Study the critical value of outburst effect inspection index in the case of regional gas predrainage

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Abstract: China is one of the nations that have grievous coal and gas outburst problems, gas outburst prediction is the key technology of gas prevention and treatment, the critical value of gas outburst prediction index in relation to coal mine production safety and the economy. In order to study the evaluation index of the regional drainaged NO.3 coal seam in Sihe mine, based on the gas outburst integrative theory, proposes gas content under the corresponding beginning outburst gas pressure is treated as evaluation index critical value. Raw coal samples were taken on site and sealed, and their residual gas content and residual gas pressure were determined after adsorption equilibrium. By this method, the law of residual gas content and residual gas pressure of raw coal under the influence of original moisture is studied, and the corresponding gas content under initial gas outburst pressure is obtained, and the critical gas content value of 10 m3/t is verified on the spot.

1. Introduction
The west well area of sihe mine of Jincheng coal industry group is a coal and gas outburst mine. After taking regional outburst prevention measures for regional pre-pumping coal seam gas, the residual gas content of 8 m3/t in the outburst prevention regulations is used for the effect inspection. Because the original gas content in No. 3 coal seam is as high as 15-25 m3/t, after a long period of pre-drainage, the residual gas pressure has been reduced to 0.74 Mpa (surface pressure), and the residual gas content is often higher than 8 m3/t. When the residual gas content of coal seam is reduced to 8 m3/t, the residual gas pressure of coal seam needs to be reduced to less than 0.5 MPa. Coal seam gas pressure needs to fall below 0.5MPa, which not only requires a long time of pre-pumping gas, but also is difficult to achieve. Therefore, it is urgent to study and establish the evaluation method and critical value of outburst prevention effect of coal seam gas pre-pumping measures in Sihe mining area, which is of great significance to effectively prevent coal and gas outburst and to improve the economic and social benefits of the mine.

2. Proposal of Inspection Index for Gas Outburst Prevention Effect of Regional Pre-pumping Coal Seam
According to the comprehensive hypothesis of coal and gas outburst, gas pressure and in-situ stress are the main power sources of outburst, so the greater the gas pressure, the greater the outburst risk of coal. However, due to the strict conditions needed for pressure measurement, high quality requirements for sealing, long testing period, a large number of cracks in the coal seam itself, and limited by sealing technology, the reliability of pressure measurement in this coal seam is poor, and the residual gas pressure index is not suitable for Sihe Coal Mine. It is feasible to use residual gas content index for...
sihe mine, but the critical gas content value of 8m3/t is unscientific and lacks theoretical basis. From the outburst mechanism, the gas pressure is the true reflection of the outburst danger degree of coal. Therefore, the corresponding gas content under the initial outburst gas pressure of coal seam is proposed as the critical gas content of coal seam outburst elimination.

3. Laboratory Determination of Critical Gas Content

3.1 Effect of Water on Gas Content of Raw Coal

The influencing factors of gas content in coal seam include water content, ash content, coal deterioration degree, specific surface area, porosity and many other factors. Generally, the higher the deterioration degree of coal, the larger the specific surface area, the greater the gas content under the same pressure, the greater the ash content, and the smaller the gas content of raw coal. In the same minefield, the degree of coal metamorphism has little change, and the specific surface and ash content have little change. It can be considered that the influence on gas content of coal is a fixed value, while the effect of moisture on the adsorption characteristics of coal is greater, and the influence on gas content of raw coal is greater.

Gas content can be obtained by inversion of gas pressure, but the theoretical basis of the inversion formula is: under different water contents, the influence coefficient of water on gas adsorption of coal refers to the empirical formula of Russian coal chemist Eichenger. However, Fushun Branch and Zhang Zhancun of the General Academy of Coal Science investigated the influence of moisture on gas adsorption under different metamorphic degrees, and obtained empirical formulas of influence coefficient. The above experimental results are all in-situ sampling, after removing moisture from coal particles with a certain size, and then filling different moisture and pure gas in the laboratory to analyze the effect of moisture on coal adsorption performance. There are still some differences between granular coal and original coal, and the uniformity of moisture is not well controlled.

