

Research on the Prevention and Control Technology of Low Oxygen in The Upper Corner of Fully Mechanized Coal Mining Face in Daliuta Coal Mine

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Abstract: In response to the problem of low oxygen in the upper corner of the return air of the 52506 fully mechanized mining face in Daliuta Coal Mine, the impact of atmospheric pressure and temperature changes on the low oxygen in the upper corner of the 52506 fully mechanized coal mining face is analyzed, and the source and cause of the low oxygen gas in the upper corner of the 52506 fully mechanized coal mining face are analyzed from multiple perspectives. A comprehensive treatment method is adopted, including installing windshields and air guide boards at the head and tail ends, joint sealing and leak-repairing at the ground and underground levels, sealing the adjacent goaf communication alleys, pressure ventilation, negative pressure suction, monitoring and control management, etc. This method solves the problem of low oxygen in the upper corner of the 52506 fully mechanized coal mining face.

Keywords: Fully mechanized coal mining face, Low oxygen, Return air upper corner, Prevention and control technology.

1. Introduction

The shallow-buried and close-distance coal seam groups are affected by multiple factors during the mining process, resulting in irregular hypoxia phenomenon in the upper corner of fully mechanized coal mining faces. The buried depth of the 52506 fully mechanized coal mining face in Daliuta coal mine is about 80~200m, and it is adjacent to the mined-out area of the 52505 working face, located in the CO₂~N₂ gas weathering zone. Due to the influence of geological conditions, coal seam occurrence, mining methods, and working face layout, during the mining activities, the roof of the mined-out area falls down, leading to the connection of the overlying mined-out area and the formation of a larger regional complex mined-out area. The large-area collapse zone causes a large number of through cracks and pores to form in the rock strata, resulting in surface and interlayer air leakage. Under the environment of surface air leakage and interlayer air leakage, broken coal body gas analysis or multiple oxidation occurs in the mined-out area, causing abnormal emergence of oxygen-deficient air in the mined-out area and leading to hypoxia phenomenon in the working face.

Numerous scholars in China have conducted extensive research on the issue of low oxygen in coal mining faces. Among them, Zhang Lihui [1] investigated the causes of low oxygen in the 22306 fully mechanized mining face of Bulianta Coal Mine in the Shendong mining area during the mining process. Based on the measurement results, the coal mining face was divided into three areas: low oxygen area in the working face, low oxygen area in the return air corner, and low oxygen area in the machine lane, providing reference for the treatment of low oxygen areas. A comprehensive analysis is conducted on the combination of gas warning, mining methods, and ventilation methods in goaf to obtain measures for low oxygen prevention and control [2-4], which has guiding significance for low oxygen prevention and control in goaf. Therefore, this article analyzes the reasons for the low oxygen problem in the upper corner of the return air of the 52506 fully mechanized mining face in Daliuta Coal Mine,

and analyzes the law of low oxygen gas emission from the aspects of temperature, atmospheric pressure, etc. A comprehensive treatment plan has been proposed, including uniform pressure ventilation and extraction technology, to provide reference for the low oxygen treatment in the upper corner of the working face in the Shendong mining area.

2. Analysis of Reasons for Low Oxygen in Fully Mechanized Mining Face

The 52506 fully mechanized mining face of Daliuta Coal Mine is located on the east side of the main roadway in the fifth panel area of 52 coal seam, the west side of the boundary of the mine field, the south side is the 52505 goaf, and the north side is the 52507 design working face. The 52506 fully mechanized coal mining face adopts a strike long wall retreat style full height comprehensive mechanized mining method. The treatment method for the roof of the goaf is the full collapse method. The working face has a mining strike length of 3871.8m, a inclined layout length of 301.0m, a design mining height of 6.8m, a geological reserve of 10.9746Mt, a mining reserve of 10.206Mt, and a recovery rate of 93%.

