TEST Engineering & Management

March - April 2020
ISSN: 0193-4120 Page No. 5568 - 5572

An Assessment of the Impact of Longwall Panel Width on the Height of Complete Groundwater Drainage in Underground Thick Coal Seam Mining

Oleg Kazanin1, Andrey Sidorenko2, Natalia Koteleva3, Dariya Belova4

1Department of Blasting, Saint Petersburg Mining University, Saint Petersburg, Russia
2,4Department of Mining Engineering, Saint Petersburg Mining University, Saint Petersburg, Russia
3Department of Technological Process Automation and Production, Saint Petersburg Mining University, Saint Petersburg, Russia

Article Info
Volume 83
Page Number: 5568 - 5572
Publication Issue:
March - April 2020

Article History
Article Received*: 24 July 2019*
Revised*: 12 September 2019*
Accepted*: 15 February 2020*
Publication*: 28 March 2020*

Abstract:
The main goal of the study is to assess the impact of longwall panel width on both the height of complete groundwater drainage above the coal being mined and water inflows into panel workings. Based on a literature review, the authors summarize the results of studies which have been conducted on the issue under consideration. By calculating the parameters of complete groundwater drainage using methodological approaches and regulatory documents currently available, it is shown that these approaches and documents have major drawbacks which make reliable forecasting of complete groundwater drainage parameters impossible. It is suggested that a numerical method should be used as it permits taking into account both the geometrical parameters of the zone above a longwall panel and the properties of rocks in this zone. The results of a case study using data from the mine named after V. D. Yalevsky are presented and a conclusion is made that increasing longwall panel width would be impractical.

Keywords:*underground mining, coal seams, longwall panel width, stress-strain behaviour, numerical simulation, height of complete groundwater drainage*.

I. Introduction

Longwall panel width is the main parameter of coal longwall mining. It influences equipment utilization efficiency [1], panel preparation costs, and the number of assembly and disassembly operations in the mine. At the moment, top coal-producing countries are demonstrating a growing trend in longwall panel width [2], which is explained by the use of modern, reliable, and high-performance equipment. For example, the average longwall panel width in the USA is currently 370 m, with the maximum width reaching 482 m. Out of 40 longwalls mines in operation today, 13 have panel widths of more than 400 m. However, Russian mines did not use such panel widths before 2017 due to complicated geological settings and the use of less sophisticated equipment. In 2017, the mine named after V. D. Yalevsky was the first one in Russia where panel width reached 400 m and the use of up-to-date equipment, including an Eickhoff SL 900 shearer and a ground support solution by CAT, resulted in a record-high production rate – 1.57 million tons of coal per month from seam No. 50 with a height of 3.7 m. In 2018, a new record of 1.63 million tons per month from the same seam was set. The successful use of panels with big widths, as well as the global trend towards increasing panel widths, resulted in the fact that managers of coal mining companies became willing to increase panel widths in other coal seams. For example, seam No. 52 with a height of 4.7 m is currently being worked in the mine named after V. D. Yalevsky. The equipment which operates there is less productive and geological conditions are more complicated. Water inflows during mining can reach 600-800 m3/h. The current panel width in seam No. 52 does not exceed 300 m; however, it is planned that sections which will be mined in the future will have a panel width of 400 m. These sections of the seam have complicated geological and geometrical characteristics requiring that the extraction sequence should be changed from bottom-up to top-down, which may result in flooding. Moreover, the

TEST Engineering & Management
March - April 2020
ISSN: 0193-4120 Page No. 5568 - 5572

sections discussed are located under the VerkhnyayaTykhta River and have a small depth of cover. In this regard, forecasting the impact of an increase in panel width on both the height of complete groundwater drainage and water inflows into the workings is extremely important.

II. METHODS

Based on what is currently known about the processes occurring above mine voids, it is argued that this area can be divided into several zones: the caved zone, the fractured zone, and the continuous deformation zone. The parameters of these zones are mainly associated with the mined height. For example, the height of the caved zone is 6 times bigger than the mined height; that of the fractured zone is 20 to 40 times bigger than the mined height. It is the emergence of the caved zone and the fractured zone that causes massive water inflows. The volume of incoming water depends on the season, the presence of aquifers above the mine void, rock properties, and the geometric parameters of the mined-out areas.

