 1st till 15th of December 2015. 5748 pressure changes for each hydraulic leg and more than 2 million pressure values were analysed.

3. Results and discussion

The longwall advance rate changed from 8 to 19 m per day, longwall output - from 5.5 to 13 thousand tons per day. The analysis of data allowed one to mark out the minimum, average and maximum values of pressure in the hydraulic leg cylinders. Uneven distribution of pressure was established. Figure 1 shows the pressure distribution curve in the hydraulic leg cylinders along the length of the longwall face.

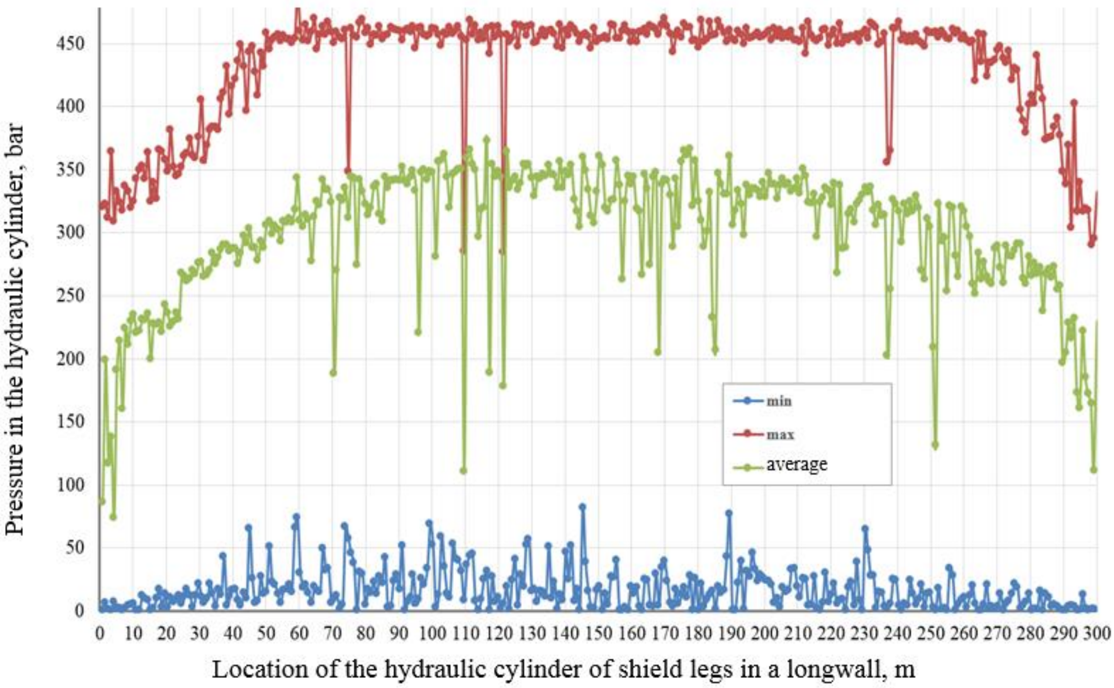

Figure 1. Pressure distribution in the hydraulic leg cylinders along the length of the longwall face

Further research of the influence of the longwall advance rate was conducted for the central part of the longwall face. Average loading dynamics on the central part of the longwall face is presented in figure 2. From figure 2 it is visible that loading of shield happens periodically: the maximum and the minimum of loadings alternate. Shield loading frequency shows the periodic roof collapse with increase in the shield load followed by a subsequent decrease in loading up to the following roof failure.

