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Applied Research on Gas Extraction Technology in High Output and High Efficiency Mine Goaf

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Abstract*:* In order to realize the high-yield, high-efficiency and safe production of high-gas outburst mines, the gas drainage technology application in the goaf of a coal mine was carried out. A test investigation to improve the gas drainage concentration in the goaf, a gas change parameter investigation on the simulated failure pump stop working face, a gas overrun and production situation inspection, and a gas extraction test to close the goaf when the tail exhaust effect is poor were carried out. The effects of gas drainage in goaf were summarized. The study results not only solved the problem of gas overrun at the return corner of the working face and gas overrun of coal production, but also provided a reference for the gas control of high-efficiency and efficient construction of similar mines.

Keywords Outburst mine, High gas, Goaf, Gas extraction technology, High-yield and high-efficiency

INTRODUCTION

China is one of the countries with the most severe coal and gas outburst disasters in the world [Li, 2019]. After years of development, the technology of drilling coal seam gas has become one of the effective means to prevent coal and gas outburst in China, and it has been widely used [Xie, *et. al.*, 2014, He, *et. al.*, 2015 and Zhang, *et. al.*, 2017]. After mining of the working face, the roof rock in the mined-out area fractures and collapses, forming "falling zone, fissure zone and curved subsidence zone" in the vertical direction, in which the fissures and fissures in the fissure zone are developed and the permeability is high. According to the O-ring theory of the crack distribution in the stope, the gas in the goaf will move along these cracks and gaps, and a large amount of gas will flow into the working face space, causing the corner and even the gas of the coal mining face to exceed the limit [Qian, *et. al.*, 1998, and Zhang, *et. al.*, 2012]. In recent years, Chinese scholars have conducted in-depth research on gas extraction technology in mined-out areas, and have achieved rich results. Ding Houcheng et al. [Ding, *et. al.*, 2011] adopted the high-level drilling to extract the gas in the goaf by optimizing the drainage parameters in the 1111 fully mechanized mining face of Zhangji Coal Mine. The results show that the high-drilling hole has a good effect on gas drainage, the gas concentration is high, and the gas drainage volume is large, which effectively solves the problem of gas overrun in fully mechanized coal mining face. Chen Jigang [Chen, 2014] carried out ground gas drainage and gas extraction tests at the N2105 working face of Yuwu Coal Company to affect the coal seam and goaf gas test, to solve the gas overrun in the working face, and realized the joint mining of coal and gas. Yuan Haijun [Yuan, 2016] first used high-level front and rear boreholes to evacuate gas in the goaf at Yuecheng Coal Mine of Qinxiu Company, and achieved good results.

With the increase in output and horizontal extension of a mine, the amount of gas emitted from the mine is getting larger and larger. To achieve the goal of high yield and high efficiency in a short period of time, a high-yield and high-efficiency gas control test must be conducted. Therefore, based on the previous research experience, using the goaf gas extraction technology, an independent goaf gas extraction test system was established on the W2701 working face of the mine to design and apply the goaf extraction system, and to investigate various parameters. the goaf gas extraction technology was used to establish an independent goaf gas extraction test system for the W2701 working face of the mine, the design and application of the goaf extraction system and the inspection of various parameters were carried out.

OVERVIEW OF WORKING FACE AND GOAF EXTRACTION SYSTEM

W2701 is a drawing working surface, consisting of W2701S surface and W2701N surface. It is located in the middle of the west zone of the first level + 350m downhill part of the mine field, which is the first mining face of the 7# coal seam in the west zone. Sloping long-wall layout, mining in an inclined manner. W2701 ground elevation + 705m ~ + 797m, working face elevation + 195m ~ + 344m. Both faces are 150m wide, W2701S working face is 1029m long and W2701N working face is 1045m long. W2701 transportation lane is 1039.5m long, W2701S return air is 1012m long, W2701N return air is 1049m long. Coal seam inclination angle is 5 ° ~ 11 °, coal seam thickness is 1.07 ~ 1.42m, average thickness is 1.30m, and gas content is 25.52m^3/t. The industrial reserves are 625809t, the recovery rate is 95%, and the recoverable reserves are 608834t.

The extraction pipeline starts from the ground pump station and passes through nanpingdong, nan maokou lane, west general return air lane, +290 general return lane, W5 # (W1 #) gas lane, and +140 boundary lane to reach W2 # gas lane and W3 #gas lane. The length of the extraction pipeline is 8370m, of which the main pipe is Φ1000mm and the branch pipe is Φ800mm. The pumping station is composed of a SKA-720 pump (900KW motor), a high-voltage inverter and high-voltage switchgear. A large diameter eyelet with a diameter of 1200mm is connected to the return air lane of the working face at a distance of 250m, and the lower gas lane with a vertical distance of 50m is connected. A double-row concrete pipe with a diameter of 600mm is installed on the return side of the working face. The goaf is used as a gas flow channel in the goaf, and a special device for processing at the lower mouth of the large-diameter vertical eye is connected with the gas extraction pipeline in the goaf.

