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Research and Application of Hydraulic Measures Combined with Permeability Enhancement Technology in Low Permeability Coal Seam

Xue-zhan XU [1.2*], Yun-long ZOU [1.2]

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

ABSTRACT. *: Based on the theory of low permeability and permeability of coal seam in Huainan mining area, a variety of measures are analyzed based on the theory of low permeability and low permeability of coal seam in Huainan mining area. Through the application in floor roadway of No.2 level and No.1 mining area in one Huainan coal mine, the results show that the hydraulic permeability enhancement technology can significantly improve the coal seam permeability. After 30 days of gas drainage, the average gas drainage pure amount of the collaborative hydraulic permeability increasing drilling hole is 9.5 times of that of the ordinary drilling hole, and can continuously ensure the gas drainage efficiency of high flow and concentration Fruit.*

KEYWORDS: *Low permeability, Gas drainage, Hydraulic fracturing, Joint permeability enhancement*

1. Introduction

At present, more than 95% of the coal seams in China are mined by underground coal mines, and the permeability coefficient of coal seams is small. It is difficult to achieve good gas drainage effect when using conventional coal seam gas extraction technology to conduct coal seam gas pre drainage. In order to solve the problems existing in the pre drainage of mine gas and improve the permeability coefficient of coal seam, a large number of experimental studies have been carried out by relevant researchers. Among them, Fan Yingchun et al. [1] improved the permeability coefficient of coal seam by improving the CO_2 presplitting and permeability increasing blasting device; Li Jiangtao et al. [2] used computer simulation technology to simulate and study the mechanism of permeability enhancement of

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hydraulic fracturing seepage in coal seam, which improved the gas pre drainage efficiency; Zou quanle et al. [3] established the gas seepage coupling realization system of hydraulic slotting, and revealed the fluid solid coupling characteristics of gas emission and spalling coal body in the process of hydraulic slotting. Although the above researchers have carried out relevant application research on CO_2 fracturing, hydraulic fracturing, hydraulic cutting and other permeability enhancement measures, and achieved some research results, there are few studies on improving coal seam permeability coefficient by using hydraulic cutting and hydraulic fracturing joint permeability enhancement technology for gas disaster caused by coupling factors.

In view of the tight situation of mining replacement in a mine in Huainan, the hydraulic cutting and hydraulic fracturing joint permeability increasing layout technology is adopted to analyze the fracture expansion characteristics of coal body after fracturing, and study the mechanism of permeability increasing and pressure relief of cutting and micro fracture expansion and permeability increasing of fracturing. Finally, through the field application test, it is verified that the combination of hydraulic cutting and hydraulic fracturing has a good application effect on improving the permeability coefficient of coal seam.

2. Mechanism of Joint Permeability Enhancement of Hydraulic Cutting and Hydraulic Fracturing

2.1 Principle of Hydraulic Slotting Technology

When the high pressure water jet is used to increase permeability and relieve pressure in low permeability coal seam, the high-pressure water jet impacts the coal body and forms a disc like gas guiding slot in the coal body. According to the theory of rock mechanics and fluid mechanics, high-pressure water jet [4-5] overcomes the influence of original rock stress, in-situ stress and cohesive resistance between coal bodies, and forms a slot along the vertical direction in the coal body. Fracture zone, plastic zone, elastic zone and original rock stress zone are formed successively from fracture groove to coal depth. The stress rising area extends to the deep part of coal body, which plays the role of pressure relief and permeability enhancement.

2.2 Principle of Hydraulic Fracturing Permeability Enhancement Technology

The deep buried coal seam is affected by the gravity of overlying strata, and the internal fissures of coal body are in closed or semi closed state due to gravity compression, and the permeability of coal body is poor. In order to improve the permeability coefficient of coal body, the fracturing hole was drilled into the coal body, and the stress distribution around the borehole was as shown in Fig. 1, according to the knowledge of rock mechanics:

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$$\sigma_r = \frac{\sigma_h + \sigma_v}{2}\left(1 - \frac{r_1^2}{r_2^2}\right) + \frac{\sigma_v - \sigma_h}{2}\left(1 + \frac{3r_1^4}{r_2^4} - \frac{4r_1^2}{r_2^2}\right)\cos 2\theta \quad (1)$$

$$\sigma_\theta = \frac{\sigma_h + \sigma_v}{2}\left(1 - \frac{r_1^2}{r_2^2}\right) - \frac{\sigma_v - \sigma_h}{2}\left(1 + \frac{3r_1^4}{r_2^4}\right)\cos 2\theta \quad (2)$$

Where:r_1 is the drilling radius,m;r_2 is the distance between the boreholes,m; σ_r is the radial principal stress,MPa; σ_h is the minimum principal stress,MPa; σ_v is the maximum principal stress,MPa;θ is the angle between a point around the borehole and the maximum principal stress σ_v,°; σ_θ is the tangential effective stress , MPa.

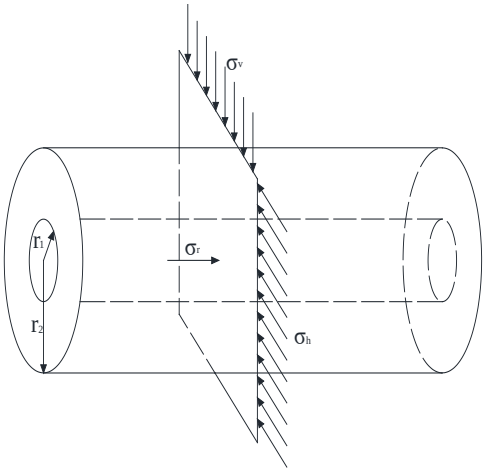

Fig.1 Stress Redistribution of Coal and Rock Around Boreholes

In the process of fracturing, the speed of fracturing fluid entering into coal body through drilling hole is far greater than the natural absorption capacity of coal body. With the increasing of fracturing fluid, the liquid pressure entering the coal body increases. Under the joint action of liquid pressure and ground stress, the closed gap in coal body opens again along the weak surface of the seam, forming a conduction network, and the permeability of coal seam increases.

