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Optimization of the Combined Ventilation System for Dust Reduction in Blind Headings of Potash Mines

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ABSTRACT

Ensuring safe and comfortable working conditions for miners in potash mines is an urgent and unresolved problem, primarily due to the high intensity of dust emissions. This is especially true for poorly studied situations when the main dust source is the area of ore transfer from the borer miner to the shuttle car. In this paper, we explore the possibilities of reducing dustiness in the atmosphere of a blind heading with an operating borer miner through the implementation of a combined ventilation system. This system integrates both exhaust and forcing ventilation ducts extending to the mouth of the blind heading. A significant innovation of this system is the prioritization of the exhaust fan over the blower fan. The efficacy of the proposed system has been evaluated both theoretically and experimentally. The theoretical analysis involved conducting 3D numerical simulations of dust-air distribution in a blind heading. The stationary turbulent flow of the air-dust mixture in the mine was calculated, taking into account the operating borer miner. The model's validity was confirmed against data from a full-scale experiment. A noticeable reduction in dust concentration was observed in the work areas of the borer miner and shuttle car when using the combined ventilation system compared to forcing ventilation. Based on these model findings, pilot tests of the effectiveness of the combined ventilation system were carried out in a real heading of a potash mine. They showed a reduction in dust concentration by 40-52% compared to the original version of the forcing ventilation system.

1. INTRODUCTION

Potash fertilizers are the most important source of potassium for the nutrition of agricultural crops. As a result of their use, the yield level increases by 30-40% [1]. The majority of the potash ore is extracted by mining enterprises using underground mining. The demand for potash ore, the primary raw material in the production of the final product, is growing, following the increase in the consumption of potash fertilizers. Whereas the extraction of potash ore is usually carried out with mechanized mining, enterprises aim to enhance the efficiency of mining operations by using high-performance equipment.

Continuous mining machinery complexes employed in potash mines usually consist of a continuous miner machine, a bunker-loader and a shuttle car. Mining technology without the use of a bunker-loader is permitted under specific conditions. In such cases, the continuous miner loads ore from the floor onto a scraper conveyor, and then into the hull of a shuttle car.

The mechanized development of minerals is accompanied by a high level of dustiness in blind headings. For instance, at the potash mines of the Russian Federation, research recorded values of the concentration of fine dust thousands of times higher than the safe limit for people, which is 5 mg/m^3 [2-4].

Currently, ventilation of blind headings is carried out within the framework of one of three auxiliary ventilation systems: forcing, exhaust, and overlap [4]. However, in the presence of significant dust content in the headings, these systems are typically supplemented with various dust removal measures.

Currently, the method of dust suppression in mine headings with the use of water prevails in iron ore and coal deposits. In coal mines, where dust can be explosive [5, 6], and polymetallic mines, wet dust suppression methods are commonly employed since fire and technical water pipelines are laid to the sites of mining operations. However, this is not as common in potash mines due to the big size of the mine field. For instance, researchers from the National Institute of Occupational Safety and Health (NIOSH) have developed a dust suppression method based on the creation of a water curtain that removes coal dust from the air stream, thereby reducing the accumulation of fine particles in the return airways of mines [7].

The research conducted by Polish scientists of the Institute of Mining Technology [8] substantiates the effectiveness of an intelligent system for dust suppression of mine headings by liquid spraying and creating a wet curtain. The authors of the study propose a unit that uses compressed air and water. Sprayers are proposed to be installed along the entire perimeter of the mine headings in one cross section, except for the floor. The operation of the spray units is regulated by a controller, which will decide on the duration and intensity of spraying water mist depending on the concentration of dust particles measured by the dust collector, aiming to reduce the concentration of dust in the air. Water and compressed air are supplied to the unit for the preparation and distribution of water and compressed air through pipelines. They are filtered first and then distributed over three independent lines controlled by check valves. Each water supply line has a different setting in the range of 0.1 ... 0.3 MPa, and each compressed air supply line has a different setting in the range of 0.2 ... 0.4 MPa.

Reed et al. [9] analyzed systems for reducing the concentration of airborne dust through the use of special foam applied to the surface of longwalls. Foam was created by two different methods. One method utilized compressed air and water pressure to form the foam, while the other method used low-pressure air generated by an air blower and water pressure using a special generator. The foams generated by the air blower had higher expansion coefficients, from 30 to 60, with lower water drainage, making them potentially suitable for dust control.

Breydo et al. [10] studied methods of dust suppression with mine roadheaders, one of which is also based on spraying of water near the face by nozzles. The optimal parameters of the water supply pressure, as well as the geometric parameters of the water stream, are described. The main problem addressed in the paper is stated as the low efficacy of the dust suppression methods used, attributed to the non-adjustability of the original dust control methods in the mine face area. These methods calculated suppression parameters in advance, without taking into account the dynamics of processes.

