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Prevention and Control Measures of Abnormal Gas Emission in Low Permeability and High Gas Mining Face

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Abstract: China is rich in coal resources, especially in Northwest China. However, due to the complex geological conditions, some low permeability and high gas seams often accompany abnormal gas emission during mining, which poses a serious threat to the safety of coal mine. This paper takes East 102 working face of Weijiadi Coal Mine in Jingyuan mining area of Gansu Province as the research object. Aiming at the abnormal gas emission phenomenon during the initial discharge period of working face, the causes of abnormal gas emission are analyzed. The prevention of abnormal gas emission should be carried out from five aspects: strengthening ventilation management, perfecting gas extraction system, perfecting safety monitoring and control system, strengthening power supply management and emergency management on site.

1. Introduction

Coal is the dominant energy in China. In 2017, coal consumption accounted for 60.4% of China's total energy consumption. According to prediction from some authoritative experts, China's coal production capacity in 2020, 2030 and 2050 is 4.4 billion tons, 4 billion tons and 3.4 billion tons respectively. Therefore, the main energy status of coal can not be changed for a long time. Gas, water, fire, dust and other disasters in the process of coal mining restrict the healthy development of the coal industry. Especially in recent years, the shallow coal resources in our country have been nearly exhausted. Many coal mines have begun to enter deep mining [2]. Ground stress and gas pressure continue to increase. A large number of shallow low gas mines have been upgraded to high gas mines or even coal and gas outburst mines. During the process, abnormal gas emission often occurs, the disaster risk is increasing, and the situation of coal mine safety production is becoming more and more serious [3].

Domestic and foreign scholars have done a lot of research on abnormal gas emission. In the aspect of gas abnormal emission characteristics, Wang Shuai [4] studied the law of gas abnormal emission in the mining process of No. 2-01 working face of a mine in Shanxi Province through theoretical analysis and field measurement of atmospheric pressure, and the results show that the surface atmospheric pressure of the mining area corresponds inversely to the absolute gas emission in the goaf, and the gas emission lags behind the change of atmospheric pressure for 1-2 hours. Yu Bin[5] aimed at the problem of abnormal gas emission during periodic weighting in fully mechanized top-coal caving face with hard roof, the calculation model of incremental gas emission in goaf during periodic weighting was established. It was concluded that the main reason for abnormal gas emission during periodic weighting



was the breakage of hard roof and rotary compression of goaf volume in fully mechanized top-coal caving face with extra-thick roof. Zhang Yonggang [6] studied large-scale seismic monitoring network data and small-scale mine seismic monitoring network monitoring data, the correlation between seismic activity and coal mine gas anomalous emission was found through data statistics, and the conclusion that seismic wave propagation would lead to coal mine gas anomalous emission was drawn. An Chaofeng and Li Shugang [7] analyzed the physical characteristics of high in-situ stress and high gas content in deep mining coal, and combining Kozeny-Carmen equation, the relationship between coal permeability and volume strain of damaged fractured coal under mining influence is established. The mechanism of gas abnormal emission induced by rock burst in deep mining is studied. The results show that the vibration effect caused by rock burst accelerates coal deformation, and destruction prompts a large number of rapid abnormal gas emission.

2. Overview of working face

East 102 working face of Weijiadi Coal Mine is the first mining face in East NO.1 area. It is arranged in No. 1 coal seam. Both the South and the north are original seams which are not affected by mining. The 2 # and 3 # coal seams in the lower part of the working face are not mineable and can not be exploited in protective seam. The length of the working face is 920 m, the inclined length is 135 m, the thickness of coal seam is 5-39.55/26.2 m, and the average recoverable thickness is 15.4 m. It belongs to extra-thick coal seam mining. The inclination angle of coal seam is 0-25 degrees, the average angle is 13 degrees, the structure of coal seam is complex, the thickness of gangue 1-7 seams is 0.32-7.01 m, basically located in the lower part of coal seam. The original gas content of coal seam is $10.17 \text{ m}^3/\text{t}$, the gas pressure is 1.88 MPa, and the permeability coefficient is $2.13 \times 10^{-3} \text{ m}^3/\text{atm}^2 \cdot \text{d}$. The coefficient f of firmness is 0.31. Coal seam belongs to spontaneous combustion coal seam. The spontaneous combustion period is 4 to 6 months. The roof is managed by U-shaped ventilation and fully mechanized top-coal caving technology.