The phenomenon of low oxygen in the upper corner of the return air of the 52506 working face is the result of multiple factors working together, mainly including coal seam occurrence, spontaneous combustion characteristics, climatic conditions, goaf air leakage, working face layout, ventilation system, and working face footage [5-10]. Based on the above factors, this paper analyzes and studies the reasons for the low oxygen phenomenon in the 52506 fully mechanized working face of Daliuta Coal Mine. By conducting bundle tube sampling analysis on the upper corner of the return air and the gas in the goaf of the 52506 fully mechanized mining face, the sampling points are arranged as shown in Figure 1. The main components of low oxygen gases were analyzed using a gas chromatograph, and the results are shown in Table 1. Based on the analysis of on-site measured data, it is determined that the occurrence of low oxygen in the 52506 fully mechanized mining face is mainly due to the high concentration of N₂.

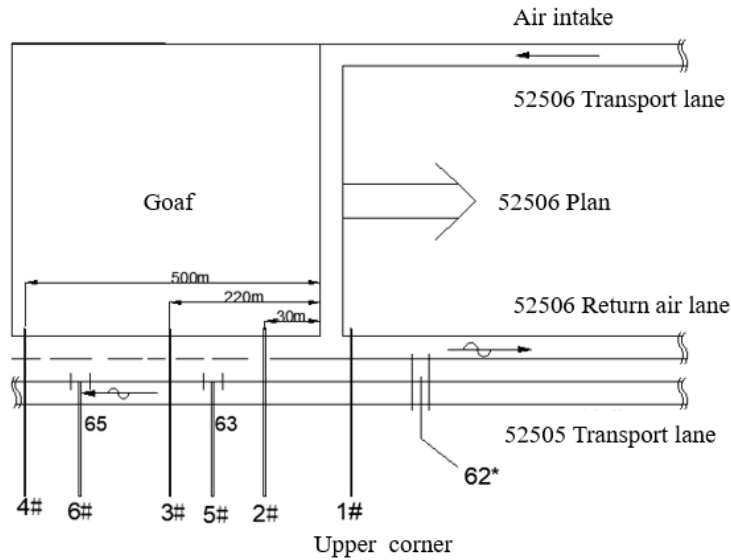


Figure 1. Layout of sampling points for the upper corner of the return air and goaf in the 52506 fully mechanized mining face

Table 1. Gas volume fraction detected at the upper corner of the return air and goaf of the 52506 fully mechanized mining face

Number	Sampling location	O ₂ /%	N ₂ /%	CO/%	CO ₂ /%	CH ₄ /%	Total/%
1#	upper corner	16.895	82.795	0.0048	0.2922	0.013	100
2#	mined out area (30m)	16.435	83.2201	0.0068	0.3381	0	100
3#	Mined out area (220m)	8.1254	91.202	0.0049	0.6028	0.0649	100
4#	Mined out area (500m)	2.9568	95.543	0.00089	1.3896	0.10971	100
5#	auxiliary transportation 63 connecting alley in goaf	9.9832	89.158	0%	0.7842	0.0746	100
6#	auxiliary transportation 65 connecting alley in goaf	3.6945	93.689	0%	1.7981	0.8184	100

2.1. Relationship between oxygen volume fraction at the upper corner of the return air and temperature and pressure

By analyzing the changes in oxygen volume fraction data at the upper corner of the return air of the 52506 fully

mechanized mining face, the relationship between oxygen volume fraction and temperature and atmospheric pressure was analyzed. The law of the temperature and atmospheric pressure at the upper corner of the return air of the 52506 fully mechanized mining face on the emission of low oxygen gas in the goaf was obtained, as shown in Figure 2.