Ovsyankin [11, 12] described attempts to use water and foam in blind headings of potash mines. The proposed measures showed their effectiveness at the initial stages of implementing of the dust suppression system, however, the main disadvantages were the absence of a permanent water source in the mine heading and the failure of nozzles spraying water and foam.

The considered methods of dust suppression using water are characterized by a high efficacy degree, but they are not suitable for potash mines. This is primarily due to the hygroscopicity of the rocks that forms the productive formation under development [13]. The second reason is the adverse impact of this method of dust suppression on the operation of mining machinery and equipment. The interaction of water, salt particles and metal leads to corrosion develops on the surface of the equipment, which can completely destroy it. Therefore, a relevant task is to develop methods of dust suppression without the use of wet methods, the point of which is to redistribute air flows and change the ventilation system of blind headings.

At present, the only methods of dust suppression in operational blind headings at potash mines in the Russian Federation are the use of a dust pump system with a cloth filter and ventilation systems, the purpose of which is to displace harmful impurities with clean air [14]. This system is not highly efficient because cloth filters quickly become clogged, and miners do not have time to track the degree of filter clogging. Moreover, the construction of the dust pump does not imply the presence of a branched air pump system. At the same time, the exhaust zone of the fans cannot exceed one meter, while the sizes of the dust-bearing vortices formed in the near-face area of the heading are much larger than the exhaust range.

According to the Safety rules for mining operations in Russian Federation, ventilation of blind headings is allowed with the use of a blower fan or a combined ventilation system, but with the dominance of the operation of a forcing fan. For the described systems, a specific feature is the creation of highly turbulent flows in a blind heading [15], preventing the formation of stagnant zones where flammable and toxic gases can accumulate. It is important to note here that the combined ventilation system differs from the well-known overlap ventilation system [16, 17] in that both ventilation ducts are laid to the mouth of the heading and go out to an adjacent mine working, ventilated by the pressure of the main fan.

We suggest that the use of a combined ventilation system with a dominance of exhaust fan will significantly reduce dust concentrations in the operational blind headings of potash mines. The idea is that the air in the heading will move from its mouth to the face, preventing dust from spreading far from the dust source. Simultaneously, due to the forcing fan, a small area near the face will be sufficiently turbulized to mix contaminated air, eliminating the accumulation of gas in the event of its release from the rock mass. The basis for the study of the described system of ventilation was researched by Isaevich et al. [18] which proved the prospects of using an exhaust ventilation system for the purpose of dust suppression in the near-face area. However, Isaevich et al. [18] did not consider the presence of a second ventilation duct.

The overlap ventilation system has been previously studied in several works. Xin et al. [17] and Wang et al. [19] found the ventilation and cooling performances of two types of auxiliary overlap ventilation systems are compared: far-forcing-near-exhausting, and near-forcing-far-exhausting. However, in both cases, air movement from the face to the mouth in the blind heading was found to be unfavorable for dust suppression, as also noted by Isaevich et al. [18]. The same assumption was made in the work [16]. In this study, the authors investigated the impact of the overlap zone length on methane concentration distribution both within and beyond the overlap zone. Parra et al. [20] compared theoretical and experimental data on velocity distribution in a blind heading under different ventilation schemes, including the overlap system. It was assumed, however, that no equipment was present in the heading face, and the exhaust duct ventilation did not lead to the mouth.

Sahu and Mishra [21] provided insights into the dispersion behavior of coal dust in the development heading with various auxiliary ventilation systems, focusing on optimizing the line brattice system for dust dispersion. It should be noted that this scheme may not be very applicable when using borer miners and shuttle cars. Adhikari et al. [22] demonstrated that the time to reach the permissible exposure limit is approximately five times faster for the forcing system compared to the exhaust system and slightly more efficient than the overlap system. This analysis considered drilling and blasting operations.

Menéndez et al. [23] optimized the energy efficiency and operational costs of auxiliary ventilation systems. Toraño et al. [24] conducted a study on dust behavior in two overlap auxiliary ventilation systems using CFD models. In one model, the exhaust ventilation duct was positioned at the bottom of the excavation, while in the other, it was placed at the top. The authors examined the scenario where air in the excavation moves from the mouth to the face. However, it's important to note that dust generation during ore transfer from the borer miner to the conveying belt or shuttle car was not considered, despite it being a significant source of dust emission, as demonstrated by Isaevich et al. [18].

