Research on characteristics of coal and gas outburst in deep mines

ZHonghua Wang 1,2,*

1National Key Laboratory of Gas Disaster Detecting, Preventing and Emergency Controlling, Chongqing, 400037
2China Coal Technology Engineering Group Chongqing Research Institute, Chongqing, 400037

*Corresponding author’s e-mail: boaidajia2007@126.com

Abstract: The single B4 coal seam mined in Fengcheng mining area is a gently inclined medium-thick coal seam with high gas pressure and high content, soft coal seam, low air permeability, and serious coal and outburst disasters. According to the gas occurrence characteristics of Fengcheng mining area, the characteristics and laws of 186 outburst accidents in the mining area are statistically analyzed, and the characteristics of in-situ stress coal and gas outburst are obtained. It provides theoretical guidance for the prevention and control of gas dynamic disasters in mining areas, which is of great significance to safe and efficient production in mining areas.

1. Introduction
Fengcheng mining area is one of the main coking coal production bases in the coal-deficient areas in the south of the Yangtze River. The mining of a single B4 coal seam is a gently inclined medium-thick coal seam with high gas pressure (Pmax=9.2MPa) and high gas content (W=13.5~25.3m³/t), The coal seam is soft (f=0.3~0.8), and the coal seam’s air permeability is low (λ=1.7×10⁻⁵~0.74m²/MPa²•d).

In history, it was also the worst-hit area where gas disasters frequently occurred, with 186 prominent occurrences in history. Fengcheng mining area enters deep mining under the environmental conditions of high ground stress, high gas, high ground temperature and low air permeability, the outburst becomes more and more serious, and the outburst mechanism becomes more complicated.

For this reason, it is of great significance to analyze and study the outburst law and prevention measures in the mining area based on the outburst accidents that have occurred in the mining area, in order to ensure safe production in the mining area.

2. Analysis on the characteristics of coal seam gas occurrence in the mining area
Qujiang, Jianxin and Shangzhuang coal mines in Fengcheng mining area are all mined at deep level. The mining elevation of coal seam B4 in the mining area has been between -530 and -970m in the past five years. The gas pressure and gas content of coal seam B4 from east to west in the mining area increase, and the relative gas emission from the mine is large, and it increases with the increase of mining depth.

The relative gas emission of various mines over the years is shown in Figure 1. Table 1 is the basic gas parameters of coal seam B4 in each mine.
Figure 1 The relative gas emission in the mining area over the years

| Parameters | Qujiang Coal Mine | Jianxin Coal Mine | Shangzhuang Coal Mine |
|------------|-------------------|-------------------|----------------------|
| W (MPa)    | 6.0–9.2           | 3.6–4.8           | 1.98–6.0             |
| P (m³/t)   | 8.96–18.53        | 9.73–18.4         | 8.99–22.45           |
| f          | 0.19–0.44         | 0.30–1.00         | 0.23–0.63            |
| Δρ (mmHg)  | 11–20             | 8–16.5            | 10–18                |

The gas pressure and gas content of coal seam B4 in the mining area gradually increase with the increase of buried depth, while the permeability coefficient of the coal seam is significantly reduced; the hardness coefficient of coal and the initial gas release velocity change law not obvious. It is more difficult to mine B4 coal seam gas drainage and gas disaster management in the deep part of the mining area. B4 coal seam roof and floor sandstone density 2.622–2.698 g/cm³, average 2.67 g/cm³; tensile strength 2.29–18.14 MPa, average 11.45 MPa; elastic modulus 18.99–31.2 GPa, roof bending energy index 307.44–322.76 kJ. Therefore, the hard rock layers of the roof and floor of the B4 coal seam have a tendency to impact, and there may be a dynamic risk of sudden release of elastic energy in areas where tectonic stress and mining stress are concentrated due to external induction.

The thin mudstone on the roof and floor of the B4 coal seam has low strength and poor energy storage characteristics. The geothermal temperature of the mining area belongs to the normal geothermal area, and it increases with the increase of mining depth; the production level B4 coal seam temperature of Qujiang and Fenglong coal mines is generally 38–39°C, and the high temperature can reach more than 40°C. Coal dust in coal seam B4 in the mining area is explosive, and the coal spontaneous combustion tendency grade is spontaneous combustion.

3. Analysis on the characteristics of coal and gas outburst disasters in the mining area
Fengcheng mining area has a total of 186 outbursts (see Table 2), and combined with the actual situation of the mining area, the analysis of the outstanding features and laws is as follows:
Table 2 Statistics of Outstanding Classification over the Years in Fengcheng Mining Area

| Parameters                  | Mining area | Qujiang | Jianxin | Shangzhuang | Pinghu | Bayi |
|-----------------------------|-------------|---------|---------|-------------|--------|------|
| Total times                 | 186         | 7       | 63      | 63          | 50     | 3    |
| percentage(%)               | 100         | 3.8     | 33.9    | 33.9        | 26.9   | 1.5  |
| Average intensity (t/time)  | 205         | 385.7   | 173.5   | 132.5       | 128.2  | /    |
| Maximum intensity (t/time)  | 1390        | 860     | 1390    | 895         | 598    | /    |
| Press out (times)           | 61          | 0       | 31      | 23          | 7      | /    |
| Pour out (times)            | 34          | 0       | 0       | 20          | 13     | 1    |
| Outstanding (times)         | 91          | 7       | 32      | 20          | 30     | 2    |

3.1. Analysis of highlighting basic characteristics

The prominent distribution has regional characteristics. There are 16 roadways in Jianxin coal mine that have outbursts for 2 to 4 times, 12 roadways in Shangzhuang coal mine have outbursts for 2 to 5 times, and 11 roadways in Pinghu coal mine have outbursts for 2 to 3 times, showing obvious regionality.

