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Research on Mine Ventilation Optimization Based on 3D Simulation System

Aiwei Jiang^{1, 2, *}, Bo Zhou^{3, a}, Hao Hu^{1, 2, b} and Jianwei Luan^{3, c}

¹State Key Laboratory of Mining Disaster Prevention and Control Co-founded by Shandong Province and the Ministry of Science and Technology, Shandong University of Science and Technology, Qingdao, China

²School of mining and safety engineering, Shandong University of Science and Technology, Qingdao, China

³Xinglongzhuang Coal Mine, Shandong Yanzhou Coal Industry Co., Ltd., Yanzhou China

*Corresponding author e-mail: 1252596161@qq.com, ^a1216662751@qq.com, ^b964088187@qq.com, ^c2303149961@qq.com

Abstract. Based on the application of Ventsim software as the analysis tool and the modern optimization design method as the theoretical basis, aiming at the current situation of the ventilation reversal, large ventilation resistance and insufficient safety equipment investment in the mine of Xinglongzhuang Coal Mine, combined with the basic data of the mine, the mine ventilation three-dimensional is established. The simulation model is used to construct a three-dimensional simulation system for mine ventilation. The mine ventilation three-dimensional simulation system is used to simulate the solutions of ventilation reversal and mine ventilation, so as to realize the optimal design of the ventilation system, effectively ensure the ventilation needs of the normal production of Xinglongzhuang Coal Mine, and improve the visualization of the regulation of the mine ventilation system. automation.

1. Introduction

With the deepening of mine mining, the mine ventilation system is becoming more and more complex, and the difficulty of ventilation management is increasing. It seriously threatens the stability and reliability of the mine ventilation system, increases the operating cost of the ventilation system, and is prone to unreasonable management of the ventilation system. The ventilation system is disordered, which seriously threatens the safety of mine production [1]. At the same time, the mine ventilation system is one of the most important parts of the entire mine production system. Whether the mine ventilation system is reliable or not will directly affect the downhole ventilation safety. After years of mining, Xinglongzhuang Coal Mine has experienced problems such as aging of wind turbines, low efficiency of wind turbines and large ventilation resistance with the continuous expansion of mining scope and deepening of mining depth [2]. Therefore, it is extremely urgent to study the safety management of actual complex mine ventilation systems.

With the continuous application of computer technology in mine ventilation systems, many mine ventilation simulation softwares have appeared in China and abroad. In China, the representative mine



ventilation simulation software mainly includes CFIRE and MVSS. Many simulation results are used to obtain many achievements [3], but most of them are complicated and poorly interactive, difficult to promote, and some difficulties and hot spots for mine ventilation system. The solution to the problem still needs to be further improved. Therefore, the use of a three-dimensional ventilation simulation system with full function, simple operation, visualization and suitable for complex coal mines is of great significance for fundamentally improving the condition of mine ventilation system and improving the ventilation system and mine safety management capability.

2. Mine overview

In this paper, the Xinglongzhuang Coal Mine was studied in the background. The coal mine was completed and put into operation in 1981. With the increase of the number of mining faces, the required air volume in the well is also greatly increased, while the Dongfeng well wind section is relatively small, resulting in large ventilation resistance. As a result, the supply air volume of the main ventilator of the mine is seriously restricted. Therefore, it is urgent to optimize the design of the underground ventilation system of Xinglongzhuang Coal Mine. However, due to the large scope of reconstruction and the high direct construction cost, in order to ensure its cost and transformation effect, it is necessary to carry out 3D simulation and optimization design before the transformation.

3. Construction of 3D simulation system for mine ventilation

The ventilation three-dimensional simulation system is mainly composed of Ventisim ventilation three-dimensional simulation software [4], electronic dog, monitoring and monitoring system related components and other supporting hardware. The system has strong adaptability to mine ventilation system management, can accurately reflect the three-dimensional graphics of the mine, and can be networked with the monitoring system to realize real-time monitoring of the mine ventilation system and enhance the safety management capability of the ventilation system.

3.1. The basis of the construction of ventilation 3D simulation system

The drawings and materials required for 3D modeling mainly include mine mining geological map, ventilation system map, ventilation stereo view, and mine section atlas. According to the mine mining engineering drawing, the mine mining engineering drawing is introduced into the three-dimensional ventilation auxiliary decision-making system by drawing the center line, and the three-dimensional figure of the mine is drawn.

The data measured in the mine roadway mainly includes parameters such as the horizon of the roadway, the section of the roadway, the support form, etc., collecting multiple measuring points, and preparing the basic data for the modeling of the three-dimensional system, for the vents, the leaking coal eyes, the wind wall, The data collection of ventilation structures and other materials fully guarantees the authenticity and integrity of the underground roadway data. In order to ensure the accuracy and comprehensiveness of the measurement of the resistance data, a total of five test lines are divided into two, the east wing two, the west wing two and the lower group coal dark inclined well, which can meet the test requirements of the mine resistance data to ensure System debugging is stable and fast.