Therefore, this experiment proposes that the original moisture of the coal sample at the sampling site should be measured by taking the coal sample on site (according to the gas content sampling standard) and immediately sealing and connecting the precision pressure gauge. The relationship between residual gas pressure P and residual gas content w of raw coal after adsorption equilibrium was studied.

The experimental steps are as follows:

a. Putting the coal sample retrieved from the site sealed and connected with a precision pressure gauge in a constant temperature water bath, adjusting the temperature of the constant temperature water bath to be as close as possible to the actual environmental temperature of the underground coal body in the west well area of sihe mine, and reading out the pressure P1 after the coal sample reaches adsorption equilibrium;

b. The control valve makes the coal sample desorb part of the gas for the first time, and then the gas pressure is reduced by 0.2-0.35 MPa and the valve is closed. Measuring the volume V01 of gas released for the first time with a measuring cylinder, and reading out the pressure P2 after the coal sample reaches adsorption equilibrium;

Step b is repeated to obtain the gas volume V0i released after the i-th and the gas pressure Pi+1 after the equilibrium, until the coal sample is desorbed i times, and the equilibrium gas pressure Pi+1 is the atmospheric pressure.

Through the above steps, a coal sample obtained the residual gas pressure after the adsorption equilibrium of the i group under the raw coal moisture and the corresponding residual gas content. Through the above steps, 12 groups of coal samples were taken from the west well area of sihe mine.

In order to analyze the influence of different water on the original coal body in more detail, the water is divided into three groups of 0-1.5%, 1.5-2.5% and more than 2.5%. The results are shown in Figure 1.

As can be seen from the picture above:
At a certain pressure, the change in gas content is stratified. That is, when the pressure is constant, the smaller the moisture, the larger the gas content of the coal.

At a certain gas pressure, the smaller the water content, the greater the gas content of coal, and the greater the water content, the smaller the gas content of coal.

Under low pressure conditions, the change of moisture has little effect on the change of gas content. With the increase of the gas pressure, the greater the influence of the change range of the gas content of the coal with water content.

The above data were fitted by Langmuir double curve, and the gas content with water content less than 1.5% was found to be in accordance with the gas pressure, \(a=31.6585, b=0.9948\), Correlation coefficient \(R^2=0.9932\); The water content is 1.5-2.5%, \(a=29.8443, b=0.9047\), Correlation coefficient \(R^2=0.9908\); Moisture greater than 2.5%, \(a=26.7940, b=0.8739\), Correlation coefficient \(R^2=0.9854\).

### 3.2 Determination of Critical Gas Content

The gas outburst pressure should be the actual gas pressure of the coal seam at or near the initial outburst location under the same height line or buried depth. Xijing district of sihe mine belongs to capital construction mine. on may 20, 2007, there was a outburst accident in No.3 coal seam west return No.6 contact lane with a depth of 458 meters. the outburst location could not measure the gas outburst pressure of the coal seam due to the influence of drainage. Therefore, the critical value of residual gas pressure of 0.74 Mpa (surface pressure) in the Regulations on Prevention and Control of Coal and Gas Outburst is used as gas outburst pressure in Sihe Mine.

From the above, the relationship between residual gas content and pressure in different moisture intervals of the original coal body is obtained, and the gas outburst pressure of 0.74Mpa is substituted into Langmuir double curve relationship, and the following results are obtained: The gas content of water less than 1.5% is 14.41m\(^3\)/t, the gas content of water is 1.5-2.5%, the gas content is 12.89m\(^3\)/t, and the moisture content of water is more than 2.5%, 11.34m\(^3\)/t.

The water content of raw coal in the west well area of sihe mine is between 0.5% and 3.5%. in order to be safe and have a certain surplus, the critical gas content is set at 10m\(^3\)/t.

