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Research on Optimization of Ventilation Method in Mining Face: A Case Study of Huoerxinhe Coal Industry

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Abstract

This paper takes the No. 3 coal seam mining face of Shanxi Huoerxinhe Coal Industry Co., Ltd. as the research object. Aiming at the problems existing in the current double-"U" type ventilation method, by comparing and analyzing the advantages and disadvantages of the single-"U" type and "Y" type ventilation methods, and considering the requirements for achieving the standard of gas drainage in the mine, the necessity and feasibility of optimizing the ventilation method are proposed. The research results indicate that the "Y" type ventilation method has significant advantages in solving upper corner gas accumulation, improving ventilation efficiency, and saving coal resources, making it an ideal choice for optimizing the ventilation method of the mining face in Huoerxinhe Coal Industry. This paper elaborates in detail on the implementation steps and safeguard measures of the optimization scheme, providing a reference for the optimization of ventilation methods in similar mines.

Keywords

Mining Face; Ventilation Method Optimization; Double-"U" Type Ventilation; "Y" Type Ventilation; Gas Drainage.

1. Introduction

As coal mining extends deeper, the problem of gas disasters in mines has become increasingly prominent, becoming one of the main factors restricting safe production in coal mines [1-2]. Ventilation, as an important means of preventing and controlling gas disasters, its rationality and effectiveness are directly related to the safe production of mines [3-5]. As a high-gas mine, Shanxi Huoerxinhe Coal Industry Co., Ltd.'s double-"U" type ventilation method adopted at the No. 3 coal seam mining face has certain limitations in solving gas problems, and urgent optimization and transformation are needed.

Domestic and foreign scholars have conducted extensive research on the optimization of mine ventilation methods, mainly focusing on the reliability, economy, safety, and gas control effects of ventilation systems. For high-gas mines, researchers have proposed various ventilation methods, such as "U" type, "W" type, "Y" type, etc., and verified their effectiveness through numerical simulations, field tests, and other means [6-11]. However, due to differences in geological conditions, gas occurrence situations, and mining technical conditions among different mines, the selection of ventilation methods needs to be combined with specific circumstances. This study aims to propose an optimized ventilation method scheme suitable for Huoerxinhe Coal Industry by comparing and analyzing the advantages and disadvantages of different ventilation methods and combining them with the actual situation of the mine, providing technical support for safe mine production.

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2. Mine Overview and Analysis of Current Ventilation Status

Shanxi Huoerxinhe Coal Industry Co., Ltd. is located in Zhangzi County, Changzhi City, Shanxi Province, with a mining field area of 71.3947 km^2 and the No. 3 coal seam as the main mining seam. The mine adopts a fully mechanized coal mining process with a production capacity of 4 million tons per year. The No. 3 coal seam has a relatively high gas content, with a maximum gas content of 15.85 m^3/t, belonging to a high-gas mine, and effective gas control measures need to be taken. Currently, Huoerxinhe Coal Industry adopts a double-"U" type ventilation method at the mining face, that is, two intake airways and two return airways are used, which are connected through communication airways. This ventilation method has, to a certain extent, increased the air distribution volume at the working face, but it has the following problems: (1) Each mining face requires the excavation of four roadways (two intake airways and two return airways) connected by communication airways, leading to a significant increase in excavation engineering, resulting in tension in mining-excavation succession. (2) The double-"U" type ventilation method requires the reservation of more protective coal pillars, causing a waste of coal resources. According to statistics, for a 1000m long mining face, the amount of coal reserved in the pillars is approximately 470,000 tons. (3) The double-"U" type ventilation method has a complex ventilation system, with serious problems of air leakage and air mixing, affecting the ventilation effect. (4) Due to the formation of an eddy current zone at the upper corner in the double-"U" type ventilation method, gas accumulation is prone to occur, leading to frequent gas over-limit alarms.

Huoerxinhe Coal Industry has built a surface gas drainage pump station and adopts four drainage methods: pre-drainage of the coal seam, drainage during mining, drainage during excavation, and drainage in the goaf. However, due to the influence of the double-"U" type ventilation method, the gas drainage effect does not meet the standard, and the gas emission at the mining face is relatively large, posing safety hazards. Specific manifestations are: (1) The existing gas drainage system has limited drainage capacity and is difficult to meet the drainage needs of high-gas-content areas. (2) Due to the complex ventilation system and serious air leakage, the gas drainage efficiency is low. (3) Although gas drainage measures have been taken, the problem of gas accumulation at the upper corner has not been fundamentally solved, and gas over-limit alarms still occur from time to time.

3. Comparison of Ventilation Methods

3.1. Single-"U" Type Ventilation Method

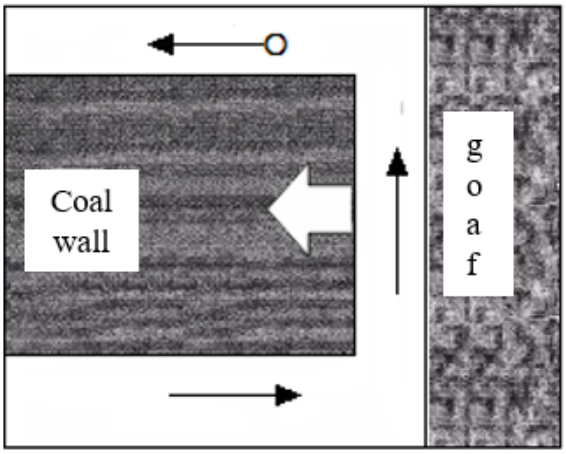

Figure 1. "U" Type Ventilation

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The single-"U" type ventilation method uses one intake airway and one return airway, with a simple and reliable system and small air leakage. However, this ventilation method has the problem of gas accumulation at the upper corner, and measures such as gas drainage through buried pipes in the goaf need to be taken to solve it. For Huoerxinhe Coal Industry, the single-"U" type ventilation method is suitable for mining faces with lower gas content. But in areas with higher gas content, it is difficult to meet the requirements of gas control.

