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Study on Comprehensive Technology of Coal and Gas Outburst Prevention in Mining Panels

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Abstract

With the goal to solve problems of coal and gas outbursts prevention in a mining panel, the method developed by the authors of this paper was employed to define the critical value of gas content based data form a panel of Mine A of a coal mining group in Shanxi Province. Outburst management in the panel was successfully implemented based on the defined critical value of gas content and gas geological maps. The principle of drainage borehole layout was studied in details. A mathematical model was established to determine reasonable drainage time, and a method was developed to evaluate the effects of measures on outbursts presentation. The research results show that coals with different rank have very different absorption capacity, and that the critical value of gas content is different and closely relevant to coal rank. Areas of outburst risk are clearly identified by gas-geological data shown on the gas-geology map, and the evaluation method was applied to make sure that the panel was free of outburst risk after gas drainage. The integration of all the research results eliminated outburst risk in the panel.

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Keywords: coal and gas outburst prevention, mining panel; Gas-geological maps; evaluating method

Coal and gas outburst is one of the most serious engineering disasters in coal mines safety. In recent years, ground stress and gas pressure increase continually with the increase of mining depth; and the geological and mining conditions for mining are becoming much more complex than ever before, so that the frequency and scale of gas outbursts in mining panels increase continuously. Because of large number of miners in mining panels, should a gas outburst occur, it would cause huge personnel casualties. For example, a serious accident of outburst occurred in panel 24110 at Mine of Pingdingshan Coal Group on November 12, 2007, and killed 12 miners. On October 13, 2008, a severe accident of coal and gas outburst happened in 21431 mining panel of Hebi No.6 mine, which caused nine deaths. On October 16, 2010, a special major accident of coal and gas outburst happened in 12190 mining panel of Pingyu fourth mine, and caused 37 deaths. Comprehensive analysis and investigation of these accidents demonstrated

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that lack of gas distribution information, poorly designed or implemented regional prevention measures and unreasonable evaluation method of outburst prevention effects are the major contributing factors to the accidents. It is therefore of great significance to study the regional four-in-one outburst prevention technique to ensure the safety on all underground work places.

1 .The determination of critical value of gas content

Gas content, contrasted to gas pressure, is more convenient to be tested, and its test results are more reliable, so it is more suitable for outburst prediction. The difference of adsorption capacity of coals to gas is very large because of differential degree in coal metamorphism and tectonic disturbance. The volume of adsorbed gas on coal may double if the differential degree of metamorphism and tectonic disturbance is big enough [1-2]. Therefore, the critical values of gas content are different for coal seams, and fortunately, they can be determined by the method put forward by a research team from the School of Safety Science and Engineering at Henan Polytechnic University. The method uses a combination of historical data, field test data, laboratory experiment results and comprehensive theoretical analysis. The particular research technical road map is shown in Fig.1.