INVESTIGATION OF GAS DRAINAGE PARAMETERS IN GOAF

Test investigation on increasing gas drainage concentration in goaf

The gas drainage in the goaf of the working face is a semi-closed system. In actual operation, the gas drainage concentration has been unsatisfactory, with the concentration between 3.5% and 6.5%, most of which is around 4.5%. How to increase the concentration of gas drainage in goaf and further improve the effect of gas drainage in goaf, the experiments and measurements were conducted.

(1) Take technical measures to control 2/4, 3/4 and 4/4 for the entrance of double-row concrete pipes in the mined-out area of this layer. According to the test, for the gas drainage in the goaf in the semi-closed state, the gas drainage concentration in the goaf has basically not changed, and the extraction mixing volume has not changed, as shown in Table 1. It can be seen from the test situation that under the condition that the exposed area of the goaf is fixed, it is very difficult for the gas drainage in the semi-closed goaf to adopt the local control measures to increase the drainage concentration.

(2) Technical measures to increase the negative pressure of the extraction pump. By adjusting the water level of the extraction pump and gradually increasing the negative pressure of extraction, the change of the gas concentration in the goaf is investigated. Through the test, under the condition that the exposed area of the mined-out area is constant, the gas concentration will increase with the increase of the negative pressure, and the flow rate of the pump will also increase, as shown in Table 2. However, in the test phase, due to the increase in air temperature and poor heat dissipation in the switch control room, the temperature of the high-voltage inverter was relatively high, and the experiment to continue to increase the extraction negative pressure was stopped.

(3) Investigation of the exposed area and extraction concentration of the mined-out area. According to the investigation, when the negative pressure of extraction is constant, the extraction concentration in the mined-out area will increase with the increase of the area of the mined-out area.

When the advancing degree of the working face is at 100m, the extraction concentration is between 3.5% and 6.5%, most of which is around 4.5%. When the working face is advanced to the position of 300m, the extraction concentration gradually rises between 6.8% and 8.2%, most of which is around 7.5%. When the working face is advanced to the 360m position, the extraction concentration gradually rises between 8.5% and 11.0%, most of which is around 9.5%.

Investigation of gas change parameters in simulated fault pump stop working face

Although the gas drainage in goaf is beneficial to the gas treatment in the goaf, if the pump stop failure occurs suddenly, poor control may cause gas accidents such as gas overrun or explosion in the face. In order to grasp the change of the gas parameters of the working face caused by the sudden stop of the pump, a simulated stop pumping and pumping test and inspection were carried out on the W2701S working face. From the test and inspection situation, the gas concentration at the return corner of the working face changes rapidly after stopping the pump, and the gas concentration increases from 0.10% to 3.00% in just 4 minutes. It continued to increase thereafter, reaching 3.82% after 27 minutes and then stabilized at around 3.80%. The gas change in the working face (in the 10 m wind at the exit of the working face) was slower. The gas concentration increased from 0.30% to 0.85% in 4 minutes, reached 1.51% in 12 minutes, reached 1.70% in 27 minutes, and then stabilized at 1.70%. The gas concentration in the return air lane changed more slowly. There was no change within 4 minutes, reaching 1.49% in 17 minutes and 1.71% in 32 minutes, and then stabilized at about 1.70%. The data from experiments and observations show that, after the gas pumping in the mined-out area suddenly stops and the pumping stops, the gas at the pumped face changes rapidly and the growth rate is large. Of course, after gas pumping suddenly stops in the goaf, the gas concentration changes in the return corner, working face and return air lane will change quickly. The level of growth is related to the amount of gas extracted in the goaf and the amount of return air from the working face.

Investigation of gas overrun and production situation

The gas overrun conditions and production conditions of the gas drainage working face in the goaf were investigated by double-sided extraction and single-sided extraction. From the inspection situation, the gas extraction in the goaf can basically solve the problem of frequent gas overrun caused by the influx of gas into the working face, affecting production and threatening safety.

(1) Double-sided full extraction inspection.

