Case analysis of in-situ stress coal and gas outburst and prevention countermeasures

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Abstract: The coal and gas dynamic disasters in Fengcheng mining area are serious. There are currently 6 pairs of coal and gas outburst mines. In view of the increase in the proportion of in-situ stress-oriented outbursts in the mining area as the mining depth increases, the establishment of classified disaster control measures is proposed. Stereo gas drainage system, and proposed to explore the use of deep hole pre-splitting blasting, roof strike long drilling, hydraulic reaming, hydraulic fracturing and other new technical measures. It is of great significance to safe and efficient production in mining areas.

1. Basic situation of the mining area
Fengcheng mining area is located in the middle of the Ping (township)-Le (ping) coal-bearing area in Jiangxi Province. It is one of the 45 pairs of mining areas with serious gas disasters under the national key monitoring. There are 6 pairs of coal and gas outburst (hereinafter referred to as "outburst") mines in the mining area, namely Pinghu, Jianxin, Bayi, Shangzhuang, Qujiang, and Fenglong coal mines.

At present, the affiliated mines Pinghu, Jianxin, Shangzhuang, Qujiang and Fenglong coal mines have entered deep mining (vertical depth 600~1100m), with approved production capacities of 0.45Mt/a, 0.81Mt/a, 0.45Mt/a, 0.9Mt/a, 0.9Mt/a. Bayi Mine has been closed due to exhaustion of resources, and Pinghu coal mine resources are about to be exploited. Qianbupinghu, Jianxin, and Bayi coal mines mined the B4 coal seam shallower than 650m. Shangzhuang Coal Mine is mining-B4 coal seam shallower than 750m. Qujiang Company uses vertical shafts to mine Pinghu, Jianxin Deep B4 coal seam, and adopts single-level up and down mining, with production elevation of -850m. Fenglong mines the B4 coal seam in the deep part of Shangzhuang Coal Mine. It adopts vertical shaft, main crosscut, and main roadway development methods. The mine is developed at two levels. The first and second levels are -900m and 1100m respectively. Inclined wells are used for multi-level development and strike longwall mining. The basic parameters of main mine gas in the mining area are shown in Table 1.
2. Analysis of gas occurrence characteristics in mining area

After the mining area enters deep mining, the gas geology is more complicated. The gas pressure and content of the B4 coal seams of Pinghu, Jianxin, and Shangzhuang coal mines generally increase with the increase of mining depth.

In Qujiang and Fenglong coal mines, the relationship between gas pressure and content of the B4 coal seam and the mining depth is complicated, and there are areas with high gas pressure and relatively high gas content (the gas pressure of the B4 coal seam at the level of Qujiang Company-850m is as high as 9.2MPa, and the gas pressure is as high as 9.2MPa. The content is 13.5~25.3m³/t), and a paleoweathering zone also appears in the southwest of the Qujiang syncline, and the gas content is low. Pinghu, Jianxin, and Shangzhuang coal seams above the level of 650m have a gas pressure of 6.0MPa and a gas content of 10~22.45m³/t. Therefore, the highlighting mechanism has become more complicated, and the difficulty of anti-outburst technology has further increased.

3. Case analysis of in-situ stress type outburst

After the Fengcheng mining area entered deep mining, despite the measures taken to pre-drain the gas by drilling along the seam and the dense shallow holes for gas discharge, outbursts still occurred. The basic situation is shown in Table 2.

| Mine     | Protruding location | Buried depth (m) | \(K (\text{mL/g·min}^{1/2})\) | \(S (\text{kg/m})\) |
|----------|---------------------|------------------|-----------------------------|-------------------|
| Qujiang  | 207 Coal lane       | 862              | 0.211                       | 13.5              |
| Jianxin  | 1113 Coal lane      | 630              | 0.21~0.24                   | 3~4               |
| Shangzhuang | 3682 Coal lane   | 670              | 0.483                       | 3.3               |

It can be seen from Table 2 that in the three outbursts, the prediction indicators of Jianxin and Shangzhuang coal mines were all less than the critical value \(K_{10}=0.7\text{mL/g·min}^{1/2}, S_{0}=6\text{kg/m}\), and the prediction index of Qujiang Company was also less than the critical value \(K_{10}=0.5\text{mL/g·min}^{1/2}, S_{0}=18\text{kg/m}\). It shows that after measures are taken, the energy involved in gas outburst has been reduced, but the hazards of high ground stress have not been completely eliminated; under the condition of insufficient pressure relief for local supplementary intensive drilling, ground stress-dominated outburst may still occur.

4. Countermeasures

In view of the new features of outstanding disasters in the mining area, the following anti-outburst countermeasures are proposed:

4.1. Establish sub-type disaster control measures

It establishes different anti-outbreak measures according to different types of prominence, and strengthen personnel and technical management.
(1) The gas geological conditions of different mines in the mining area are quite different, and gas geological work should be strengthened, and the understanding of the outburst mechanism under different gas geological units and mining technology conditions should be continuously deepened.