As part of the study, we analyzed Russian regulations prescribing safe depths of cover for mining operations carried out under bodies of water [3]. To assess the impact of panel width on the height of complete groundwater drainage, we analyzed the results of groundwater drainage monitoring conducted in top coal-mining countries [4-11, 15-18] and the current methods of forecasting water inflows and calculating the parameters of the area influenced by mining operations in terms of groundwater drainage [12].

The direct link between the fractured zone and the height of complete groundwater drainage has been discussed by many researchers [13] and taken into account by the regulations in force [3]. In the study being discussed, the finite element method was used in order to find the parameters of the caved zone and those of the fractured zone. The two-dimensional model of a block of rock mass included rocks, the mined-out area, and mine workings. When setting the parameters of the model, the strength and deformation properties of the coal seam and the surrounding rocks were taken into account. The starting stress field was created by setting the weight of the overlying rock mass up to the surface. Data on the strength properties of the rocks were obtained from uniaxial compression and tension tests using coal and rock samples. The data were later adjusted to describe the properties of the rock mass rather than those of the samples by using a loosening factor which corrects for the fracturing of the rock mass.

III. RESULTS AND DISCUSSION

Of considerable interest are the results of the studies presented in [12], in which the author summarizes data on the influence of various factors on the height of complete groundwater drainage and proposes the following equations:

$$H = 1438\, ln\, (4.315 \times 10^{-5} u + 0.9818) + 26 \quad (1)$$

$$u = w\, t\, 1.4\, d\, 0.2 \quad (2)$$

Where H is the height of complete groundwater drainage above the mined-out area, m; u is a parameter depending on w – longwall panel (void) width, m; t is the mined height, m; d is the depth (overburden thickness), m.

Using the equations (1-2) for the conditions in the mine named after V. D. Yalevsky, a graph was plotted showing the relationship between the height of complete groundwater drainage H and panel width w (Figure 1). As can be seen from Figure 1, an increase in panel width leads to a significant increase in the height of complete groundwater drainage, which is 379 m at a panel width of 300 m and reaches 486 m, which exceeds the overburden thickness, at a panel width of 400 m. Thus, even when using panels with a width of 300 m, the height of complete groundwater drainage should reach the earth's surface.

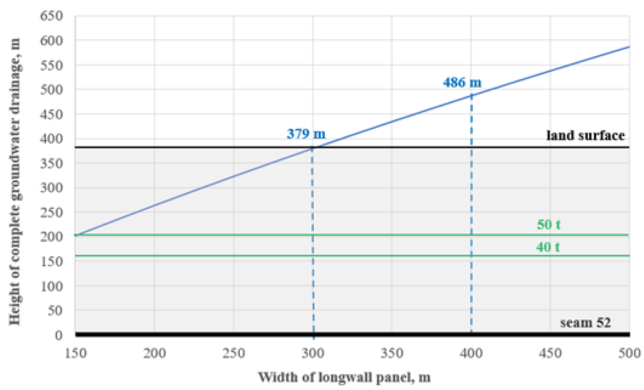

Fig 1 The impact of panel width on the height of complete groundwater drainage

However, these results do not correspond with other methodological approaches to finding the height of complete groundwater drainage. For example, according to the regulatory document used in Russia [3], the mining depth which is safe for conducting mining operations under bodies of water located on the earth's surface is determined only by the composition of the rocks above the mine void. If there are more than 40% of clay rocks, the mining depth must be equal to the mined height multiplied by 40; in other cases, it must be equal to the mined height multiplied by 50. It is noted that this approach is valid only for coal seams with thicknesses less than 4 m. When mining thicker seams, it is necessary to find the height of the zone of water-conducting fissures. The results of calculations based on the regulatory document are also shown in Figure 1 to demonstrate the differences. As can be seen from Figure 1, 40t and 50t are much lower than the predicted height of complete groundwater drainage even at a panel width of 150 m.

Figure 2 presents the results of numerical simulation obtained with the help of the model which was developed. They let us make conclusions about how much the mine void influences the height of the fractured zone at different panel widths. As can be seen from Figure 2, an increase in panel width leads to a growth in the tensile zone (the fractured zone) whose height reaches 130 m and 180 m at panel widths of 300 m and 400 m, respectively.