2.3 Principle of Joint Antireflection Technology

The joint permeability enhancement technology of hydraulic cutting and hydraulic fracturing in low permeability coal seam refers to the drilling of pressure

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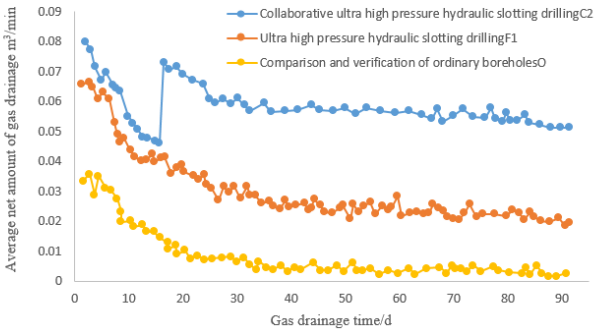
relief and permeability increasing boreholes in low permeability coal seam. Combined with the characteristics of hydraulic cutting and hydraulic fracturing permeability increasing technology, hydraulic cutting and hydraulic fracturing permeability increasing measures are respectively adopted for some boreholes, and hydraulic fracturing permeability increasing measures are adopted for some boreholes, forming a cross arrangement within the space scope. The disc-shaped plastic fracture slot formed by high-pressure water jet cutting coal body provides weak surface effect for hydraulic fracturing and improves the effect of fracturing permeability enhancement. At the same time, the slotted slot and hydraulic fracturing expansion gap are connected and interconnected, the influence range of single hole permeability increasing and pressure relief is increased, and the coal seam permeability is improved.

3. Field Test and Effect Analysis

In order to investigate the enhanced permeability effect of hydraulic cutting and hydraulic fracturing on low permeability coal seam, the author selected a floor roadway of No.2 level and No.1 mining area in Huainan mine. the occurrence structure of one group of coal in the mining area is stable, with an average coal thickness of 7.0 m, and there is 0.9 m thick gangue in the middle. The gas content is 9.1 ~ 11.7 m^3 / T, and the gas pressure is 0.71 ~ 1.68 MPa. The vertical distance between test floor roadway and 1 group coal seam floor is 18.0 m.

3.1 Analysis of Test Results

In order to test the enhanced permeability effect of hydraulic cutting and hydraulic fracturing technology on low permeability coal seam, as shown in Fig. 2, the gas drainage inspection instrument is used to compare and verify the collaborative hydraulic slotting drilling, collaborative hydraulic fracturing drilling, hydraulic cutting drilling, hydraulic fracturing drilling and common drainage drilling near the drilling field.



(a) Comparison and verification of hydraulic slotted drilling

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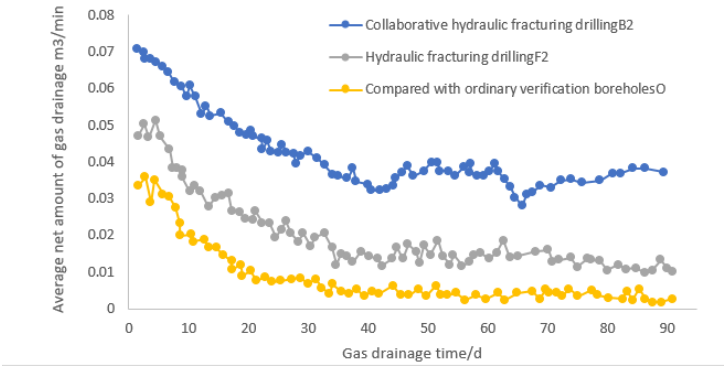

(b) Comparison and verification of hydraulic fracturing borehole pumping effect

Fig.2 Comparison and Verification of Average Purity of Gas Drainage from Boreholes

As shown in Fig. 2a, the attenuation characteristics of gas drainage pure quantity of collaborative hydraulic slotting drilling, hydraulic slotting drilling and comparison and verification of ordinary drainage boreholes are shown. After 30 days of gas drainage, the average pure gas drainage amount tends to be stable and maintained at 0.058 m^3 / min, about 2.2 times of that of pure hydraulic slotting drilling, and 9.5 times of that of conventional extraction drilling in adjacent drilling fields.

As shown in Fig. 2b, the comparison and verification effect of gas drainage of common boreholes by collaborative hydraulic fracturing boreholes, hydraulic fracturing boreholes and adjacent drilling fields is shown. At the initial stage of three kinds of boreholes, the average pure gas drainage volume decreases significantly, and the net amount of gas drainage is basically stable after 30 days. The average gas drainage pure volume of the collaborative hydraulic fracturing permeability enhancement measures is maintained at about 0.036 m^3 / min, which is about 1.9 times of the gas drainage effect of the simple hydraulic fracturing permeability increasing measures, and about 6.4 times of the comparison and verification of the ordinary drainage boreholes.

4. Conclusion

Ultra high pressure hydraulic cutting and hydraulic fracturing technology can significantly improve the permeability coefficient of low permeability coal seam and improve the gas drainage effect. After the gas drainage is stable for 30 days, the average gas drainage pure quantity of the collaborative hydraulic slotting borehole is 9.5 times of that of the ordinary drilling hole under the slotting and fracturing collaborative layout technology; the average gas drainage pure amount of the

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collaborative hydraulic fracturing drilling is 6.4 times of the ordinary drilling hole, and can continuously ensure the gas drainage effect of higher flow rate and concentration.

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