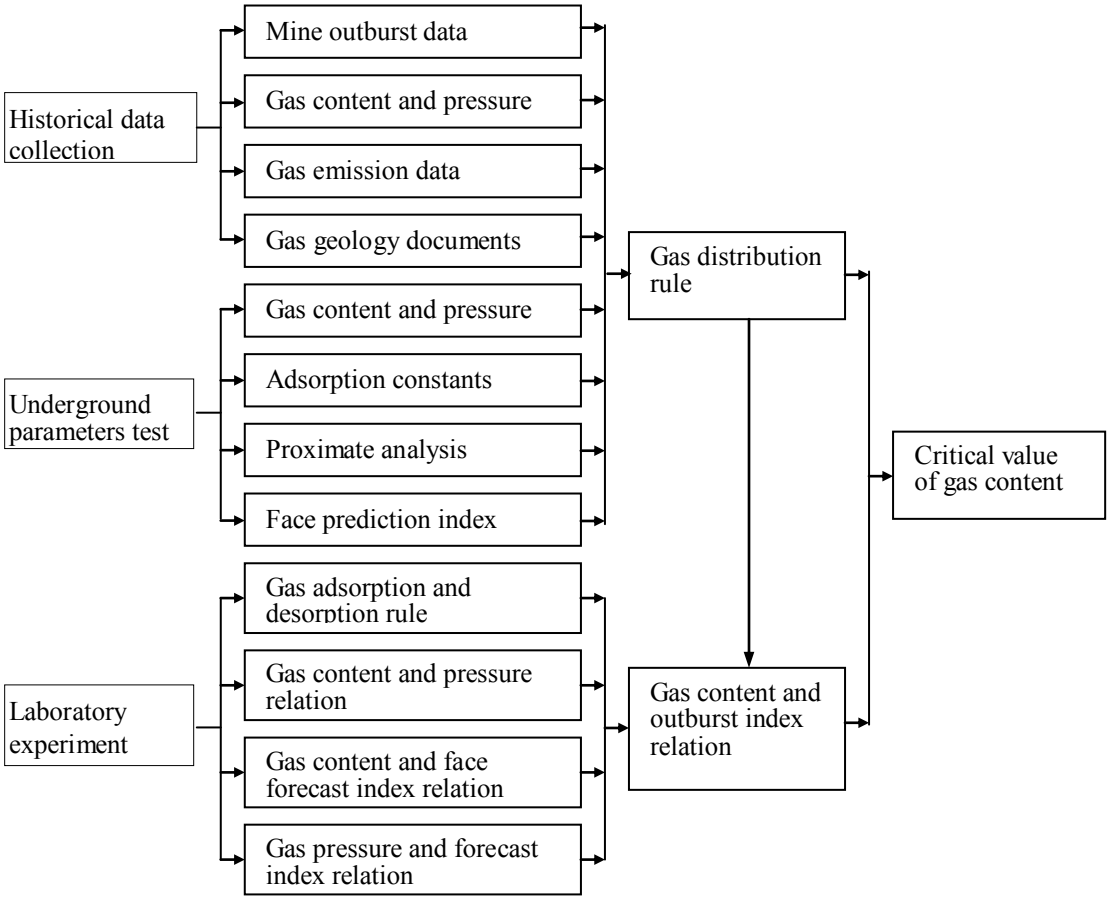

Fig.1 The research technical road map

The authors has determined the critical values of Ⅱ1 seam in Hebi area, No.3 seam in Jincheng area

and Ⅱ1 seam of Longshan mine by use of the method shown in figure 1, the results are respectively 9.0 m^3/t, 12.0 m^3/t and 10.0m^3/t. The research results have been applied and work safety has been achieved with high productivity. The critical value in panel 3102 was determined to be10.0 m^3/t.

2. Regional prediction of mining panel based on gas-geological maps

It is required by Regulations on Outburst Prevention, jointly issued by the State Administration of Work Safety and State Administration of Coal Mine Safety, that indexes, including gas content, *f* value, $\triangle p$ and other important parameters, be tested or observed every 30-50m during roadway development. The requirement also applies to other parameters, including but not limited to, gas emission from roadway, tectonically disturbed coal, and coal seam thickness, geological structures (faults and folds) whenever they are technically available. When all these data were ready, they were then analyzed and transferred onto the gas geological map oriented to the target panel.

Figure 2 is the gas-geological map of panel 3102 of Mine A. It is clear that gas content and absolute gas emission, expressed as cubic meters per minute, has good consistency from Fig.2, and gas content decreases gradually from the opening, marked as zero, to the end of the roadway. The gas content contours of panel 3102 were drawn by absolute emission and gas content data.

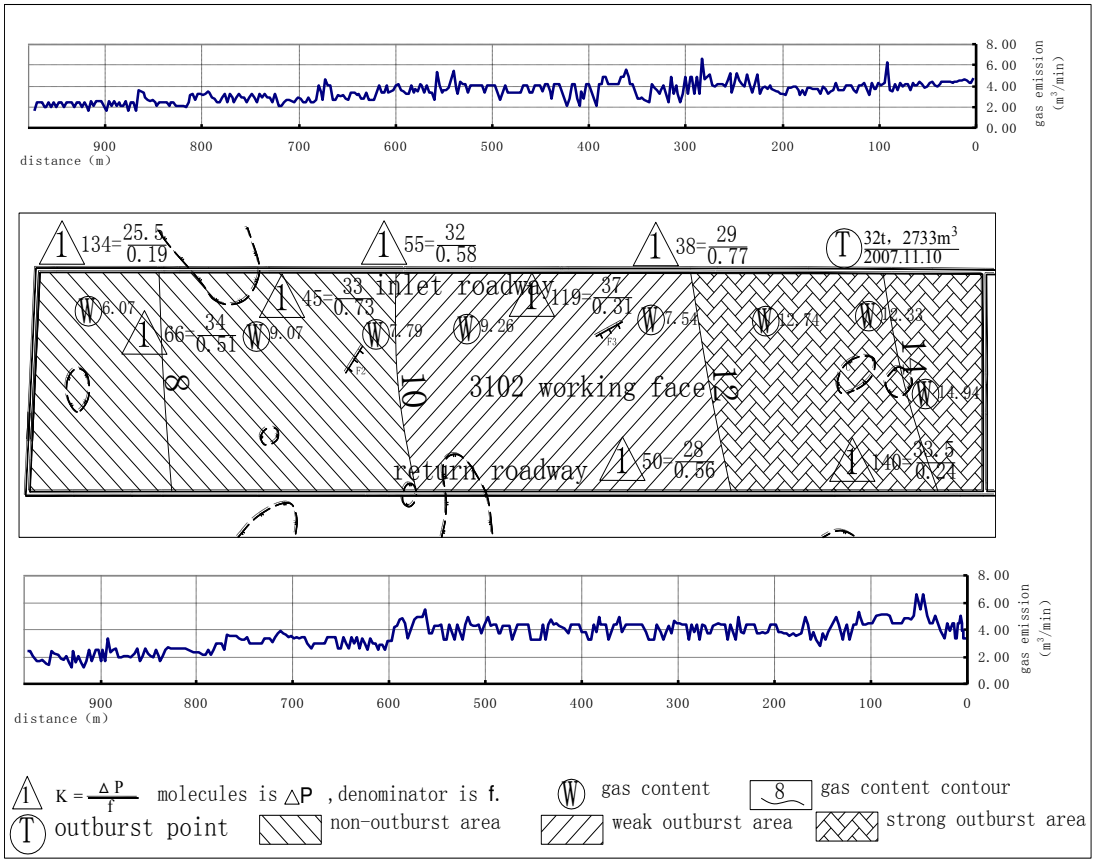

Fig.2 Gas-geological map of panel 3102

Gas content data can reflect the general trend of gas distribution along the panel; however, it cannot