In addition, the northeast section of the mining area is more prominent than the central and western regions. Most of the outbursts in the northeast section of the mining area are at the concentration of ground stress (or geological structural stress), rapid changes in coal seam occurrence, relatively developed faults and the end of the geological structure, and coal seam gas occurrence is more concentrated, and the gas content is higher.

Complete prominence types. There were 186 outbursts in the mining area, among which the proportions of coal extrusion, dumping and outburst were 32.8%, 18.3%, and 48.9% respectively; the in-situ stress-dominant outburst accounted for 51.1%, and the proportion increased with the increase of mining depth.

Most of the outbursts in mining areas have obvious signs, but there are also obvious macro signs. Outburst signs are mainly manifested as increased gas emission, lower temperature, slag slag removal, coal wall bulging, drilling with top drill, stuck drill, jet hole and sometimes gas, water squeezing out and squeaking, etc., deep mining The sound of coal and rock bursts increased significantly in the outburst area. In addition, when there is no outburst foreboding, the coal seam of the working face is relatively hard and there is no soft stratification.

Outbursts in the mining area are dominated by coal tunnel excavation outbursts. The outbursts of coal roads, crosscuts, and coal mining faces account for 96.8%, 1.6%, and 1.6% of the total outbursts, respectively. According to the analysis of outburst strength: outburst coal is less than 100t, 116 times, accounting for 62.4%; outburst coal is more than 100t, 70 times, accounting for 37.6%.

3.2. Highlight the main influencing factors analysis

Outbursts are closely related to geological conditions. Geological structures such as faults, folds, and coal thickness changes are recorded for 129 times, accounting for 69.4%; there are 30 outbursts without geological structure records, accounting for 16.1%; no record 27 times, 14.5%.

The outburst increases with the increase of the thickness of the coal seam, especially with the increase of the thickness of the soft layer; in addition, the outburst risk of the outburst coal seam increases as the dip angle increases. The greater the gas pressure in the coal seam, the greater the risk of outburst.

From the analysis of the outburst inducement, the coal falling process, blasting and vibration shooting are more likely to cause outburst. 171 times caused by blasting, accounting for 91.9%; vibrational operations such as machine digging, pneumatic pick operations, and drilling, were prominent 6 times, accounting for 3.3%; other processes accounted for 4.8%.

The initial outburst depth of the mining area is 325m. As the mining depth increases, the outburst risk increases; after the mining area enters deep mining, the comprehensive outburst prevention measures are taken to significantly reduce the number of outbursts. Among them, Jianxin coal mine outbursts 63 times, accounting for 33.9% of the total outbursts; Shangzhuang coal mine outbursts 63
times, accounting for 33.9% of the total outbursts; Pinghu coal mine outbursts 50 times, accounting for 26.9% of the total outbursts; Qujiang company outbursts 7 times, accounting 3.8% of the total outbursts; Bayi coal mine outbursts 3 times, each accounting for 1.5% of the total outbursts.

3.3. Highlight new features analysis
As the mining area enters deep mining, the dynamic phenomena of coal and gas dominated by in-situ stress increase; the outburst characteristics of in-situ stress dominated are as follows:
- Generally have certain holes;
- The thrown coal rock is far away, but the accumulated coal rock has no obvious separation property;
- A large amount of coal and rock are thrown out, and the amount of gas emitted per ton of coal is small, and the phenomenon of wind flow reversal is not obvious;
- The roof and floor where the dynamic disaster occurs are cracks, floor heaves, or coal walls move out and other obvious mineral pressure manifestations. In addition to the elastic energy of coal seam deformation and gas potential, the high ground stress deformation elastic energy of the roof and floor is also Participate in power work.

4. Conclusion
With the increase of mining depth and mining intensity, Fengcheng mining area, like other mining areas across the country (such as Chongqing area, Huainan mining area, etc.), has experienced abnormal gas dynamic phenomena with ground stress as the leading role.
- The mining area has entered deep mining, and the mining face has adopted regional gas pre-drainage and partial comprehensive outburst prevention measures, reducing the potential for gas to participate in outbursts, reducing the outburst frequency of the dominant factors in the mining area, and increasing in-situ stress-dominant coal and gas dynamic phenomena.

Fund Project
This work was financially supported by the national key research and development program of China (2017YFC0804206), General project of Chongqing Research Institute Co., Ltd (2019YBXM31), General project of Chongqing Research Institute Co., Ltd (2020YBXM22).

References
[1] Liao Wende, Lai Dajin, Peng Chengxi. Discussion on Gas Occurrence Law of B_4 Coal Seam in Fengcheng Mining Area[J]. Jiangxi Coal Science and Technology, 2007, 02:69-72.
[2] Wu Huiming, Liao Huan. Analysis of factors affecting the occurrence of coalbed methane in Fengcheng mining area[J]. Science and Technology and Enterprise, 2014, 18:82.
[3] Han Qiu, Qin Weiying, Li Lin. Analysis of Gas Occurrence Law and Influencing Factors in Fengcheng Mining Area[J]. Science and Technology Information, 2011, 33:36.
[4] Gong Jingbin, Cai Baojia. Mine Gas Drainage and Utilization of Fengcheng Mining Bureau[J]. Jiangxi Coal Science and Technology, 2007, 01:24-26.
[5] Li Aopeng. Comprehensive outburst prevention measures in the coal road belt area of Fengcheng Mining Bureau [J]. Jiangxi Coal Science and Technology, 2012, 02:1-2.