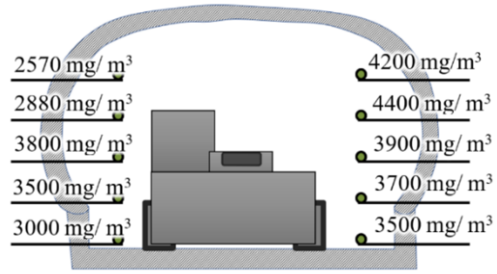
Furthermore, neither by Toraño et al. [24] nor in the other referenced works is the case of a shuttle car positioned behind the borer miner addressed. Yet, ore transfer from the borer miner to the shuttle car is also a notable source of dust emission.

As a result, the issue of dust distribution in a blind heading during the operation of a borer miner in conjunction with the presence of a shuttle car remains unresolved for the case of a combined ventilation system. To address this gap in the scientific literature, we conducted a series of numerical calculations to validate the effectiveness of the proposed combined ventilation system with the dominance of the exhaust fan. Additionally, we validated the model on a real-world case - a deep potash mine in Russia. This paper also outlines the requirements for the legalization of the proposed dust suppression system in operational blind headings of potash mines.

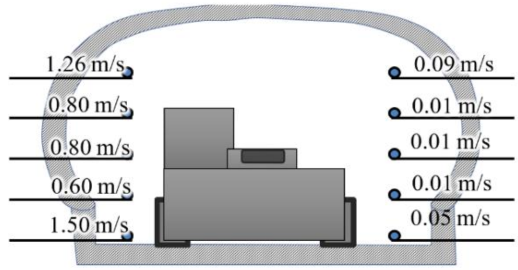
2. EXPERIMENTAL STUDY

The field measurements necessary for the validation of the created model were carried out to build a three-dimensional mathematical model. The object of research in this work is a blind heading with a continuous mining machinery complex located in it. The complex includes a borer miner "Ural 20R-12", as well as a shuttle car V17K. The area of the observed mine heading is 15.6 m^2, and its length is about 100 m. Ventilation of the face is carried out by a VM-8 blower fan. The ventilation duct of the forcing air duct line was mounted along the side of the mine from the side of the borer miner operator's cabin. The gap between the end of the duct and the operator's cabin was 10 m, and the air velocity at the outlet of the duct line was 9 m/s. It is remarkable that the end of the ventilation duct was deformed and the cross-sectional area at the outlet was 0.5 m^2. During the research, the following measurements were made: geometric parameters of the mine heading; the distances between the equipment relative to each other; temperature and humidity parameters of the work area; the temperature of the working equipment; the concentration of fine dust in the air in three cross sections; local air velocities in three cross sections.

Measurements of the dust concentration in the blind mine heading were carried out using the PKA 01 device, which is designed to measure the mass concentration of floating dust of any origin. The principle of operation of the device is based on the determination of the aerodynamic resistance of the filter element. After converting the received data, information is displayed on the device screen indicating the amount of pumped air during the measurement, as well as the amount of dust concentration at the measurement site. The measurement time varies depending on the degree of dustiness, getting shorter with the increase of dust concentration. The maximum measurement time is 3 minutes. The definition of the local velocities of the air flow was carried out using an anemometer APR 2. The operation of the anemometer is based on the tachometric principle of converting the velocity of the airflow into the frequency of an electrical signal using a metal impeller, the angular velocity of rotation of which is proportional to the velocity of the incoming airflow. At the same time, a sequence of voltage impulses is formed, the frequency of which is also proportional to the air flow velocity. The devices used in the field measurements are included in the State Register of Measuring Instruments of the Russian Federation and have been verified in a proper time. The results of experimental measurements are shown in Figures 1-3.

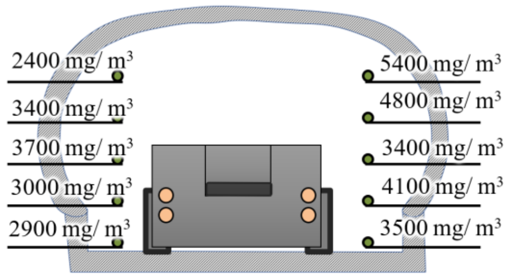


(a) dust concentrations

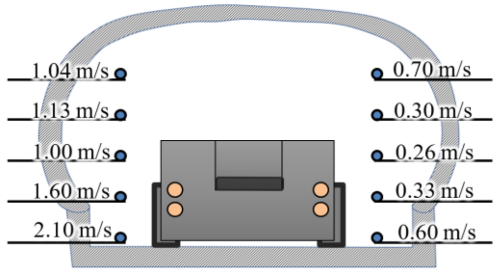


(b) air velocities

Figure 1. Measured values of dust concentration and air velocity at the location of the borer miner