3.2. Ventilation 3D simulation system model visualization

The three-dimensional simulation system of Xinglongzhuang Coal Mine's ventilation mainly includes three-dimensional visualization of the ground and three-dimensional visualization of the underground roadway, and the data of the elevation, length, width, height and roadway shape of the roadway can be accurately obtained from the ventilation three-dimensional simulation system model, which is the system ventilation system. Management provides basic data. At the same time, the system model can visually display dozens of items such as air volume, wind speed, wind pressure, drag coefficient, roadway section and ventilation cost.

4. Ventilation 3D simulation system function introduction

4.1. Ventilation system transformation plan optimization

The ventilation three-dimensional simulation system proposes the ventilation system reconstruction scheme [5] through the analysis of the current situation of the ventilation system, and constructs the wind network model after the implementation of the scheme through the system platform, and compares the feasibility of the scheme to select the optimal scheme. It is convenient for technicians to manage the ventilation system.

4.2. Anti-wind simulation and cyclic wind self-test

The ventilation three-dimensional simulation system can simulate the air volume at various locations in the downwind period, and can simulate the influence of natural wind pressure on the mine backwind when the wind is reversed in different seasons, and the auxiliary technicians can more rationally formulate the mine anti-wind emergency plan [6]. At the same time, combined with the mine wind measurement data analysis management system to display the roadway and dangerous roadway beyond the design requirements, improve the level of mine ventilation and anti-wind exercise plan.

4.3. Mine disaster simulation analysis

The ventilation three-dimensional simulation system can simulate downhole dust, toxic and harmful gases, internal combustion engine particles, gas and other harmful substances, and can display the diffusion path, concentration and attenuation of harmful substances. Through the simulation analysis results of the three-dimensional ventilation simulation decision analysis system, the technician can assist the technician to quickly and accurately formulate the emergency rescue plan and the escape route [7].

The ventilation three-dimensional simulation system can predict the economics of the operation of the underground ventilation system, analyze the relationship between roadway driving and ventilation economy, reduce the ventilation operation cost of the mine, and save the underground management cost [8, 9].

5. On-site management application case of ventilation three-dimensional simulation system in Xinglongzhuang Coal Mine

In order to verify the practicability and effectiveness of the ventilation three-dimensional simulation system of Xinglongzhuang Coal Mine, the application simulation of mine ventilation three-dimensional simulation system was carried out in combination with the existing problems in Xinglongzhuang ventilation system.

5.1. Ventilation reversal case simulation

According to the original ventilation system design, the lower group of coal pedestrians and the lower group of coal track dark inclined wells should be ventilated downwards, and the lower group of coal belts will return to the wind. However, when the ventilation system is formed, the lower group of pedestrians will not enter the wind, but will go out.

Therefore, in order to analyze and solve the above problems, the causes and solutions of ventilation reversal in the lower group of coal underground wells were simulated. Firstly, data collection and model construction are carried out for the next group of coal dark inclined well areas. The physical parameters of the lower group of dark inclined well areas are optimized from the model, and then the wind window at the bottom of the mine's dark inclined well area is adjusted and simulated. Adjust the effect of the windshield on the ventilation system. The effect simulation diagram after adjusting the size of the windshield opening is shown in Figure 1.

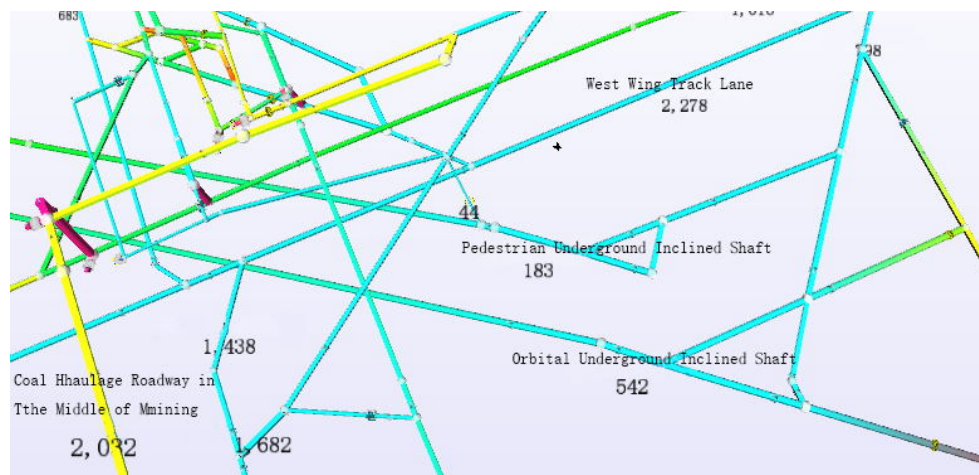


Figure 1. Adjusting the wind window opening effect simulation.