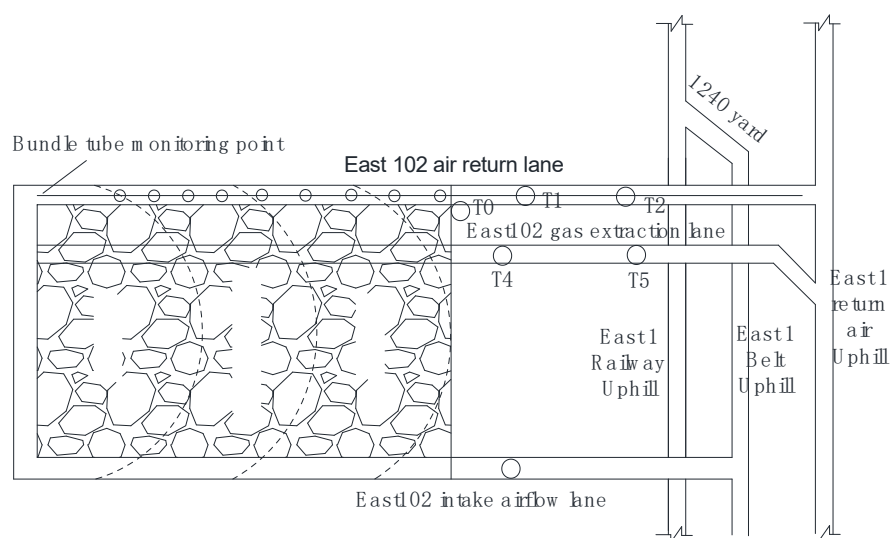


Fig. 1 East 102 Working Face Layout

3. Abnormal Gas Emission from Working Face

When the mining face is pushed to a distance of about 24 m from the cut hole (24 m from the airway and 23.8 m from the return air), a total of 90172 tons of coal are produced. When the working face is pushed 15.5-18.5m, the hydraulic support bears the maximum pressure. From the KJ24 on-line monitoring system, the maximum pressure rises from 20MPa to 40MPa, lasts about two hours, and then returns to the normal pressure of 20-28MPa. When advancing to 24 m, the fractured rock beam collapsed in the huge space formed after mining, resulting in a large amount of high concentration gas in the goaf

pouring into the working face from behind and between the supports. According to the KJ95n safety monitoring and control system, the gas concentration of T₁ gas sensor in return air roadway has reached 4.05% since about 16:15, and then a large amount of gas has spread to the return air roadway in the East NO.1 mining area and the wellbore of South and north air wells, with the maximum gas concentration reaching 1.79%. During this period, the gas blockade immediately operated, cutting off all power supply in the East 102 intake and return air lanes in the first time, and evacuating the operators to 1240 parking lot and East 102 intake air lane respectively. Subsequently, the power supply in 1260 east-middle roadway and the power supply of west-first track and belt conveyor were cut off artificially, and 1115 withdrawal surface was stopped. The workers were evacuated to 1150 east-middle roadway, and the guards were set up at the West NO.1 track, 1310 crossing and the West NO.1 belt crossing respectively. The East 102 working face was on guard and gas was released. On February 9, the abnormal gas tends to be normal in the East 102 working face.

4. Cause Analysis of Abnormal Gas Emission

Through the analysis of the abnormal gas emission in East 102 working face, the reasons for the abnormal gas emission can be summarized as follows: (1) the thickness of the coal seam in the initial mining section of the working face is very thick, the thickest is up to 30m, and the gas content in the coal body itself is relatively high; (2) there is a small reverse fault oblique cutting face in the cutting section of the working face, and the working face is in the geological abnormal structure zone; (3) Drainage roadway runs through the roof of coal seam to the floor and the cut hole. This section of roadway is a coal roadway (60m). There is collapse in the gas drainage roadway during mining, and the effect of gas drainage is not good, which results in the uneven gas drainage in the goaf; (4) the initial caving of the working face, the roof first collapse, resulting in a large amount of gas gushing out from the goaf.

Through the analysis of the above reasons, in order to effectively prevent the abnormal gas emission during the period of periodic weighting, the following aspects will be carried out to prevent and implement the abnormal gas emission.

5. Preventive measures for abnormal gas emission

5.1. Strengthen the management of ventilation system to ensure the stability and reliability of ventilation system

The air supply capacity of East 102 working face is 2000 m³/min, and 700 m³/min is provided by two air ducts in roof and return air lanes, totaling 2700 m³/min, which can basically meet the needs of working face production. The ventilation teams should strengthen the management and maintenance of the air doors of East 102 centralized uphill, 1260 East exploration lane and 1260 garage to ensure the stability and reliability of the ventilation system; the mechanical and electrical teams should strengthen the management and maintenance of the main ventilator in the South and north to ensure the safe and reliable operation of the main ventilator; the second fully mechanized caving team should strengthen the management of four local ventilators in the working face, strictly prohibit unplanned power outage and wind outage, and ensure tiles. The air supply safety in the drainage lane and upper corner.