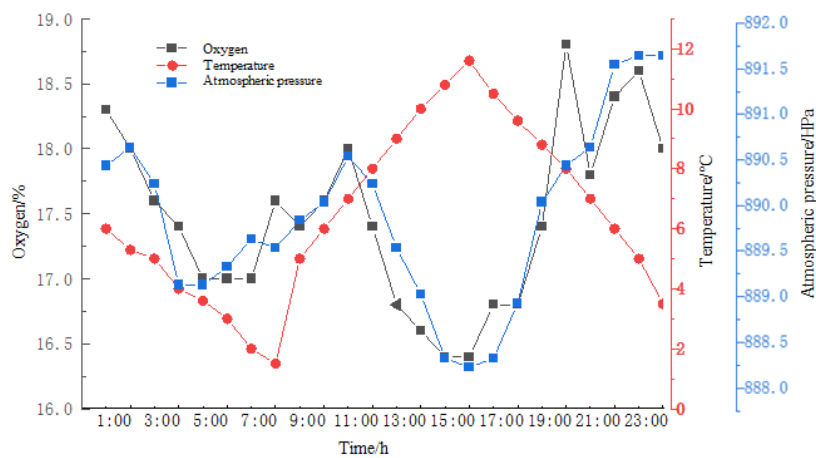


Figure 2. Changes in oxygen concentration at the upper corner of the return air in the 52506 fully mechanized mining face

According to the analysis in Figure 2, it can be seen that from 0:00 to 12:00, the range of oxygen volume fraction changes is 17% to 18.5%, showing an overall downward trend. During this period, atmospheric pressure shows a first decrease and then an increase trend, and the temperature first

decreases and then increases. From 12:00 to 16:00, the oxygen volume fraction gradually decreases and a phenomenon of low oxygen occurs, with the lowest oxygen volume fraction reaching 16.4%. At this stage, the atmospheric pressure decreases by 200Pa and the temperature

shows an upward trend. From 17:00 to 24:00, the oxygen volume fraction gradually increases, with a range of 16.8% to 18.6%. During this period, the temperature and atmospheric pressure showed an overall upward trend.

Based on the actual situation underground in Daliuta Coal Mine and the data analysis in Figure 2, the environmental temperature, atmospheric pressure, and low oxygen gas emission law of 52506 fully mechanized mining face are obtained. An increase in ambient temperature over a period of time can lead to a decrease in atmospheric pressure. Due to the correlation between the air supply of the 52506 fully mechanized mining face and the ground atmosphere, the pressure on the working face decreases accordingly, resulting in a pressure difference between the working face and the goaf, leading to the influx of low oxygen gas into the working face. The amount of low oxygen gas emitted is related to the pressure difference. When the static pressure is lower than the pressure in the goaf, the gas in the goaf is in an expanding state, presenting an output state similar to the sound of wind. As a result, low oxygen gas flows into the working face in the goaf, leading to low oxygen phenomenon in the upper corner of the return air of the working face.

2.2. Sources and causes of low oxygen gas emission in 52506 fully mechanized mining face

(1) The 52506 fully mechanized mining face is located in the $\text{CO}_2\text{-N}_2$ gas weathering zone. According to the analysis of mine gas composition, N_2 ranges from 83.72% to 99.14%, with an average of 97.71%; CH_4 ranges from 1.67% to 15.29%, with an average of 7.28%; CO_2 ranges from 0.85% to 5.33%, with an average of 3.61%. So the 52506 fully mechanized mining face is located in the $\text{CO}_2\text{-N}_2$ gas weathering zone, and the main gas emitted is N_2 .

(2) The impact of shallow and deep mining. The burial depth of the 52506 fully mechanized mining face is about 80~200m. During the mining process, there may be cracks communicating with the surface. Under the negative pressure, gas from the 52506 goaf gushes out towards the working face, causing the occurrence of low oxygen phenomenon.

(3) The impact of adjacent goafs. The 52506 fully mechanized mining face is adjacent to the 52505 goaf. As the roof of the goaf collapses, the coal pillars or connecting tunnels between the 52506 return flow and the 52505 transport flow are sealed, resulting in air leakage channels. Under the action of negative pressure ventilation, low oxygen gas from the 52505 goaf gushes out towards the 52506 working face, causing the occurrence of low oxygen phenomenon.

(4) Affected by changes in atmospheric pressure. Through observation, it was found that the highest atmospheric pressure in a day at the 52506 fully mechanized mining face generally occurs between 21:00 and 2:00, and the lowest value generally occurs between 14:00 and 18:00 in the afternoon. This change in atmospheric pressure also leads to breathing phenomena in the goaf, which can easily induce hypoxia.

