The Designing of the New Type of Mine Ventilation Wall

Alexander Nikolaev[1], *Rafail* Gazizullin[2], and *Valery* Nesterov[3]

[1] Perm National Research Polytechnic University, Russia, 614990, Komsomolsky Prospect street, 29
[2] West-Urals Department of Rostechnadzor
(Russian Federal Service for Ecological, Technical and Atomic Supervision), Russia, 614900, Komsomolsky Prospect street, bld, 34 "b"
[3]T.F. Gorbachev Kuzbass State Technical University, 650000 Kemerovo, 28 Vesennya st., Russian Federation

Abstract. Within the underground mining enterprises, in the event of a fire underground, it is necessary to isolate the mining site or mine workings to protect miners from poisoning by flue gases. To do this, the Mine Ventilation Wall (MVW) is used. Its second purpose is to regulate the air distribution underground, to fence sections not designed for ventilating. This survey describes the design of the MVW new type, which will have a number of competitive advantages in regard analogues existing. The results of mathematical modeling of the MVW properties under different conditions are represented.

1 Introduction

Ventilation of underground mining facilities is considered to be the most important technological process, as it is necessary to supply the air into the working area to ensure the possibility of mineral deposits mining. Wherein, the air supply into the mine (ore mine) in the volume required does not guarantee that all mining sites will be supplied with fresh air in the amount necessary to ensure safe working conditions. The reason for this is a large branching of mine workings, as significant part of the air upon moving throughout, is "dissipated" within the space mined. In addition, it is necessary to regulate not only the air distributing amongst underground mine workings to maintain the required operating conditions of miners within mining sites, but also to ensure safety within in the event of a fire in the mine (ore mine), blocking the flue gases spreading [1-4]. The solving of both problems requires the use of devices for rapid and reliable isolation of mine workings, which are taken to be called Mine Ventilation Walls (MVWs).

2 Materials and Methods

Nowadays computer modelling is the main tool for mining operation design [5-6]. It is known that the MVWs have the best properties regarding reliability and quality of insulation [6-9]. This is due to the fact that, inflating, the wall smoothes all the irregularities

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

and roughness of the mine workings, resulting in a maximum area of contact between the walls, soil and roof with the MVW.

However, the air MVWs have got their significant disadvantage. Their construction requires significant amount of air, and hence the energy source for the compressor, as well as significant time costs. As in case of fire and upon MVWs using within the industrial process to control the air distribution, the time factor is considered to be priority. Therefore, the use of air walls, despite their advantages upon isolating the mine workings, is limited.

To solve the problem of rapid and reliable isolation of mine workings, the design of the mine mobile ventilation wall has been developped, as presented in Fig. 1 (the legend: 1 – cloth; 2 – telescopic supports; 3 – rotating masts; 4 – reinforcing frame; 5 – sleds; 6 – locking rings; 7 – pneumohose; 8 – hasps).

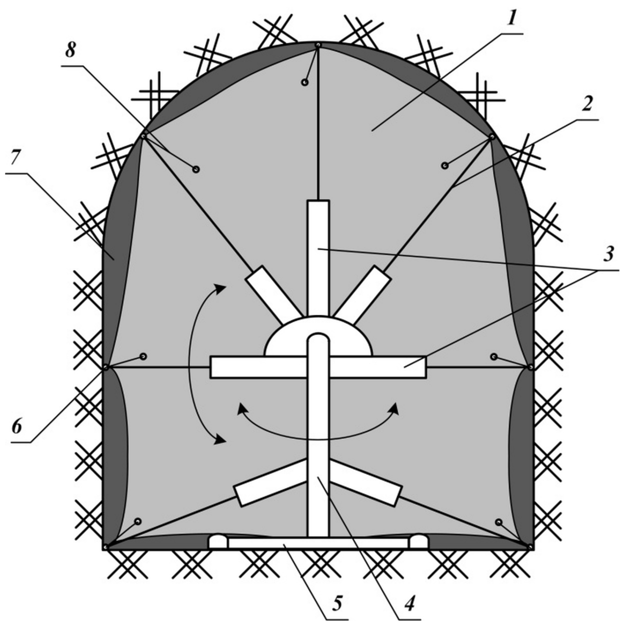

Fig. 1. The Principal Technical Solution Regarding the Design of the Air MVW: 1 – cloth; 2 – telescopic supports; 3 – rotating masts; 4 – reinforcing frame; 5 sleds; 6 – locking rings; 7 – pneumohose; 8 – hasps.

The term for the developping of the new type of MVW is reduced due to the fact that the main part of the production is overlapped by a cloth stretched along its cross section by means of sliding telescopic stops, and the air is pumped into the sleeve only located along the perimetre of the wall (hereinafter – the pneumatic hose). In this case, reliable isolation of the mine workings is provided under a small volume of the air pumped in. This does not require a power supply, since the pumping may be performed via a compressed air cylindre or a low-power compressor (battery-based).