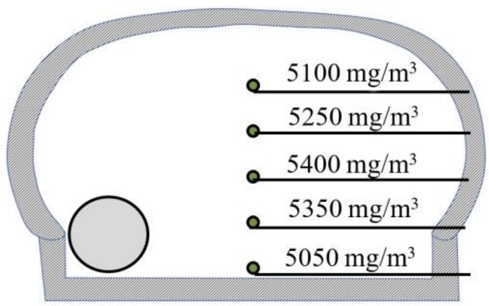


(a) dust concentrations

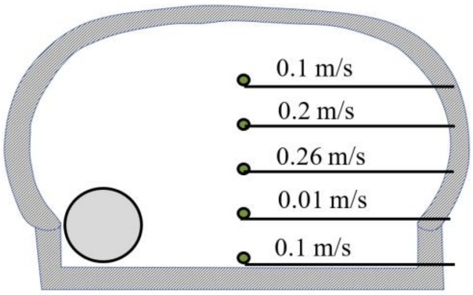


(b) air velocities

Figure 2. Measured values of dust concentration and air velocity at the location of the shuttle car



(a) dust concentrations



(b) air velocities

Figure 3. Measured values of dust concentration and air velocity in the cross section of the location of the forcing ventilation duct line

Figure 1 shows the cross section passing through the cabin of the borer miner's operator. The cross section shown in the Figure 2 goes through the end of the borer miner's scraper conveyor. Figure 3 shows measurements made at a distance of 30 m from the cabin of the borer miner's operator. Each value of the represented point in the figures is the result of statistical processing. The locations of the selected measuring sections are also presented in Figure 4.

The following technological processes are attributed to the main sources of dust emission [14]:

- Destruction of rocks by cutter heads of cutting unit of borer miner.
- Transloading of rocks from the borer miner's scraper conveyor to a shuttle car.

The visualization of the obtained dust concentration measurements is shown in Figure 4. The figure also shows the averaged by height concentrations at the measurement points.

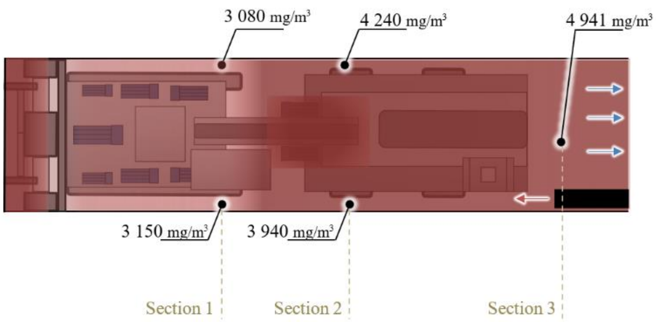


Figure 4. Gradient fill characterizing the dustiness situation in the studied face with a quantitative representation of dust concentrations (measurements averaged by height) – *top view*

An analysis of the measurements obtained as well as a visual assessment of the dustiness situation during field studies showed that the bulk of the floating fine dust is appear at the stage of transloading the rock mass from the borer miner to the shuttle car. In the cross section passing through the end of the borer miner's scraper conveyor, the average dust concentration on the right side of the borer miner was 4,240 mg/m^3, and on the left side – 3,940 mg/m^3. Further along the path of the outgoing air flow, the average dust concentration increased to 4,941 mg/m^3, due to the fact that the air flow raises up the dust falling into the hull of a shuttle car and blows it towards the mouth of the mine heading.

Dusting during transloading is caused by three factors. Firstly, dusty air flows are formed as a result of the displacement of air from the hull of a shuttle car when it is filled with ore. Secondly, the falling ore ejects the air flow. As a result, local turbulent vortices are created. Thirdly, the low value of the relative humidity of the air, the percentage of which was 20%, contributes to the intensification of the dusting process.

3. MATHEMATICAL MODELLING

To calculate the distribution of dust particles in the atmosphere of a blind heading, a three-dimensional model has been developed in the Ansys software package. When defining the model, it is assumed that in normal ventilation conditions, the air flow in a blind heading is steady, incompressible, continuous and turbulent. The description of the nature of the movement of the turbulent flow carried out using the realizable k-ε-model [25]. This model has previously been repeatedly used to solve practical problems of mine ventilation and provides better results when compared with experimental measurements [26-28].

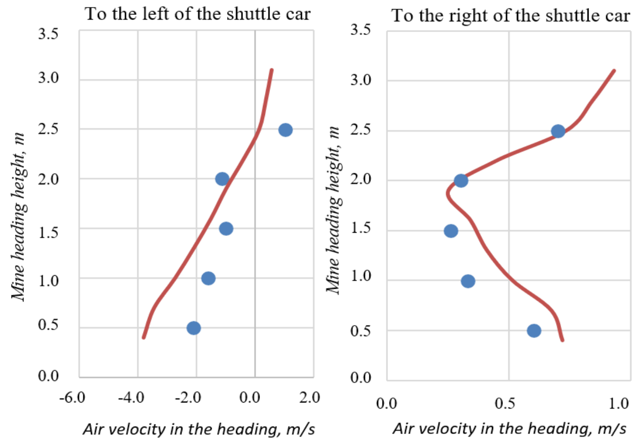


Figure 5. Comparison of the measured values of air velocity and the calculated profiles by the height of the operational heading with the forcing ventilation system