(2) More than 69.4% of the dynamic disasters in the mining area are related to geological structures such as faults, folds, and coal thickness changes, and geological detection near faults should be strengthened.

(3) In view of the increase in the proportion of in-situ stress-dominant outbursts as the mining depth increases, measures to eliminate outbursts and in-situ stress are adopted, and a comprehensive outburst prevention technology system combining gas drainage (drainage) drilling and hydraulic measures can be adopted.

(4) Strengthen personnel and technology management, establish a training system, conduct regular safety and anti-outbreak training, and improve personnel safety awareness and anti-outbreak technology level.

4.2. Establish a gas drainage system

The mining area is a single serious outburst coal seam, which does not have the conditions for mining with a protective layer. Therefore, priority is given to the use of gas outburst prevention measures; the following drainage system is established according to the characteristics of the mining area:

(1) Pre-drainage by drilling along the bedding: The mining face is equipped with long boreholes along the bedding for pre-draining coal seam gas, with a hole spacing of 4-6m, using polyurethane and cement slurry, and a sealing depth of 8-10m.

(2) Drainage of high drainage roadway: A horizontal rock roadway (high drainage roadway) is arranged at the roof of the coal mining face 15-18m away from the coal seam and 25-30m horizontally from the return airway. The rock roadway is constructed to coal mining. The position of the cut hole in the working face; in the early stage of mining, 5~7 drilling holes shall be constructed at the position of the high-drainage roadway in the working face, and two closed wall pipes shall be built at the opening of the roadway with a diameter of not less than 219mm. Pick.

(3) Extraction from the goaf of the high-position borehole in the return air lane: The first drilling field is arranged at a position of 60~80m from the cut hole in the return airway of the coal mining face, and there will be a drilling field every 30~40m. The field is arranged with 3~5 boreholes, the final hole position is 20~35m from the return airway horizontally, and 10~15m from the top of the coal seam in the fissure zone. Use surface or underground mobile drainage pumps for extraction.

(4) Extraction from the goaf of the return air tunnel with horizontal boreholes: In the return air tunnel of the coal mining face, construct a drill yard every 50m to the roof. The position of the drill yard is 10~15m away from the coal roof, and each drill yard is constructed 5~ There are 6 horizontal boreholes in the strike direction, and the final hole position is 20~35m away from the wind tunnel.

(5) Floor rock roadway drilling and pre-draining coal roadway strip gas: A rock roadway is arranged along the coal seam strike at a distance of 8~12m under the severely outburst coal seam in the deep. The drilling field is arranged every 4m, and 15m on both sides of the control roadway strip is arranged for gas pre-drainage and outburst prevention.

4.3. Exploring new technologies for gas prevention and control

Due to the poor air permeability coefficient of the coal seam in the mining area and it is a single severely outburst coal seam, deep hole pre-splitting blasting, hydraulic reaming, hydraulic fracturing and other pressure relief and permeability enhancement measures can be tested according to different geological conditions.

The high-drainage roadway can play a certain role in preventing outburst, but the cost is high. The outburst prevention measures can be studied using long holes along the roof.
5. Conclusion
Studies have shown that after taking measures, the energy involved in gas outburst has been reduced, but the hazards of high ground stress have not been completely eliminated; local supplementary intensive drilling may still occur ground stress-dominated outburst under the condition of insufficient pressure relief.

In view of the increasing proportion of in-situ stress-dominant outbursts in mining areas as the mining depth increases, the establishment of classified disaster control measures, the establishment of a three-dimensional gas drainage system, and the exploration and use of new outburst prevention technical measures have been proposed for safe and efficient production in the mining area. The importance of.

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References
[1] Lin Fujin, Jiang Wangang, Shu Guide. Research on reasonable layout parameters of bedding pre-drainage boreholes in Fengcheng mining area[J]. Mining Safety and Environmental Protection, 2011, 05:47-49.
[2] Wang Xiongyou. Study on the occurrence and distribution characteristics of gas in B_4 coal seam in Fengcheng mining area[D]. Anhui University of Science and Technology, 2011.
[3] Gong Xuanping. Research on the application of gas three-dimensional drainage technology in outburst thick coal seam protection layer mining face [J]. Mining Safety and Environmental Protection, 2014, 04: 73-76.
[4] Chang Xiaocun. Outburst thick coal seam gas drainage technology and drainage effect analysis [J]. Mining Safety and Environmental Protection, 2013, 03: 92-95.
[5] Chen Jianzhong, Lv Youchang. Experimental study of high-pressure hydraulic fracturing technology in outburst coal seam with high gas and low permeability[J]. Mining Safety and Environmental Protection, 2012, 04: 21-23.
[6] Zhao Xusheng, Zou Yinhui. Experimental study on gas drainage of adjacent layers with horizontal long boreholes in rock[J]. Mining Safety and Environmental Protection, 2000, S1: 13-15+148.