The design of the MVW shall be determined per each individual mining enterprise, depending on the method of mineral deposits mine working. In this case the main idea consists in overlapping the main cross section of mine working with the cloth and pumping of air only into the pneumohose located onto the wall perimetre, as it will persist.

3 Results

The first version of the design of the new type of the MVW is designed for potash mines of the Verkhnekamskoye Deposit of Potassium-Magnesium Salts (VDPMS), which mine workings have got their large cross section and complex configuration. Both of these factors significantly complicate the development of the MVW design, the selection of materials regarding the manufacture of the frame and cloth able to withstand the pressure of the air flow, and as a result, the choice of optimal dimensions and weight of the components is complicated. These problems are solved at the stage of mathematical modelling.

The considered Estimated Cases (ECs) correspond to the following relative overlap of the flow section of mine workings: Ecs No. 1, 2, 3, 4, 5 – with overlap, respectively per 20, 40, 60, 80 and 100 %.

The results of modelling the pressure distribution onto the MVW per all ECs at an air flow rate of 10 m/s are shown in Fig. 2-3.

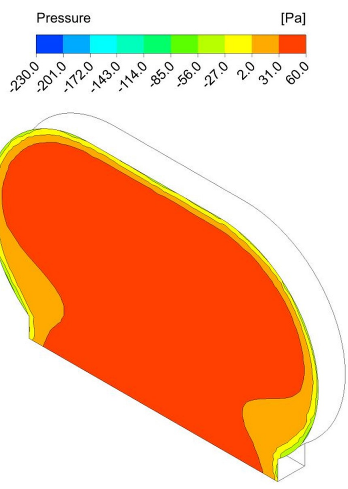

Fig. 2. The Isolines of Excessive Pressure from the Air Incoming Flow for the EC No. 1.

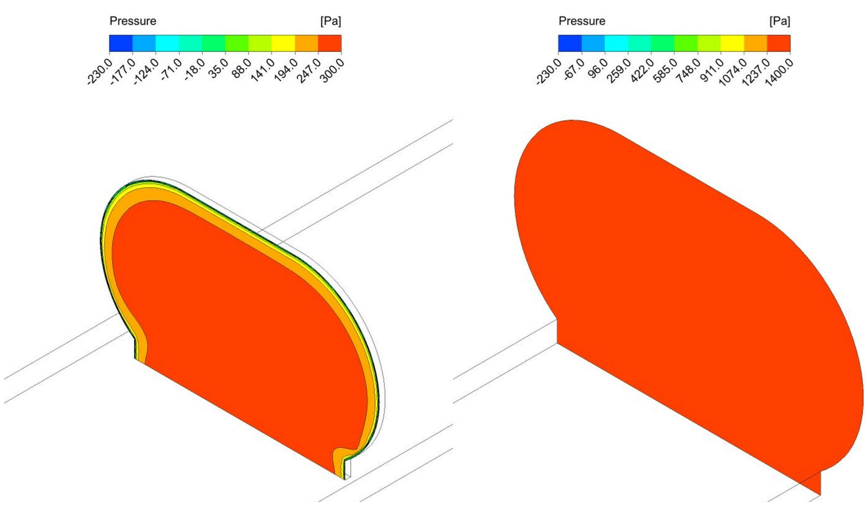

Fig. 3. The Isolines of Excessive Pressure from the Air Incoming Flow for the EC No. 4 and 5.

It follows from Fig. 2-3 that the excessive pressure is distributed unevenly across the MVW. The negative pressure value is established at the edges of the wall due to the uneven flow within the gap through its poorly streamlined shape. The flow, running onto the cloth, is re-transferred and then passes throughout the slit (the classic EC of sharp narrowing of the passage section with its sharp edge). The excessive pressure amount directly onto the wall from the side of the air incoming flow does not exceed 1400 Pa. However, due to the formation of separated flows within the gap and behind the obstacle, where the pressure of the discharge is established, the force acting into the direction of the flow increases significantly. Taking into account the fact that the air flow rate is taken to the maximum rate (according to the Safety Regulations of 10 m/s), the specified pressure value of the air incoming flow may also be considered the maximum and further calculations shall be performed, taking it as the main one.

4 Discussion

The problems need to be solved are related to the pressing of the pneumatic hose along the perimetre of the mine workings and the ability of the MVW to withstand the load of the air flow incoming. To solve these problems, the design of the MVW has been developped, the power frame of which is shown in Fig. 4.