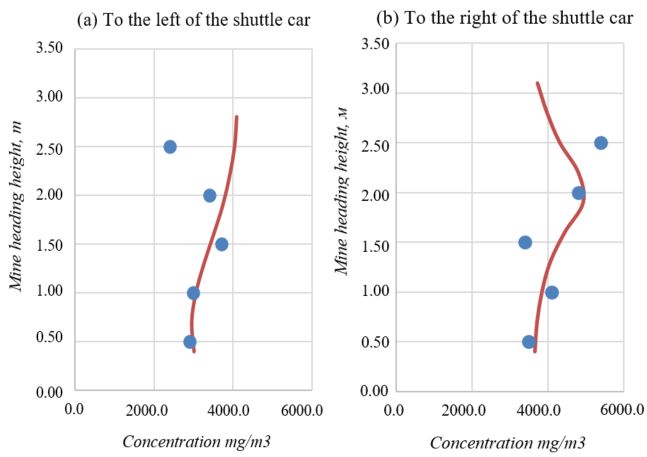


Figure 6. Comparison of the measured values of dust concentration and the calculated profiles by the height of the operational heading with the forcing ventilation system

When determining the boundary conditions, it was assumed that an air flow exits the hole of the forced air duct line, and the mouth of the mine heading has zero excessive pressure.

Special attention is paid to modeling the operation of the air-cooling system of electric motors of a borer miner. These elements are capable of creating certain local vortices, as well as creating thermal convection due to their strong heating. Two sources of dust emission were identified: the work of cutter heads and the trans loading zone.

At the first stage of the research, a mathematical model of the distribution of dust concentration in a blind heading was validated for compliance with the results of field studies. The mathematical model was also verified by comparing the results of numerical simulation of the turbulent flow of the air stream and the dust distribution caused by it with the data of field measurements of the longitudinal velocity and dust concentration obtained in a blind mine heading at the researchable mine. Figures 5 and 6 show some examples of calculated profiles and measured points of the velocity of local air flows, as well as dust concentrations along the entire height of the heading near the operator's cabin of a shuttle car.

A comparison of the calculated and measured profiles of longitudinal velocity and dust concentration in the longitudinal sections of the heading passing through the cabin of the borer miner and the shuttle car showed that the calculation results have a satisfactory qualitative and quantitative correspondence with the data of field measurements. There are some quantitative discrepancies associated with the sensitivity of the measured quantities to the location of measurement, as well as with the slight unsteadiness of flows in the experiment. The average relative deviation of the calculated dust concentrations from the measured points is approximately 8%. The average relative deviation of the calculated flow velocities from the measured points is approximately 18%. At the same time, the theoretical curves well reflect the qualitative dependence of the air flow speed and dust concentration on the vertical coordinate. The integral characteristics of the flow (total air flow and average dust concentration in the outgoing stream) in numerical modeling coincide with experimental data.

The results of calculations obtained during validation of the model are shown in Figure 7. The gap to the ventilation duct line was 10 m, the diameter of the outlet of the ventilation duct line was 0.5 m.

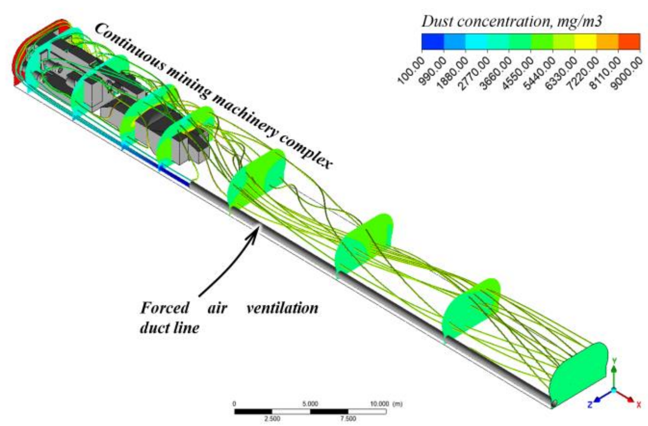


Figure 7. Distribution of the air flow lines and the dimensional dust concentration during the forcing ventilation system in a blind mine heading

The air stream coming out of the ventilation duct line located on the left side of the borer miner moves towards the heading face and the operator's cabin. At the same time, the workplace is subject to a high level of dustiness, which, according to the gradient fill, exceeds 5000 mg/m^3. The reason of this is the presence of vortices formed by this system of air ventilation. The flow of air near the face leads to additional saturation with dust, so the dust concentration in the right part of the mine becomes greater than in the left part. After that most of the air flows over the hull of the shuttle car in the direction of the mouth of the mine heading, carrying dust formed during transloading of crushed ore. However, a recirculating vortex appears. It is characterized by the fact that part of the flow with a high concentration of dust swerves towards the left side of the heading, and then is captured by the flow from the forcing ventilation duct line and is directed to re-ventilate the working space of the borer miner's operator. Together with the dust formed during transloading of crushed ore, this leads to an increase in the dustiness near the cabin of the borer miner's operator.