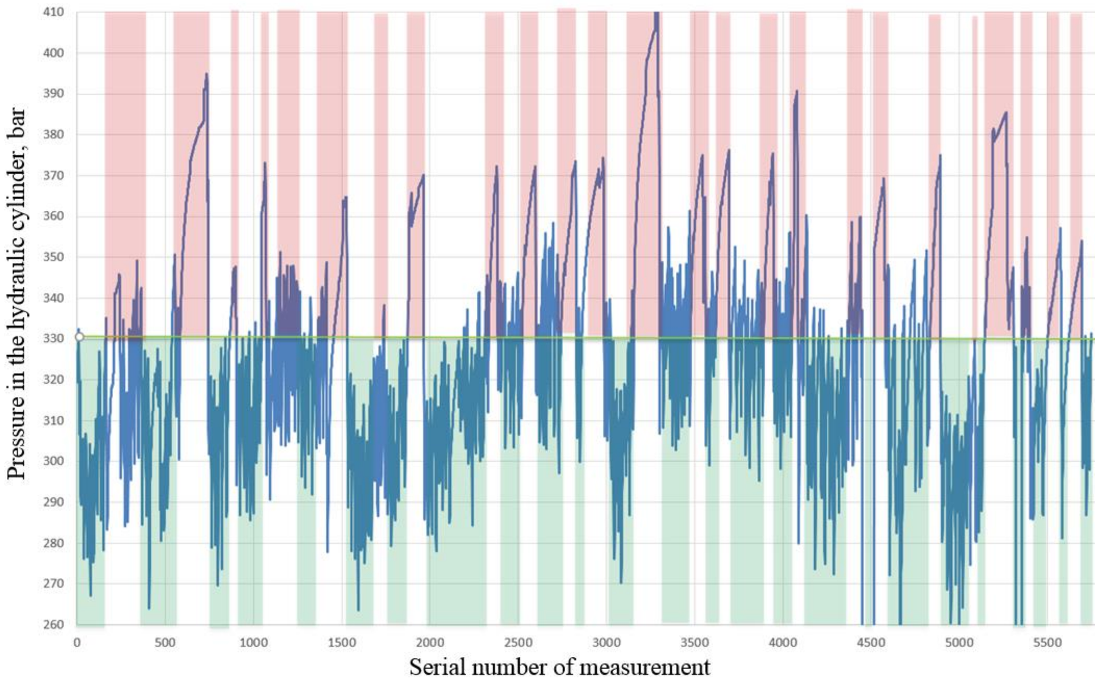

Figure 2. Changing in the average values of the pressure in the hydraulic leg cylinders in the central part of the longwall.

The analysis of data allows one to establish that during equipment downtimes the gradual growth of the pressure in hydraulic leg cylinders along the entire length of the affected part of the longwall (figure 3) is observed. The longwall downtimes normally did not exceed 3 h for which growth of pressure in hydraulic leg cylinders was from 12 to 20 %.

Analysis of the data, taking into account equipment downtime, shows that the extreme pressure is connected with significant increase in the longwall advance rate or its stop.

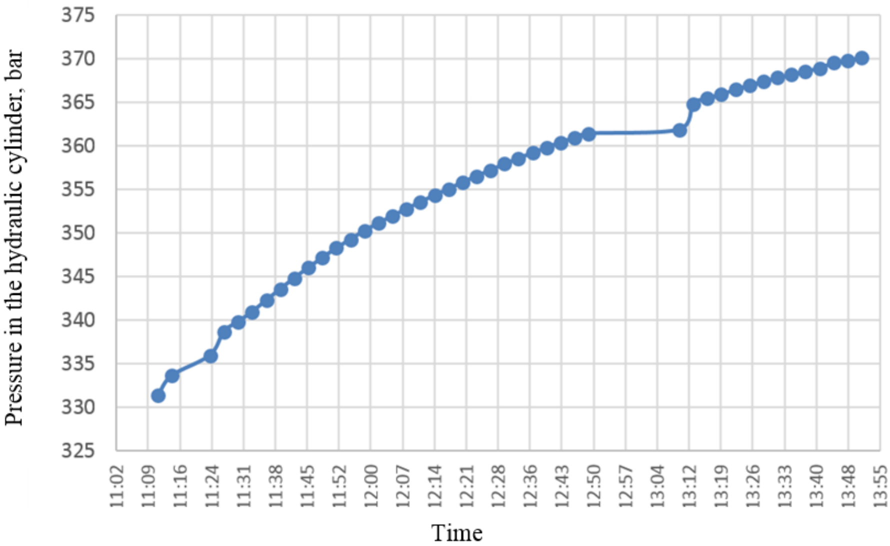

Figure 3. Changing in the average values of the pressure in the hydraulic leg cylinders in the central part of the longwall face.

Thus, using control systems of electro-hydraulic shield supports allows one to monitor changes of the loadings in hydraulic leg cylinders and to define the recovery room rational locations for effective and safe remove of longwall equipment.

4. Conclusion

The preformed data analysis of control systems of electro-hydraulic shield supports allowed drawing the following conclusions:

- the longwall stop during several hours leads to a gradual increase in shield loads;
- the maximum loads frequency, caused by the main roof collapse, is defined by both the containing rock properties and longwall advance rate;
- loadings distribution throughout the longwall panel width is uneven: the maximum loads are observed in the central part of a coal face, and zones of decrease in shield loads (up to 50 m long) are situated near the headgate and tailgate.

For the purpose of decreasing shield loads in the conditions of heavy roofs it is necessary to provide the high longwall advance rate and to exclude its long stops.

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