3. Low Oxygen Prevention and Control Measures in Fully Mechanized Mining Face

(1) Install wind curtains and air flow guide plates at the front and rear of the working face. Install wind curtains and

airflow guide plates at the upper and lower corners of the 52506 fully mechanized mining face to prevent the airflow from flowing into the goaf. Install an L-shaped air guide curtain in the tail lane of the machine to guide the airflow of the 52506 fully mechanized mining face to the upper corner and increase the oxygen volume fraction of the return air at the upper corner of the 52506 fully mechanized mining face.

(2) Joint measures will be taken above and below the mine to backfill the surface, optimize the sealing facilities in the goaf, and improve the sealing effect. Due to the shallow burial depth of the 52506 fully mechanized mining face, there may be cracks communicating with the surface during the mining process. Under the negative pressure, gas from the 52506 goaf gushes out towards the working face, causing the occurrence of low oxygen phenomenon. Therefore, timely backfilling and sealing of surface cracks should be carried out. Due to factors such as repeated mining, water flow erosion, and natural factors, multiple collapses have occurred, resulting in the emergence of new cracks and pores. Multiple backfilling is required to improve the sealing quality of backfilling and prevent air leakage.

(3) Seal the adjacent goaf connecting roadway to improve its sealing quality and prevent the inflow of low oxygen gas into the 52506 fully mechanized mining face, which may cause low oxygen phenomenon in the working face.

(4) Adopting uniform pressure ventilation system to prevent low oxygen. When there is a large area of low oxygen and a low degree of low oxygen in the 52506 fully mechanized mining face, timely use of a uniform pressure ventilation system for regulation. While ensuring the basic demand for underground air volume, reducing the air volume of the 52506 fully mechanized mining face can increase the resistance along the return air section, achieve a reduction in the pressure difference of the return air at the upper corner of the 52506 fully mechanized mining face, and reduce the inflow of low oxygen gas into the 52506 fully mechanized mining face. The use of uniform pressure ventilation system can significantly increase the oxygen volume fraction of 52506 fully mechanized mining face, effectively solving the problem of low oxygen in 52506 fully mechanized mining face.

(5) Install a negative pressure pumping system at the upper corner of the return air of the 52506 fully mechanized mining face. Cooperate with the overlying goaf extraction of the 52506 fully mechanized mining face to achieve the effect of low oxygen treatment. Install a ventilation duct at a distance of 100m from the 52506 fully mechanized mining face, and use negative pressure ventilation to create a negative pressure zone at the upper corner of the return air of the 52506 fully mechanized mining face, thereby changing the direction of toxic and harmful gas flow in the upper corner of the return air of the working face and avoiding the influx of toxic and harmful gases into the 52506 fully mechanized mining face. At the same time, install wind barriers at the cutting line of the upper and lower hydraulic supports to ensure the extraction of gas from the upper corner of the return air in a closed space and improve the extraction efficiency.

(6) Strengthen the monitoring and control of oxygen volume fraction at the upper corner of the return air of the 52506 fully mechanized mining face. By installing "oxygen sensors" and "portable oxygen alarm devices" to detect changes in the oxygen volume at the upper corner of the return air in the 52506 fully mechanized mining face, timely grasp the changes in the oxygen volume fraction at the upper corner

of the return air. Timely analyze the variation law between oxygen volume fraction, ground temperature, and atmospheric pressure in the 52506 fully mechanized mining face, and then take effective governance measures [11].

4. Conclusion

Low oxygen in the 52506 fully mechanized mining face of Daliuta Coal Mine is a unique disaster caused by the mining conditions of shallow, deep, and close range coal seams. Through the analysis of the reasons for low oxygen in the 52506 fully mechanized mining face, various technologies such as installing wind curtains and guide plates at the head and tail of the machine, implementing joint mining measures above and below the shaft, sealing the adjacent goaf connecting roadway, uniform pressure ventilation, negative pressure extraction technology, monitoring and management, etc. were comprehensively managed to successfully solve the problem of low oxygen in the upper corner of the return air in the 52506 fully mechanized mining face, ensuring the safe production of the mining face.

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