It can be seen from the figure that the air volume of the pedestrian's dark inclined well is 183m³/min, which does not meet the requirement of design air volume of 300m³/min. According to the pressure distribution above and below the dark inclined well, it is possible that the reason why the ventilation system is difficult to descend is that the pressure difference between the two ends is small, and the cause may be ground temperature, heat resistance, and the ground temperature factor is turned off in the system. The simulation result is shown in the figure. 2 is shown.

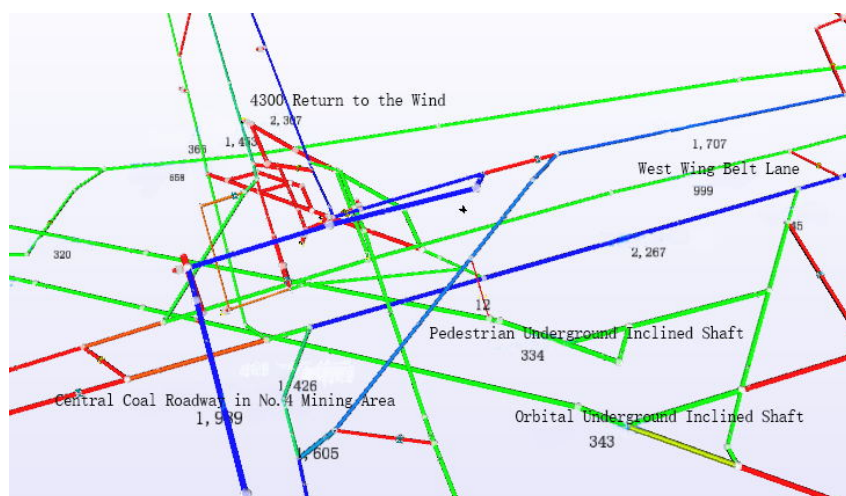


Figure 2. Close ground temperature ventilation system simulation results.

From the simulation results, it is concluded that the design requirements are met after the temperature is turned off, indicating that this is due to the difficulty of ventilation in the dark inclined well area caused by the high ground temperature, and can be completed by increasing the adjustment of the windshield section. Ventilation system management in the inclined well area.

5.2. Mine wind regulation case simulation

For example, the connection between the four-way middle lane in the ten mining area and the lower collecting lane in the fourth mining area is selected as an example. According to the requirements of the mine ventilation department, the mine ventilation system is simulated and adjusted for the requirement that the controlled air volume of the four-way intermediate tunnel in the ten mining area is not higher than 250m³/min. The effect of the structure before and after the addition of the structure

of the four-way middle lane in the ten mining area is compared. Figure 3 is a simulation diagram after installing the structure [10].



Figure 3. Installation structure simulation.

From the results of the simulation, it can be concluded that the four-way intermediate connecting lane in the ten mining area and the lower collecting lane in the fourth mining area need to set 40% installation strength damper and 0.2m² wind window in the four horizontal middle lanes of the ten mining area. It can solve the problem of internal control air volume in the middle of the four horizontal crossings in the ten mining area. By comparing the ventilation adjustment optimization schemes, the technician is assisted in optimizing the ventilation scheme and assisting the optimization scheme, thereby saving the ventilation operation cost.

5.3. Mine ventilation economy budget simulation

According to the economic budget of the ventilation system of Xinglongzhuang Coal Mine, it is assumed that the cost per metre of the excavation rock roadway is 4,000 yuan, the cost per metre of coal roadway is 1,000 yuan, the electricity cost is 1.2 yuan per degree, the input cost of the wind turbine is 10 million yuan, and the service is 20 years. The yellow roadway is a high-energy-consuming roadway. According to the suggestions put forward by the three-dimensional ventilation assisted decision-making analysis system, the roadway can be improved, which can save more than 20,000 yuan.

Using the ventilation three-dimensional simulation system, the economic analysis of the underground roadway was carried out: 7 high-energy lanes were found, with a cumulative length of 1700 meters, and the ventilation and high-energy lanes were separately treated; the ventilation facilities were reduced 4 times, and the main ventilator operating pressure was alleviated. Reduce the required air volume by 1500m³/min; pre-evaluate the feasibility and implementation effect of the scheme, reduce the 1000-meter coal roadway in the roadway, and reduce the underground ventilation management cost by 1000 meters.

6. Conclusion

Xinglongzhuang Coal Mine adopts ventilation three-dimensional simulation and decision-making system to display complex ventilation parameters and ventilation process through three-dimensional dynamic graphics in a simple and intuitive way, so that the manager can observe and adjust the ventilation system from any angle to realize the roadway. Real-time solution and analysis of air volume distribution.

Through the simulation of the mine ventilation scheme, the feasibility and implementation effect of the scheme are pre-evaluated, the economic loss caused by the design error is reduced, the precision of

mine ventilation adjustment is improved, and manpower, material resources and financial resources are saved. By scientifically scheduling and managing the fan operating conditions during the change of the underground ventilation network and seasonal changes, the fan power consumption is reduced, the operating cost of the fan is saved, and the mine production safety is guaranteed.

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