describe the accurate gas occurrence in the panel because of limited gas content test points and dramatically changed gas distribution. Studies have shown that absolute gas emission rate in an indirect indication of gas content, gas pressure, coal seam permeability, etc. in the case of similar roadway development rate. These are closely related to outburst potential [3-4]. Therefore, gas absolute emission rate can be employed as an index to predict outburst zones in the panel. The critical value of gas emission rate was defined as 4.0m^3/min based on analysis of the relationship of gas content and gas emission.

Based on data collected, outburst zones were identified in Panel 3102 by indexes of gas content gas emission rate. Their critical values are 10.0m^3/t and 4.0m^3/min. A strong outburst zone and a weak one was shown the geological map of panel 3102. An area with gas content of 10.0-12.0m^3/t was considered as a weak outburst zone, and an area with gas content of over 12.0m^3/t as a strong outburst zone. The proportion of non-outburst area is about 37.8%. The classification of outburst zones has been proved to be beneficial and helpful to outburst management.

3. Implementation of regional outburst prevention measures

The corresponding regional outburst prevention measures could be designed and implemented according to gas-geological map. The borehole density and the time of gad drainage are increased in the strong outburst zone. The length, angle, interval of boreholes are recorded in details; and attention was also paid to early warnings of impending outbursts in the process of borehole drilling, such as coal and gas blowouts, drill sucking, drill sticking and coal noises and so on. Wherever there is any indication of these early warnings, supplementary and intensive regional and local comprehensive outburst prevention measures will be designed and applied immediately. Generally, intensified and prolonged gas drainage boreholes are the most effective tools that could be employed to obtain the expected gas drainage effects.

If, in any case, it is impossible to drill boreholes as planned within some areas, they must be marked, and local outburst prevention measures must be taken to remove outburst risk radically before panel mining. After a borehole was finished, it must be sealed and connected to the drainage network as soon as possible. Gas drainage parameters, such as methane concentration, mixed gas flow rate, temperature, need to be measured and recorded in details.

4. The evaluation method of the prevention effect of outbursts

4.1 The definition of reasonable drainage time

The relationship of flow rate with time of a single gas drainage hole can be described as following long and well established equation:

$$q_t = q_0 e^{-\beta t} \tag{1}$$

Where: q_t - gas flow rate of 100m borehole, m^3/d;

q_0 -initial gas flow rate, m^3/d;

β -attenuation coefficient of gas flow, d^{-1}。

Then the total gas drainage volume Q_t in t days is:

$$Q_t = \int_0^t q_0 e^{-\beta t} dt \tag{2}$$

The reasonable drainage time T_{hc} is:

$$T_{hc} \geq -\frac{1}{\beta} \ln\left(1 - \frac{100\beta(W_0 - W_s)(L_1 - d_1)(L_2 - 2d_1)m\rho}{nq_0 L_3}\right) \tag{3}$$

Where:

W_0 - original gas content, m^3/t;
W_s - critical value of gas content, m^3/t;
L_1 - strike length of mining panel, m;
L_2 - length of long wall face of the panel, m;
m - seam thickness, m;
ρ −density of coal, t/m^3;
n − number of drainage holes, a;
L_3 - average length of hole, m.

4.2 The evaluation of the prevention effects on outbursts

The first procedure is to examine records of the drainage boreholes to make sure that they have been finished according to the design. If the examination results are negative, supplementary boreholes must be drilled until requirements are fully met as planned in the design. When the drainage boreholes meet the design requirements, and the drainage time reaches the reasonable drainage time, the evaluation moves to its next procedure. Then the panel is divided into small zones and calculations are made of gas drainage efficiency and residual gas contents zone by zone according to gas volume drained and total gas storage in a particular zone. If any of the residual gas contents is less than the critical value, the whole panel is considered as outburst risk free, otherwise, additional regional outburst prevention measures must be conducted or gas drainage time be extended until residual gas content is lower below the critical value .

5 Conclusions

(1) The method to define the critical value of gas content was put forward, and the classification management of coal and gas outburst prevention in mining panel was achieved based on gas-geological maps by gas content and gas emission as an index.

(2) The layout principle of drainage borehole was studied in details, and the prediction model of reasonable drainage time was formulated.

(3) The evaluation methods of eliminating coal and gas outburst were studied, which provides technical support for coal and gas outburst prevention in mining panel.

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