3.2. "Y" Type Ventilation Method

The "Y" type ventilation method transforms one return airway into an intake airway through gob-side entry retaining technology, forming a ventilation system with two intake airways and one return airway. This ventilation method has the following advantages: (1) Solving upper corner gas accumulation: The "Y" type ventilation method effectively solves the problem of upper corner gas accumulation by optimizing the ventilation system, improving ventilation efficiency. (2) Reducing excavation engineering volume: Compared with the double-"U" type ventilation method, the "Y" type ventilation method reduces the excavation engineering volume and saves coal resources. (3) Improving ventilation reliability: The "Y" type ventilation method has a simple system and low ventilation resistance, improving the reliability of ventilation. (4) Facilitating gas drainage: Gob-side entry retaining technology provides convenient conditions for gas drainage, helping to improve gas drainage efficiency.

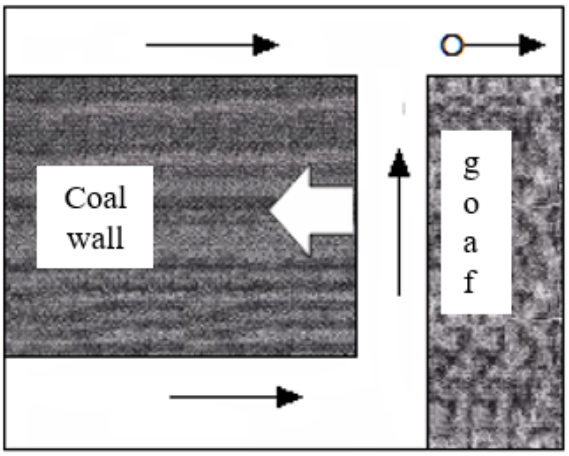

Figure 2. "Y" Type Ventilation

By comparing the advantages and disadvantages of the single-"U" type and "Y" type ventilation methods and combining them with the actual situation of Huoerxinhe Coal Industry, the following conclusions can be drawn:

(1) Applicability: In areas with lower gas content, the single-"U" type ventilation method has certain applicability; in areas with higher gas content, the "Y" type ventilation method is more superior.

(2) Gas control effect: The "Y" type ventilation method performs better in solving upper corner gas accumulation and improving gas drainage efficiency.

(3) Economy: The "Y" type ventilation method reduces excavation engineering, saves coal resources, and lowers ventilation system maintenance costs, with higher economy.

(4) Technical feasibility: With the development and maturity of gob-side entry retaining technology, the "Y" type ventilation method is technically feasible.

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4. Effect Analysis

4.1. Ventilation Effect Analysis

After adopting the "Y" type ventilation method, the ventilation effect of the mining face in Huoerxinhe Coal Industry has been significantly improved. Specific manifestations are:

(1) Reduction of gas concentration at the upper corner: By optimizing the ventilation system, the problem of gas accumulation at the upper corner has been effectively solved, and the gas concentration has been significantly reduced.

(2) Improvement of ventilation efficiency: The "Y" type ventilation method reduces ventilation resistance, improves ventilation efficiency, and ensures that the working face has sufficient fresh airflow.

(3) Reduction of air leakage: After system simplification, the phenomenon of air leakage has been effectively controlled, improving the reliability of the ventilation system.

4.2. Gas Drainage Effect Analysis

The "Y" type ventilation method provides convenient conditions for gas drainage and improves gas drainage efficiency. Specific manifestations are:

(1) Increase in drainage volume: Gob-side entry retaining technology provides more space for the layout of gas drainage boreholes, increasing the gas drainage volume.

(2) Improvement of drainage concentration: The optimized ventilation system helps to improve the gas drainage concentration and reduce the phenomenon of gas dilution.

(3) Enhancement of drainage efficiency: Through reasonable layout of drainage boreholes and optimization of drainage parameters, the gas drainage efficiency has been significantly improved.

4.3. Economic Benefit Analysis

After adopting the "Y" type ventilation method, Huoerxinhe Coal Industry has achieved significant economic benefits. Specific manifestations are:

(1) Reduction of excavation costs: The reduction of excavation engineering has lowered excavation costs.

(2) Conservation of coal resources: The reduction of protective coal pillars has saved coal resources.

(3) Reduction of ventilation system maintenance costs: After system simplification, the maintenance costs of the ventilation system have been reduced.

(4) Reduction of gas control costs: The improvement of gas drainage efficiency has reduced gas control costs.

5. Conclusion

This study takes the No. 3 coal seam mining face of Shanxi Huoerxinhe Coal Industry Co., Ltd. as the research object, conducts an in-depth analysis of the problems existing in the current double-"U" type ventilation method, and proposes an optimization scheme of the "Y" type ventilation method by comparing and analyzing the advantages and disadvantages of different ventilation methods, combining with the actual situation of Huoerxinhe Coal Industry and the requirements for achieving the standard of gas drainage. The research results have achieved significant achievements. This research has important practical significance and promotional value for the optimization of ventilation methods in similar high-gas mines, providing strong support for the safe production and sustainable development of mines.

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