5.2. Improving the extraction system and increasing the intensity of extraction

There are two gas pipelines in the working face, and the gas drainage pipeline is connected with the main system of mine gas drainage. There are two mobile gas drainage pipelines in the upper corner and roof gas drainage roadway, and the low concentration gas extracted is directly discharged into the air return roadway in the mining area. On this basis, it is required to increase the intensity of gas extraction, mainly from the following aspects: (1) increase the negative pressure of gas extraction, increase the extraction flow, make the extraction flow not less than 10 m³/min, and dock the two-pass mobile extraction pipeline exhaust pipe with the ground drainage pipe, add control valves, when high concentration gas enters the extraction pipeline, timely merge into the ground drainage intake pipe,

reduce. (2) Speed up the installation of high-power gas drainage pumps on the ground, restore the zonal gas drainage as soon as possible, increase the negative pressure and gas drainage volume in East 102 area; (3) Implement the construction of surface gas drainage shaft, further increase the gas enrichment in East 102 goaf and reduce the gas influx into the working face during the period of periodic pressure.

5.3. Improve safety monitoring and control system to ensure accurate, sensitive and reliable data

There are seven gas monitoring sensors installed in the upper corner of the intake lane, return lane, roof lane and working face of East 102 coal mining face. On the basis of existing safety monitoring, gas monitoring points are added in other locations: (1) A gas sensor is installed at 80# support to monitor the gas emission of the tail beam behind the support, so as to alarm when the CH₄ concentration reaches 1%. When the concentration of CH₄ reaches 1.5%, the safety inspectors and tile inspectors stop working in the face and stop the power supply of the scraper conveyor and shearer before and after the operation artificially; (2) Hanging a portable gas monitor in the lower part of the 80# bracket of the working face with five brackets, a total of four. When the concentration of CH₄ reaches 1.5%, the safety inspectors and tile inspectors stop working in the face and stop the power supply of the scraper conveyor and shearer before and after the operation; (3) A CH₄ sensor is installed at the motor of the scraper conveyor behind the working face. When the concentration of CH₄ reaches 1% , there is abnormal gas emission, it can cut off the power supply of front and rear scraper conveyor, shearer, transporter and the lighting signal power supply of the working face in time; (4) Strengthen the calibration of all gas sensors in East 102 working face, including the cutter power off instrument, gas transmission in the air inlet and return lane. Sensors are calibrated once a day and shearer power cutter is calibrated every 3 days to ensure accurate, sensitive and reliable data. Every 10 days, the standby batteries of the gas monitoring substation are checked and replaced. When there is abnormal gas emission stopping power supply, the transmission signal batteries should be used for no less than 2 hours; (5) The power-off function of the environmental monitoring sensors of the two mobile gas pumps in East 102 should be improved. When the concentration of CH₄ reaches 0.5%, the mobile gas pumps should be stopped.

5.4. Strengthen the Safety Management of Power Supply System

In view of the particularity of East 102 working face and return air lane, in order to further improve the intact power supply equipment, the inspection, maintenance and management of all equipment, cables, five small electrical appliances and junction boxes along East 102 working face area are strengthened. The second fully mechanized caving team is required to conduct an investigation once a day, and the mechanical and electrical department is required to conduct an investigation once a week. Collisions are strictly prohibited, sparks and flames are created and explosion is eliminated.

5.5. Strengthen technical guidance and coordination of dispatch in the process of on-site emergency disposal

(1) When abnormal gas emission occurs in the working face, tile inspectors and security inspectors immediately report to the dispatching information center, and carry out on-site power cuts, evacuation and setting up alerts.

(2) When the dispatching information center receives the abnormal gas outflow, according to the gas exceeding limit, it gives priority to implementing the system of power cut and evacuation to ensure the evacuation of personnel to safe locations in disaster areas, and timely report to the mine leaders.

(3) According to the data of the mine pressure observation system installed in East 102 working face, the production department and the second fully mechanized caving face team timely forecast periodic weighting and find out the law of rock pressure appearance so as to accurately provide the law of the change of rock pressure and gas, and further improve the ability of gas prevention and disposal in advance.

(4) According to the area and intensity of gas emission, the ventilation department rapidly formulates the technical scheme for disposal of abnormal gas emission. The second fully mechanized caving team

is responsible for formulating safety technical measures and organizing and implementing emergency disposal measures for abnormal gas emission.

(5) During the initial caving period, the first weighting pressure of the goaf appears abnormal. The second fully mechanized caving team should reduce the amount of coal caving appropriately, but it must give priority to the amount of coal caving in the middle of the working face. The production department and the second fully mechanized caving team should formulate the caving technology and system, strictly implement it, ensure the smooth extraction of gas from roof roadway and upper corner, equally drain the gas from the goaf and reduce the gas accumulation in the goaf.

6. Conclusion

Aiming at the difficult problem of gas abnormal emission and gas prevention in the low permeability and high gas East 102 mining face of Jingyuan Coal Mine, during the initial stage of mining, the measures to prevent gas abnormal emission are formulated: (1) Ensure the stability and reliability of ventilation system and increase the air distribution in working face; (2) Improve the gas extraction system and increase the intensity of gas extraction; (3) Improve the safety monitoring and control system to ensure the sensitivity and reliability of monitoring and control; (4) Strengthen the safety of power supply; (5) Strengthen the dispatching and coordination of emergency disposal process on site.

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