The proposed design is collapsible. At the first stage, the lower part of the MVW is assembled, consisting of the base 1 and the ski sled 2 (Fig. 4). The base 1 is manufactured with the ability to be rotated around its axis. The vertical racks 3 are inserted into the base, the horizontal racks 4 are attached to. The racks consist of two parts: mobile and stationary, so that they may be moved apart regarding the dimensions of the mine workings.

By means of stops 5, the design of the MVW is raised into its vertical position and then they act as a support. To exclude the possibility of the wall tilting, the ski sleds 2 are installed onto the back side are located, which also allow to move the structure from one place into another.

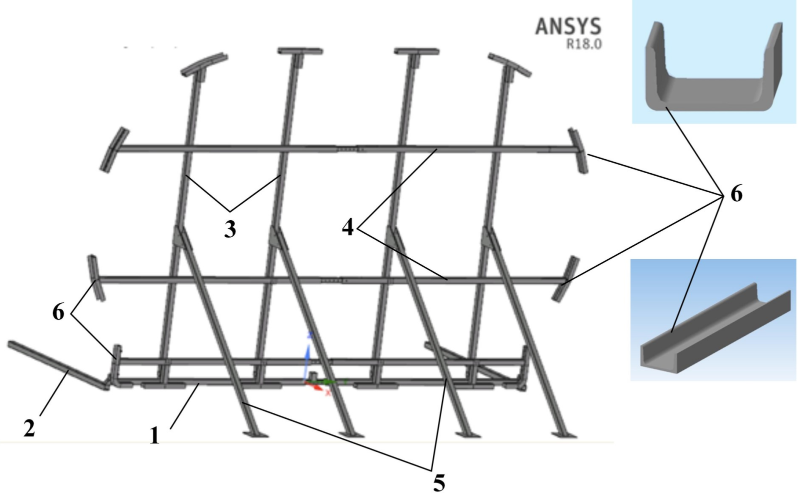

Fig. 4. The Power Frame of the MVW: 1 – base; 2 – ski sleds; 3 – vertical racks; 4 – horizontal racks; 5 – supports; 6 – grooves.

Upon setting the MVW into the grooves 6, the pneumatic hose is inserted (Fig. 4). The grooves are made in such a way that they repeat the contour of the mine workings. The cloth shall be put over the top onto the structure assembled (not shown at Fig. 4) and the air hose is pumped.

The appearance of the experimental (testing) sample of the new type of MVW proposed is shown in Fig. 5.

Fig. 5. The Appearance of the New Type of MVW Power Frame Assembled: 1 – base; 2 – supports; 3 – vertical racks; 4 – horizontal racks; 5 – skiing; 6 – groove.

The design of the experimental (testing) sample was assembled within the manufacturing workshop. As a result, it is established that the term for the MVW adjusting into its working position does not exceed 12 minutes. This result is much better than the analogue walls. The tests are currently planned at one of VDPMS mine workings.

5 Conclusion

As a result of the calculation of the pressure that will be applied to the MVW by air under its flow rate of 10 m/s, mathematical modelling of the clamping forces of the pneumatic hose onto the walls, soil and roof of the mine workings, the new type of the MVW design has been developped. According to the results of calculations, an experimental (testing) sample was manufactured, and was tested within the conditions of the assembly workshop, revealing the advantages of the design proposed regarding the terms of constructing velocity. At the next stage, it will be necessary to test the MVW under the real conditions of the mine to determine the wall's insulating properties.

References

1. Jianwei Cheng, Yan Wu, Haiming Xu, Jin Liu, Yekang Yang, Huangjun Deng, Yi Wang, Tunneling and underground space technology, **45**, 166 (2015)
2. K.G. Wallace, M.J. McPherson, D.J. Brunner, F.N. Kissel, Bur. Mines US Dep. Inter, **1,** 9307 (1990)

3. A. Nikolaev, N. Alymenko, A. Kamenskih, V. Nikolaev, E3S Web Conf., **15**, 7 (2017)
4. S.G. Gendler, S.V. Kovshov. Eurasian Mining, **2017:3**, 3 (2016)
5. F. Abu-Abed, E3S Web Conf., **41**, 01025 (2018)
6. F.N. Abu-Abed, D.V. Martynov, A.V. Ivanova, R.V. Dopira, R.Y. Kordyukov, ARPN Journal of Engineering and Applied Sciences, **11:16,** 9636-9645 (2016)
7. M.A. Trevits, C. McCartney, H.J. Roelots, Printed works of SME Annual Meeting and Exhibit, **9,** 11 (2009)
8. M.Yu. Nazarenko, V.Yu. Bazhin, S.N. Saltykova, F.Yu. Sharikov, Coke and Chemistry, **57,** 10 (2014)
9. A.V. Nikolaev, P.V. Maksimov, R.N. Gazizullin, A.G. Timarov, Bezopasnost' Truda v Promyshlennosti, **4,** 21 (2019)