4. SIMULATION OF A COMBINED VENTILATION SYSTEM

A combined system of ventilation of a blind mine heading may be necessary in the following cases:

- if the exhaust fan is planned to be placed in the mine face,
- when the face is characterized by a high gas content of the rock mass for the purpose of turbulizing air flows by a blower fan, which is part of the combined ventilation system.

In the presented calculations, ventilation occurs through two ventilation duct lines located in the mine heading, one of which forces in the clean air, and the other, on the contrary, exhaust out the dusty air.

The first ventilation duct line, which is used to force the clean air, was located in the lower left corner of the mine heading so that the distance between the outlet of the ventilation duct line and the operator's cabin was 10 m. The second ventilation duct line, used to exhaust out dusty air, was located on the right side of the mine heading. Therefore, the distance between the outlet of the second ventilation duct line and the shield of the tunneling and cleaning combine is 50 cm. The duct line is also 50 cm away from the roof and the right side of the mine heading. The diameter of the ventilation duct line is 500 mm.

Earlier in this paper, it was mentioned that the combined ventilation system with a dominance of exhaust fan has greater efficacy in terms of normalizing the dustiness situation when compared with the forcing ventilation system. The dominance of the exhaust ventilation implies that the air in the mine heading will flow in the direction from the mouth of the chamber to the face area of the heading. In this case, the outgoing air flow is moving through the ventilation duct line of the exhaust fan. As a result, there will be a phenomenon of displacement of fine dust in a blind mine heading. The forcing ventilation system is characterized by processes of mixing of variously dusted air flows, which entails the circulation of dust particles in the area of the location of the continuous mining machinery complex. The mixing of air flows and the formation of local vortices with the combined ventilation system is confirmed by the numerical calculation presented in Figure 8. The main vortex is formed around the borer miner, in area of the zone of ore transloading from the borer miner's scraper conveyor into the shuttle car. As a result, the dust is raised up by the air flow and moves into the working area of the borer miner's operator.

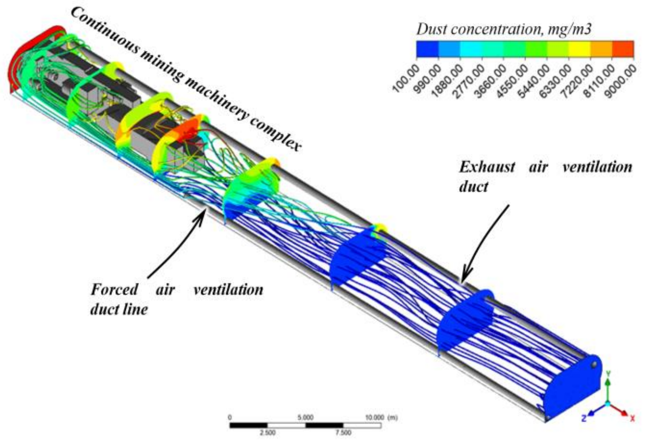


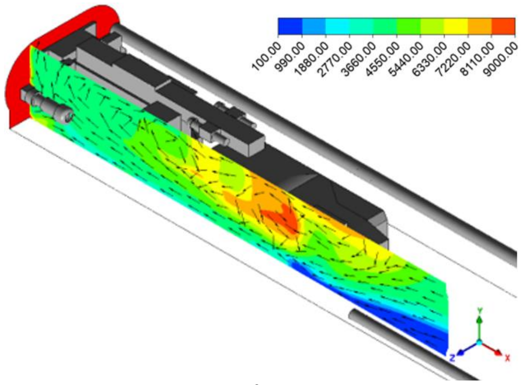
Figure 8. Distribution of air flow lines and the dimensional concentration of dust in the air with a combined ventilation system

The clean air flow forced from the first ventilation duct line moves along the floor in the left part of the heading in the direction of the face, capturing dusty air flowing down the shuttle car hull to the left side of mine heading. Near the face, air flows along the top side of the borer miner from the left to the right part of the heading, a reversal flow is also formed, which moves along the roof in the direction of the mouth of the heading.