### 4. Field Investigation of Critical Gas Content

X13012 lane, X13013 lane and X13014 lane are tunnelled in parallel along the floor of coal seam, with a large amount of gas emission, which belongs to outburst dangerous tunneling face. therefore, a long horizontal borehole along the seam is constructed in the tunnelling face. X13012 lane, X13013 lane and X13014 Lane adopt three lane layout (25 m coal pillar interval), alternately shield driving, and arrange 94 mm pre-drainage drilling hole in front of work and between two lanes. The drilling distance is 1m, and a total of 25 parallel pre-drilling holes are arranged, with a hole depth of 180-220m. At the same time, drainage drill fields are respectively constructed at the outer side of the roadway, and each drill field is constructed with 4 drainage holes, with a hole spacing of 0.6m, a hole spacing of 50m, and a hole depth of 120~150m.

After three months of pre-pumping, the tunneling starts in lane X13012, lane X13013 and lane X13014. before tunneling, the residual gas content of coal seam is measured at a drilling hole with a construction depth of about 30m at the working face to test the outburst elimination effect of the pre-pumping drilling hole. Only when it meets the requirements of "Regulations on Prevention and Control of Coal and Gas Outburst", and the prediction index of working face is used to verify the effect of regional outburst elimination in the process of excavation. The residual gas content and test results are shown in Table 1.

| location                  | sampling depth (m) | residual gas content (m\(^3\)/t) | field condition       |
|---------------------------|--------------------|----------------------------------|-----------------------|
| 13102 tunneling           | 30                 | 7.12                             | Dynamical phenomena  |
| X13014 tunneling          | 32.5               | 6.45                             | Dynamical phenomena  |
X13014 tunneling & 32.5 & 6.01 & Dynamical phenomena \\
X13012 tunneling & 30 & 6.31 & Dynamical phenomena \\
X13013 tunneling & 30 & 8.58 & Dynamical phenomena \\
X13013 tunneling & 30 & 8.34 & Dynamical phenomena \\
X13012 tunneling & 30 & 9.42 & Dynamical phenomena \\
X13013 tunneling & 30 & 7.51 & Dynamical phenomena \\
X13013 tunneling & 30 & 6.66 & Dynamical phenomena \\
X13013 tunneling & 30 & 6.89 & Dynamical phenomena \\
X13013 tunneling & 30 & 7.86 & Dynamical phenomena \\
X13013 tunneling & 31 & 7.35 & Dynamical phenomena \\

After pre-drainage, among the 12 groups of residual gas content tested, three groups exceeded the reference critical value of 8 m³/t given by the Basic Indicators of Coal Mine Gas Drainage (AQ1026-2006) and the Regulations on Prevention and Control of Coal and Gas Outburst. According to the inspection of residual gas content, it can be seen that the coal body in this area is still not completely outburst-free. According to the critical value of gas content of 10 m³/t, the coal outburst in this area has been eliminated.

In order to further verify the outburst danger of lane X13012, lane X13013 and lane X13014, the outburst danger prediction method was adopted to verify the outburst danger in the process of tunneling. Tested X13013 Lane drilling cutting gaseous desorption index (K1 and coal powder quantity of bore S) See Figure 2.

According to Figure 2, coal powder quantity of bore S and gaseous desorption index K1 did not exceed the standard in 74 prediction cycles. According to the prediction results of the prediction indexes of the working face, the coal bodies in lane 13012, lane 13013 and lane 13014 have eliminated the outburst danger after pre-pumping.

Therefore, it is feasible and reasonable to have a gas content threshold of 10 m³/t.

5. Conclusion

1) the residual gas content and gas pressure of the original coal body under different water conditions were measured, and the influence of water on the gas content of the original coal body was analyzed.

2) The critical gas content of outburst elimination in No.3 coal seam in Xijing District of Sihe Mine is preliminarily determined to be 10 m³/t.

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