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Practice of Outburst Prevention Technology for Uncovering No.2 Coal Seam in Donger Return Air Shaft of Weijiadi Coal Mine

Jufeng Zhang ^{1,*}, Tai Xu ¹, Fengfeng Yang ¹, Chao Zheng ¹, Jianjiang Zhang ² and Zaiquan Miao²

¹School of Energy Engineering, Longdong University, Qingyang 745000, China

²Weijiadi Coal Mine, Jingyuan Coal Mine Industry Group, Baiyin 730913, China

*Corresponding author e-mail: 422622510@qq.com

Abstract. In Weijiadi Coal Mine, the No.2 coal seam is uncovered by the Donger return air shaft. According to the concept of "regional measures first, local measures supplement", the measures are taken strictly in the outburst seam, the gas pressure $P=0.2\text{MPa}$ and the gas content $W=1.4729\text{m}^3/\text{t}$ in the coal seam are determined by pre-construction prediction drilling, and there are no gas dynamic phenomena such as drilling jam and sticking in the drilling process. It is proved that there is no outburst danger, and then it is implemented according to the local "four in one" outburst prevention measures. The maximum gas pressure determined is 0.2 MPa in the working face, and the validity check is still no outburst danger. Finally, safety protection devices are installed in the working face to ensure the No.2 coal seam to be uncovered smoothly by return air shaft.

1. Introduction

Because uncovering coal seam by the shaft is a relatively dangerous and complex system engineering, gas prevention and control is very vital in the process of uncovering coal seam, otherwise it will bring potential safety hazards, even to the extent that coal and gas outburst accidents may occur, which will cause great harm to mine safety production. Many scholars [1-9] have studied the anti-outburst technology of uncovering coal seam by vertical wells and achieved fruitful results. This paper is mainly aimed at uncovering No.2 coal seam by the Weijiadi Coal Mine Donger return air shaft, in order to ensure the safety of mine production, outburst prevention measures were carried out.

2. General situation of engineering

Weijiadi Coal Mine is a coal and gas outburst mine with an annual output of 3.0Mt. In order to satisfy safety production in the later stage of the mine, it is necessary to construct Donger return air shaft with designed depth of 766m, cross-section of 31.17m^2 , and net cross-section of 23.76m^2 . According to the data of "the actual column chart of the inspection hole of Donger return air shaft in Weijiadi Coal Mine", the section with -670.88m ~ -677.6m of No.1 coal seam, the section with - 690.45m ~ - 690.78m of No.2 upper coal seam, and the section with - 696.5m ~ - 697.17m of No.2 - lower coal seam were all uncovered by shaft excavation.



After the No.1 coal seam is uncovered, the No.2 upper coal seam and No.2 lower coal seam should be uncovered immediately. We should strictly implement the "four in one" measures to prevent and control outburst. When entering the scope of uncovering coal seam, long-distance blasting will be used to uncover coal seams.

3. The scheme of uncovering coal seam and the process of outburst prevention

3.1. The scheme of uncovering coal seam

After uncovering No.1 coal seam is completed, the No.2 upper coal seam and the No.2 lower coal seam will be uncovered at one time, and there be no old goaf and other roadways in uncovering coal area. According to the requirements of Outburst Prevention Regulations, the scheme of uncovering coal seam is determined as follows:

(1) According to the data of pre-construction prediction borehole at the shaft with -650.55m (from -650.55 to -710.55m) on July 20, 2018, the maximum gas pressure $P=0.2\text{MPa}$ and the gas content $W=1.4729\text{m}^3/\text{t}$ were determined in coal seam. The two parameters are less than the critical value $P < 0.74\text{MPa}$ and $W < 8\text{m}^3/\text{t}$, and there are no gas dynamic phenomena such as blowout, pinch drilling and pushing up drilling during drilling construction. It shows that there is no outburst danger in the area of borehole excavation in the No.1 coal seam, the No.2 upper coal seam and the No.2 lower coal seam, but regional verification measures and local "four in one" comprehensive outburst prevention measures must be taken.

(2) When the minimum normal distance from the working face to the No.2 upper coal seam is 5 m, five predictive boreholes must be arranged, and the regional verification of No.2 upper coal seam and the No.2 lower coal seam should be carried out by the method of working face prediction. When there is no danger of outburst, the excavation will continue. If the outburst risk is determined, gas drainage will be carried out by gas drainage boreholes arranged in the working face, and the radius of gas drainage holes should be 2m, and the outburst prevention measures should be checked. After the outburst prevention measures are effective, when there is no outburst danger, the rockshaft excavation will be resumed.

(3) When the normal distance between the working face and the No.2 upper coal seam is 2 m, five predictive boreholes are arranged, and the region of the No.2 upper coal seam and the No.2 lower coal seam is finally validated by the method of working face prediction. When there is no danger of coal and gas outburst, the rockshaft excavation is carried out directly; if the danger of coal and gas outburst is determined, gas drainage will be carried out by gas drainage boreholes arranged in the working face, and the radius of gas drainage holes is 2 m, and the validity test of anti-outburst measures is carried out. After anti-outburst measures checked are effective, when there is no danger of coal and gas outburst, the section of uncovering coal seam by rockshaft will be resumed.