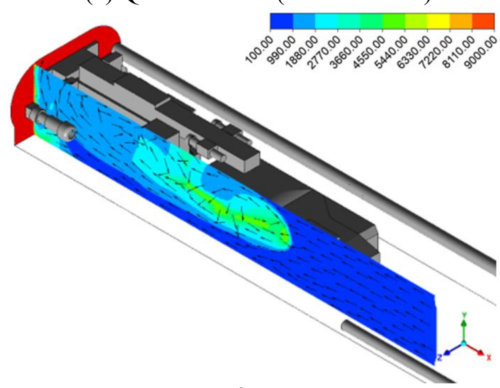
With the comparison the nature of the movement of air flows with the combined (with a dominance of exhaust) ventilation system with the forcing ventilation system, the results of what are shown in Figure 7, it can be noted that with the combined ventilation system, a larger volume of air flows into the right side of the mine heading. This phenomenon is associated with the influence of the exhaust ventilation system by means of a second exhaust ventilation duct line. However, despite the low air velocity of the forcing ventilation, the rate of reverse flow remains sufficient enough so that the dust is transferred behind the shuttle car. Considering the reference plane passing along the operator cabin, it can be seen how the dusty air carried away behind the shuttle car by the reverse flow is carried exactly by the flow caused by exhaust ventilation to the outlet of the forcing ventilation duct line, and, merging into the forced air stream, moves in the direction of the operator cabin. To determine the optimal parameters of the ventilation equipment, a multivariate simulation is carried out, in which several possible values of the exhaust fan capacity are considered.

4.1 Comparative analysis of multiparameter modeling results

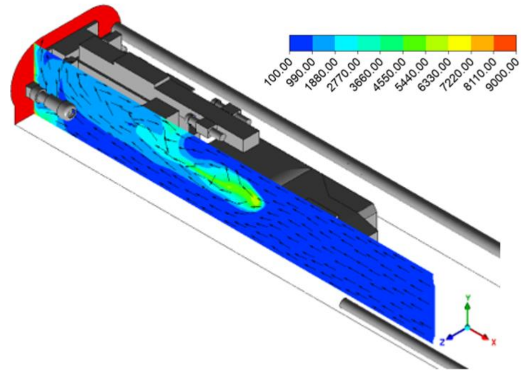
The comparison of results of the combined ventilation system with the dominance of the exhaust system with different exhaust fan capacity was carried out to reduce dustiness in the mine heading. The calculations were performed with the air flow rate on the exhaust fan: 1.76 m^3/s; 3.50 m^3/s; 5.20 m^3/s; 7.00 m^3/s. The additional condition was that in all the situations under consideration, the blower fan operated with a constant capacity of 0.8 m^3/s. This condition is stated to increase the speed of air movement in a blind mine heading. Figure 9 shows the longitudinal planes passing through the cabin of borer miner operator, which were used to compare the parameters of the combined ventilation system.



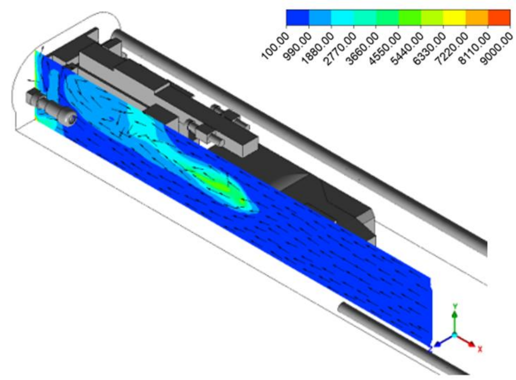
(a) Q = 1.76 m^3/s (V = 0.11 m/s)



(b) Q = 3.5 m^3/s (V = 0.22 m/s)



(c) Q = 5.2 m^3/s (V = 0.33 m/s)



(d) Q = 7.0 m^3/s (V = 0.45 m/s)

Figure 9. Distribution of vector fields of air flow velocities, along the longitudinal section of the borer miner along the operator's cabin, with different air flow rates, combined ventilation system

The analysis shows that the use of forcing ventilation does not exclude the presence of some turbulence in the area of the borer miner operator's cabin. In addition, the analysis of the obtained calculation results indicates that an increase in the exhaust ventilation rate helps to reduce the size of the dust cloud over the hull of a shuttle car. Moreover, with an increase of the exhaust ventilation rate, it is possible to prevent the occurrence of a stagnant area with a high concentration of dust over the hull of shuttle car near its cabin. A comparison of quantitative values of the mass concentration of dust in the operator's cabin area is shown in Figure 10.