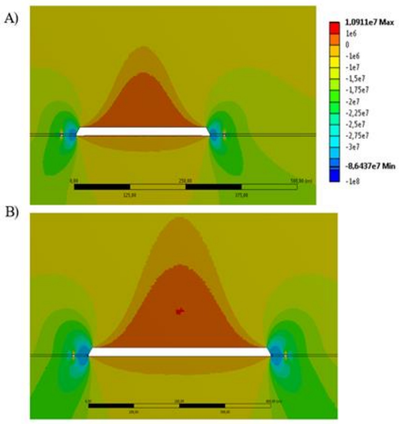

Fig 2 The impact of panel width on the tensile zone in the rocks above the mine void: A) l = 300 m; B) l = 400 m

Water inflows into the mined-out area are mainly influenced by the following factors [14]:

1. the permeability of the aquifers drained by the zone of water-conducting fissures and the pressure in them;

2. distances from the boundaries of the zone of water-conducting fissures to the external boundaries of the aquifers being drained;

3. the size and shape of the mine working;

4. the mining rate (face advance);

5. permeability of rocks in the zone of water-conducting fissures;

6. the intensity of water flow through impermeable rocks from the aquifers located above the zone of water-conducting fissures.

IV. CONCLUSION

A significant difference between the results of numerical simulation and the data obtained using the method discussed in [12] can be explained by the fact that the authors of the calculation method considered average figures without taking into account the physical and mechanical properties of rocks. Therefore, it should be noted that even though the method discussed in [12] is of considerable practical interest, the fact that it does not factor in the physical and mechanical properties of rocks is a major drawback. We also believe that the methodology presented in the regulatory document [3] requires improvement as it does not take into account panel width while most researchers highlight that this parameter is the main one in terms of influencing the height of groundwater drainage. It should be noted that the results of the numerical simulation discussed here correspond with the regulatory document [3], which makes it possible to recommend using the numerical method for predicting the parameters of the fractured zone and those of the height of complete groundwater drainage above mined-out areas.

The numerical simulation has shown that an increase in panel width leads to a significant expansion of the fractured zone. At an increase in panel width from 300 m to 400 m, the expansion of the fractured zone will be accompanied by a growth in the distance impacted by mining operations and a growth in gas emissions into the mined-out area from the overlying layers (both contiguous coal seams and surrounding rocks), as well as an increase in water inflows into the mined-out area. Bigger gas emissions and water inflows will be a result of a growth in the distance at which the impact caused by mining operations is felt, a growth in the zone of overlying rocks impacted by mining operations, and a growth in the zone of intensive drainage. It should be noted that both gas emission and groundwater drainage processes in the mined-out area are most intensive at a distance from the coal face that is not less than one advance step and least intensive at a distance of more than 120-150 m from the panel.

The results of the study enabled us to conclude that as the mine named after V. D. Yalevsky is prone to massive water inflows, an increase in panel width up to 400 m is impractical and it is recommended that this parameter should be kept at a value from 250 m to 300 m.