(4) When the distance between No.2 upper coal seam and the No.2 lower coal seam is 5.72 m, the No.2 upper coal seam is uncovered, the regional verification measures of the No.2 lower coal seam are implemented immediately, and five predictive boreholes are arranged, the regional verification of the No.2 lower coal seam is carried out by the method of working face prediction. When there is no danger of coal and gas outburst, the rockshaft drilling is carried out directly; if the danger of coal and gas outburst is determined, gas drainage will be carried out by gas drainage holes arranged in the working face. After the gas drainage are completed, the measures of coal and gas anti-outburst are tested. After the measures of anti-outburst checked are effective, when there is no danger of coal and gas outburst, the section of uncovering coal seam by rockshaft will be resumed.

3.2. The process of outburst prevention of uncovering coal seam

Prediction of regional outburst danger of the No.2 upper seam and the No.2 lower seam before excavation was carried out, it proves that there is no danger of coal and gas outburst in uncovered area of the No.2 upper and No.2 lower coal seam. Regional verification is carried out before excavation to 5m from coal seam, and measures of outburst prevention are taken according to the judgement results

until the measures of anti-outburst are effective. The final area of working face is restored when excavation is 2m from the No.2 upper seam. According to the judgment results, Verification outburst prevention measures are taken in the working face until the measures are valid, resume excavation, implement the operation of uncovering the No.2 upper coal seam, and immediately implement the regional verification measures of the No.2 lower coal seam after uncovering the No.2 upper coal seam. According to the judgment results, outburst prevention measures are taken in the working face until the measures are valid, resume excavation and implement the operation of uncovering the No.2 lower coal seam.

4. Regional verification and local measures of "Four in One" outburst prevention

4.1. Regional Verification

If there is no outburst danger, the final regional verification of the working face should be carried out when the excavation is resumed 2m from the No.2 upper coal seam; if there is outburst danger, the final regional verification of the working face should be carried out before 5 m from the working face. When there is no outburst danger, coal excavation is carried out directly. If outburst danger is determined, gas drainage is carried out by gas drainage boreholes arranged in the working face, outburst prevention measures are checked. After the measures of outburst prevention are checked, when there is no outburst danger, the section of the uncovering coal seam by the shaft will be resumed. After uncovering the No.2 upper coal seam, the regional verification measures for the No.2 lower coal seam are implemented immediately. When there is no outburst danger, the coal excavation is carried out directly. If the outburst danger is determined, gas drainage is carried out in the working face, and the measures of outburst prevention are checked. After the measures of outburst prevention are checked, when there is no outburst danger, the excavation of the No.2 lower coal seam will be resumed.

4.2. Prediction of outburst hazard in working face

Before the normal distance is 5 m from coal seam, prediction boreholes are drilled. The method of drilling cuttings desorption index is used to predict the outburst danger of the working face. Five predicted boreholes are arranged and controlled not less than 5 m outside the outline of the wellbore.

When the distance between the working face and the coal seam is 2 m, the outburst danger of the working face was predicted by the method of drilling cuttings desorption index. Five drilling holes are arranged to control the position not less than 5 m outside the outline of the shaft. The drilling cuttings desorption indexes are: dry coal sample $K_1 < 0.5 \text{ mL}/(\text{g} \cdot \text{min}^{1/2})$, wet coal sample $K_1 < 0.4 \text{ mL}/(\text{g} \cdot \text{min}^{1/2})$. The plan layout of the working face prediction borehole is shown in figure 1 and figure 2.

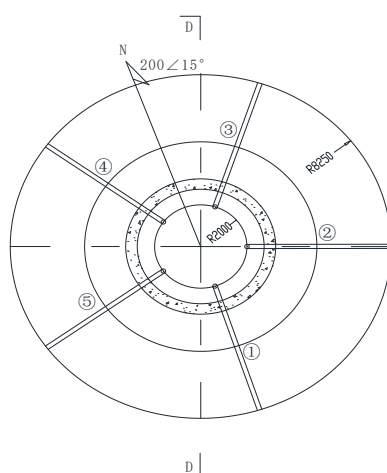


Figure 1. Predictive drilling plan

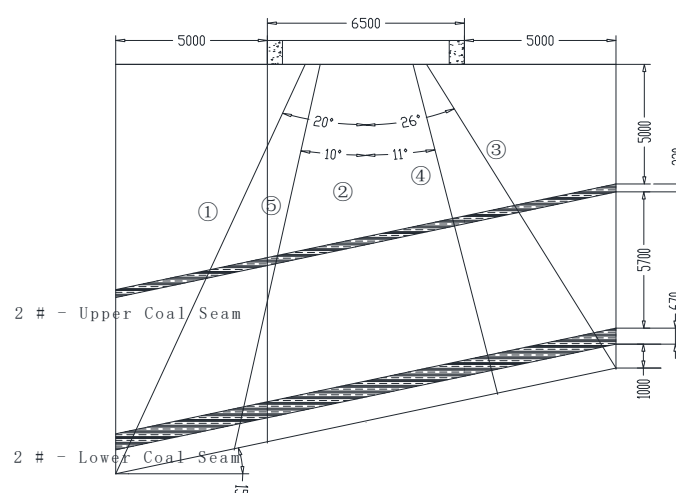


Figure 2. Prediction of borehole profile

The pressure of 1#, 3#, 5# boreholes is measured for three days. The pressure change of 1#, 3#, 5# boreholes is shown in figure 3.