In the 9 days before the normal production of gas in the mined-out area on February 1-9, a total of 33.7 knives were cut in the W2701S and N face, with 63 gas overruns, a gas overrun rate of 1.9 blows/knife, and a productivity of 3.74 knifes per day. During the 6 days of normal production after gas extraction in the mined-out area on February 11-16, a total of 24.9 knives of coal was cut in the W2701S and N working faces. The gas exceeded the limit by 0 times, and the productivity was 4.15 knives per day. The comparison between before and after gas extraction in the mined-out area shows that after the implementation of gas extraction in the mined-out area, the gas overrun reduction rate is 100% and the productivity is increased by 11%.

(2) Inspection of key extraction and auxiliary extraction.

In August, the full extraction of W2701N face was conducted, and the controlled extraction of W2701S face + tail row (the goaf area was 1/3 of the N face) was tested. In the test, the W2701N working face pumped in the full goaf was pushed forward by 46.5m for the whole month, and the W2701S working face with auxiliary pumping was pushed for 35m in the whole month. The N-face production efficiency was increased by 33% compared to the S-face. Because the working face of W2701S and N is opposite to the pull face, the two sides are constrained by the wrong distance. After advancing a certain distance, the N face has to slow down and wait for the S face. In the test in August, there were 419 times of gas overrun on W2701S face, and no gas overrun on W2701N face. The maximum advancement of N face is 7.1 knives per day.

(3) Single-face goaf extraction and tail row test.

In October, W2701N face was used for goaf extraction. W2701S face was not used for goaf extraction but tail row was used. The W2701N working face with goaf extraction produced 7 days, cutting coal 40.1 knives, the gas overrun was 0 times, and the average production was 5.81 knives per day. The W2701S face with no goaf extraction produced 7 days, cut coal 27.5 knives, gas exceeded the limit of 84 times, the average production was 3.93 knives per day, the gas overrun rate was 3.05 times per day, and the gas overrun affected time was 1.81 hours day. The maximum number of coal cutting knives for W2701N working face is 8.5 knives per day, and the maximum number of coal cutting knife for W2701S working face is 5.2 knives per day. The production efficiency of W2701N working face is 48% higher than W2701S working face.

Closed goaf drainage test when tail row effect is poor

On the morning of November 28, the goaf of W2701 working face was closed, and it was adjusted to a ventilated negative pressure tail row. Before the closure of the W2701 working face, the gas concentration in the air flow of the return airway was 0.95% when the goaf extraction was performed. After the closed goaf extraction, the gas concentration of the return airway was adjusted to 1.24% ~ 1.55% after the negative pressure tail row ventilation. The wind current continued to exceed the gas limit and could not be produced, and the night shift had to resume the mining of the goaf.

After recovering the goaf, the gas concentration dropped to 0.9%. This shows that not implementing goaf extraction when the tail row effect is poor will greatly restrict production and even threaten safety.

ANALYSIS OF GAS DRAINAGE EFFECT IN GOAF

Through more than 10 months of test operation, the gas extraction in the goaf has achieved the following effects.

(1) SKA-720 pump in the long-distance W2701 goaf gas extraction system has a minimum extraction gas flow of 350 m^3/min, a maximum extraction gas flow of 560 m^3/min, and a general extraction gas flow of 500 m^3/min.

(2) When the area of the mined-out area is not large, the extraction concentration in the mined-out area is between 3.5% and 6.5%, generally around 4.5%. When the area of the mined-out area is large, the extraction concentration in the mined-out area will gradually increase, reaching between 8.5% and 11.0%, generally around 9.5%. The extracted gas volume is about 17 ~ 30m^3/min.

(3) During the double-face test goaf extraction, the gas extraction rate of the working face is 83% ~ 89%, of which the goaf extraction amount accounts for 26% ~ 66%. Single-face test goaf extraction, the gas extraction rate of the face is 94%, of which the goaf extraction volume accounts for 43%.

(4) Since the negative pressure of extraction in the mined-out area is guaranteed, the large amount of air extraction is conducive to improving the air distribution of the entire working face. Basically, it can solve the problems that the gas in the empty area flows into the airflow of the working face and causes the gas to exceed the limit, and the production of falling coal causes the gas to exceed the limit. The gas overrun rate of working face with goaf can be reduced by more than 95%.

(5) Gas extraction in goaf double-sided extraction improves production efficiency by more than 10%, and single-sided extraction improves production efficiency by more than 30% to 48%.

CONCLUSION

Gas drainage in the goaf can effectively control and eliminate the gas overrun caused by the gas influx into the face of the goaf or the overrun of the face caused by the production of coal gas.

At the same time, the technical problems that the gas concentration in the exhaust air flow at the end of the tunnel is difficult to control and the safety problems that may occur in gas explosion accidents are eliminated. It can increase the production efficiency by 10% ~ 48%, which is one of the high-efficiency and high-efficiency gas control methods for high gas

outburst mines.

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