V. REFERENCES

1. Kazanin O.I., Sidorenko A.A. &Meshkov A.A. Organizational and technological principles of realization of the modern high productive longwall equipment capacity // Ugol' – Russian Coal Journal, 2019, no. 12, pp. 4-13. (In Russ.). DOI 10.18796/0041-5790-2019-12-4-13.
2. Longwall production remains steady. Coal Age. January/February 2019. pp. 24-28. https://www.coalage.com/flipbooks/january-february-2019.
3. Regulations concerning the protection of structures and natural objects from the harmful effects of underground coal mining. PB 07-269-98. 1998.
4. Singh T.N., B. Singh. 1985. Model simulation study of coal mining under riverbeds in India. International Journal of Mine Water 4, no. 3: 1–10.
5. Singh M.M., and F.S. Kendorski. 1981. Strata disturbance predictions for mining beneath surface water and waste impoundments. In Proceedings of the 1st Annual Conference on Ground Control in Mining, West Virginia University, Morgantown, West Virginia, 76–89.
6. Jeffery, R.I., J.W. Summers, and M.D. North. 1991. The numerical analysis of subsurface deformation in relation to minewater ingress at Wistow Colliery. In 4th International Mine Water Congress, Ljubljana, Slovenia, Yugoslavia, September.
7. Gabov V. V., Zadkov D. A., Mathematical model of simple spalling formation during coal cutting with extracting machine / Journal of Physics: Conference Series, № 1015, T 52007, 2018. pp. 1-6. DOI :10.1088/1742-6596/1015/5/052007.
8. Golubev D. D. Development of the technological schemes of the extraction of coal seams for modern mines //Topical Issues of Rational Use of Natural Resources: Proceedings of the International Forum-Contest of Young Researchers, St. Petersburg, Russia, 18-20 April 2018. – 2018. – C. 55-60.
9. Nguyen, K.L., Gabov, V.V., Zadkov, D.A., Le, T.B. Justification of process of loading coal onto face conveyors by auger heads of shearer-loader machines. IOP Conference Series: Materials Science and Engineering, № 327, T 42132, 2018. pp. 1-6. 2018 DOI:10.1088/1757-899X/327/4/042132.
10. Kazanin O.I., Drebenstedt C. Mining Education in the 21st Century: Global Challenges and Prospects. ZapiskiGornogoinstituta. 2017. Vol. 225, p. 369-375. DOI: 10.18454/PMI.2017.3.369
11. European Commission. 2012. Prediction and monitoring of subsidence hazards above coal mines (Presidence). Directorate General for Research and Innovation, Research Fund for Coal and Steel Unit. Report No. EUR25097EN. Brussells, Belgium.
12. Tammetta P. Estimation of the height of complete groundwater drainage above mined longwall panel. Groundwater. 2013. pp. 723–734.
13. Singh, R.N. 1986. Mine inundations. International Journal of Mine Water 5, no 2: 1–28.
14. Cherkashin A.A. Parameter justification for the intensive mining of flat coal seams in Kuzbass mines characterized by massive water inflows. Thesis for the degree of candidate of technical sciences. St. Petersburg. 2014. 135 p.
15. Zhukovskiy, Y.L., Korolev, N. A., Babanova, I. S., &Boikov, A. V. (2017). The prediction of the residual life of electromechanical equipment based on the artificial neural network. IOP Conf. Series: Earth and Environmental Science 87 (2017) 032056 doi :10.1088/1755-1315/87/3/032056.
16. Zhukovskiy, Y.L., Starshaia, V. V., Batueva, D. E., &Buldysko, A. D. (2019). Analysis of technological changes in integrated intelligent power supply systems. Innovation-Based Development of the Mineral Resources Sector:

March - April 2020
ISSN: 0193-4120 Page No. 5568 - 5572

Challenges and Prospects - 11th Conference of the Russian-German Raw Materials, 2018, 249-258.

17. Ilyushin, Y.V., Afanaseva, O.V. Development of scada-model for trunk gas pipeline's compressor station. Journal of Mining Institute. 2019. Vol. 240, P. 686-693. DOI: 10.31897/PMI.2019.6.686.
18. Marinin M.A., Khokhlov S.V., Isheyskiy V.A. Modeling of the Welding, Process of Flat Sheet Parts by an Explosion. Journal of Mining,Institute. 2019. Vol. 237, p. 275-280. DOI: 10.31897/PMI.2019.3.20.
19. "Classification of Geological Conditions Using Geostatistics in Coal Field, Sangatta, East Kalimantan, Indonesia ." IMPACT: International Journal of Research in Applied, Natural and Social Sciences (IMPACT: IJRANSS) , vol. 4, no. 10, pp. 129–140.
20. "Assessment and Impact of Ambient Air Quality in Sonepur- Bazari Opencast Project – An Approach towards Sustainable Environment, Ranging Coalfield, Barddhaman, West Bengal, India ." International Journal of Applied and Natural Sciences (IJANS) , vol. 5, no. 4, pp. 83–92.
21. "Audio-Magnetotelluric Surveying and Its Application for the Concealed Orebodies Prospecting in Yuele Lead-Zinc Deposit Area, Daguan District, Northeastern Yunnan Province, China." International Journal of Applied and Natural Sciences (IJANS) , vol. 3, no. 3, pp. 5–14.
22. "Surface Mining and Heavy Metal Pollution of Water and Soil: A Case Study in Simlong Coal Field in Sahebganj District, Jharkhand." International Journal of Applied and Natural Sciences (IJANS) , vol. 4, no. 1, pp. 17–24.
23. "CFD Analysis of Membrane Helical Coil for Optimization of High Pressure and Temperature of Syngas in Underground Coal Mines." IJMPERD, vol. 9, no. 1, pp. 365–372.
24. "An Optimization of High Pressure and Temperature of SYNGAS in Underground Coal Mines by Using CFD Analysis of Membrane Serpentine Tube." IJMPERD, vol. 9, no. 1, pp. 617–624.