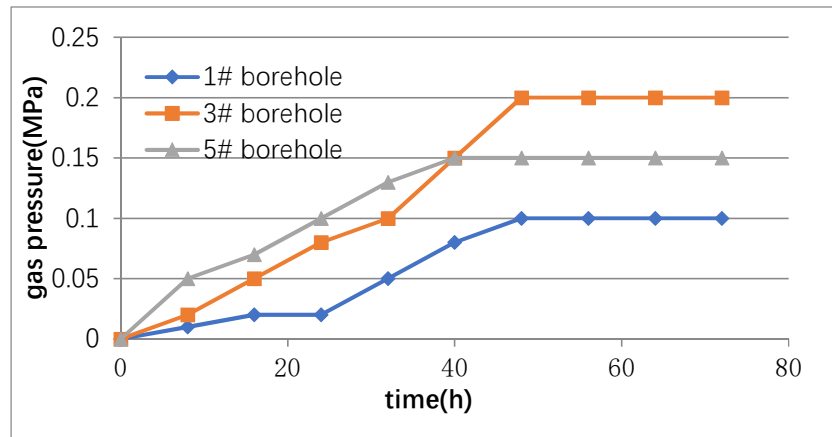


Figure 3. the pressure changes of 1#, 3#, 5# boreholes

4.3. The measures of outburst prevention in working face

When the normal distance is 5m between the working face of drilling rockshaft, the outburst danger area judged or the prediction of the outburst is danger, the measures of outburst prevention of the working face must be taken. The specific requirements are as follows:

(1) In order to improve the efficiency of gas drainage, the drilling rig is arranged at the minimum normal distance of 5 m from the coal seam roof, and the drilling holes are arranged strictly according to the layout of gas drainage holes.

(2) The method of drilling cuttings gas desorption index is used to predict the outburst danger of working face. When the working face is predicted to be of outburst danger, the effective influence radius of single gas drainage hole is less than 2m arranged according to the design.

(3) Gas drainage boreholes must penetrate the coal seam, and be more than 1 m entered the rock.

(4) The area of gas drainage is within 5 meters of shaft contour line.

(5) Gas drainage time is determined according to the effect test of outburst prevention measures. When the measures of outburst prevention is checked, and the results are considered effective, the drilling hole of outburst prevention measures in working face can be stopped, otherwise, the time of gas drainage can be prolonged until the effect test is effective.

When the normal distance between the working face and the coal seam is 2m, or the outburst danger area and the prediction of the working face has outburst danger, the measures of outburst prevention must be taken. The specific requirements are the same as the above.

4.4. The effectiveness test of outburst prevention measures in working face

After the outburst prevention measures are adopted in the working face, the effect prevention measures of the outburst is tested. After drilling into the coal seam with a down-the-hole drill, the coal cuttings discharged from drilling holes are collected, and the gas desorption indexes of drilling cuttings are checked: dry coal sample $K_1 < 0.5 \text{ mL}/(\text{g} \cdot \text{min}^{1/2})$, wet coal sample $K_1 < 0.4 \text{ mL}/(\text{g} \cdot \text{min}^{1/2})$ and other abnormal phenomena such as no blowout and no pushing up drilling are detected during drilling. The measures of outburst prevention are effective in the working face. Otherwise, the extraction time of drilling holes must be prolonged until the effect test is effective.

4.5. Safety protection measures

Pressure air self-rescue system: two sets of pressure air self-rescue system are set up in the second-floor suspension tray, one of which is movable, and is lowered to the shaft working face by using hemp rope. Each set of pressure air self-rescue system must be available for 8 people. The supply of compressed air

must not be less than 0.1m³/min for each person. A storage box is set up on the second-floor suspension tray of the shaft, and 10 oxygen-isolating self-rescue devices are stored for reserve.

Water supply and rescue: During coal uncovering, the water supply pipeline in the wellbore acts as both water supply and rescue pipeline to ensure that the pipeline is unobstructed.

Communication and liaison system: During the period of uncovering coal seam, an explosion-proof telephone was added to the working face of uncovering coal seam to ensure contact with the dispatching room smoothly.

5. Conclusion

During the period of uncovering the No.2 coal seam by Donger return air shaft in Weijiadi Coal Mine, detailed special design and system management of outburst prevention were carried out. In accordance with the Regulations on Prevention-Control of Coal and Gas Outburst, the outburst prevention concept of "first regional measures, then local measures, mainly regional measures, supplemented by local measures" was implemented in Shimen (well) uncovering outburst coal seam. The gas pressure in the area of shaft uncovering coal seam is up to 0.2 MPa, which proves that it has no outburst danger through regional verification. Finally, the implementation of "four in one" outburst prevention measures are taken in the working face to ensure the safe and rapid uncovering coal seam.

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