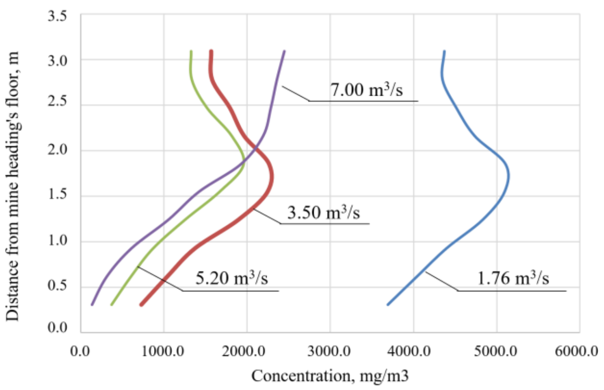


Figure 10. Vertical stratification of the mass concentration of dust in the area of the borer miner operator's cabin depending on the exhaust ventilation rate with a combined ventilation system

According to the obtained graphs, an increase in the air flow rate with the combined ventilation system at a distance of up to one and a half meters from the floor entails a decrease in the mass concentration of dust. The best values of dustiness reduction in the area of the borer miner operator's cabin are achieved with an exhaust fan capacity of 3.5 and 5.2 m^3/s. With a fan capacity of 7 m^3/s, the efficacy of dust suppression the upper part of the face is noticeably reduced. Therefore, in order to reduce dustiness in the workplace area of borer miner operator with the use of the combined ventilation system, it is recommended to maintain the mine heading air flow velocity in the range of 0.22-0.33 m/s.

4.2 On-site tests of the combined ventilation system

Based on the results of the simulation, on-site tests of the operation of the ventilation system using a combined ventilation system (with a dominance of an exhaust fan) were carried out in the conditions of one of the potash mines of the Russian Federation. The object of the study was a blind mine heading with a Continuous mining machinery complex located in it, which included a borer miner "Ural-20R" and a shuttle car. The comparison was made with the forcing ventilation system. At the time of the measurements, the air velocity in the mine heading with forcing and combined ventilation systems was 0.18 m/s. The workspace of the borer miner operator, which is located on the left side of the borer miner near the cabin, is considered as a dustiness research area. The obtained values of dust concentrations are shown in Figure 11.

Comparison of the simulation results presented in Figure 10 (capacity 3.5 m^3/s) and the results of field measurements of the combined ventilation system (Figure 11) allow us to conclude that the results are well converged: at point 1, the simulated dust concentration is 1250 mg/m^3 (real value – 1750 mg/m^3), at point 2, the simulated concentration is 2250 mg/m^3 (real value – 2450 mg/m^3), at point 3, the simulated concentration is 1700 mg/m^3 (real value– 1850 mg/m^3). The reduction in dust concentration when using a combined ventilation system ranges from 40 to 58% compared to the initial case with a forcing system. The results of field measurements presented in Figure 11 confirm the effectiveness of the combined ventilation system in comparison with the forcing ventilation system by the dustiness.

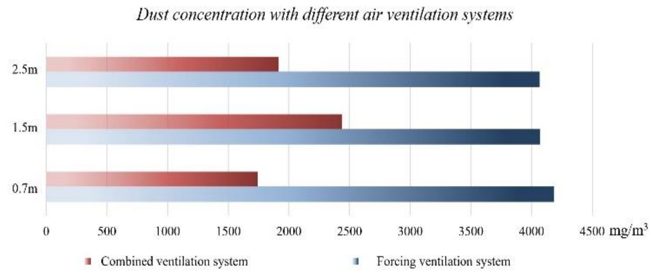


Figure 11. Comparison of forcing and combined (with dominance of exhaust) ventilation systems in the borer miner operator's cabin area

5. CONCLUSIONS

The issues of normalizing the dust situation in operational blind headings are quite relevant at potash mines at the moment. First of all, it follows specific mining, geological and technological conditions. The existing methods of dust suppression are based on changing the parameters of the auxiliary ventilation systems used of blind headings.

The authors of this study propose a combined ventilation system with a predominance of exhaust fans to reduce the concentration of fine salt dust both in the face area and along the entire length of the blind heading. The system's effectiveness is confirmed by the results of three-dimensional numerical simulations, as well as during on-site tests. The experimental results demonstrate that the combined ventilation system reduces dust concentrations by 42 to 50% compared to the forcing ventilation system. These findings significantly improved living conditions for miners in the dead-end face.

The main difficulty in implementing the proposed system is the limitations of the use of a combined (with a dominance of exhaust) ventilation system at the legislative level in Russian Federation. Currently, the only way to legitimize the proposed solutions is to develop a safety justification for a hazardous production facility, establishing additional requirements for inclusion in current federal norms and regulations.

To develop such a justification, it is crucial to analyze the gas situation with combined ventilation for blind heading with an operating borer miner. We are currently conducting these studies and will continue them in the future. As a result, we plan to develop technical and organizational measures aimed at reducing the risk of emergency situations. The outcome of this work will be a regulatory document. This document should be accompanied with developed compensating measures, the essence of which is to establish technical and organizational requirements. These requirements will enable the safe use a combined ventilation system with a dominant exhaust fan.

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