Gas Prevention and Control of Protective Seam Working Face in Close Outburst Coal Seam Group

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Abstract: Pressure relief gas of protected layer poured into the protective layer seriously restricts the safety recovery of protective layer. Gas prevention and control of protective seam working face in close outburst coal seam group explored by studying the stress and displacement characteristics of close outburst coal seam group after mining combined with the law of gas overflow under the influence of coal seam group mining. The results show that stress of coal and rock strata in the protected area presented U shape changes and the displacement of protected layer presented arched shape changes so that the pressure relief effect is obvious. Gas extraction of protective layer under the influence of upper protective layer can reach to 0.81-2.03m^3/min with an average of 1.47m^3/min so that realized the safe opening of working face of protective layer.

1. Introduction

The economic and effective regional measure to prevent and control coal and gas outburst is protective seam mining and which has become the preferred measure for mines with protective seam mining conditions [1]. Stress of protected layer could be reduced so that caused expansion and deformation and fully relieved under the mining effect of protective layer in close outburst coal seam group [2]. At the same time crack passage expanded simultaneously resulting in transverse and vertical cracks connect with each other. Absorbed gas desorbed and influx into protective layer working face through interlayer crack passage and affects the mining safety of protective layer working face seriously [3].

Coal mining of Hunan provinces with serious outburst disasters and it generally has the characteristics of small well size and complex geological structure and coal seam occurrence [4]. The main mining seams of test mine are II、III、IV、V coal and in which III、IV、V coal are outburst coal seams. The second coal was selected as the protective seam in order to prevent coal and gas outburst effectively. Mining of II Coal protective seam caused protected seam fully relieving pressure and absorbed gas influx into protective seam working face so that seriously restricts the safety of production. Stress and displacement characteristics of the protected seam were studied and relevant experiments were by carried out the author based on close outburst coal seam group mining combined with the law of gas overflow in coal seam in order to explore the gas prevention technology of protective seam working face in close outburst coal seam group.

2. Stress and displacement numerical simulation of protected layer after mining

The numerical model of test face constructed according with 78 m cut hole and 20 degree inclination of coal seam and 75 degree relief angle as the boundary of protected area along the inclination. The average stress load of working face determined to be 10.50MPa according to the characteristics of coal seam and it’s occurrence combined with the calculation formula of buried

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depth and overlying strata uniform load [5]. The basic parameters were showed in Table 1.

$$q = \sum \rho g h \tag{1}$$

Where ρ, h, g are average density of overlying strata, buried depth of coal seam and acceleration of gravity.

Table 1 Basic parameters of working face on load calculation of uniform distribution

Lithology	Young modulus (MPa)	Density (kg/m^3)	Poisson ratio	Cohesion (MPa)	Internal friction angle(°)
Overlying strata	1.08×10^4	2.55×10^3	0.30	5.50	30
Mudstone	1.22×10^4	2.65×10^3	0.24	6.80	29
Sandstone	1.25×10^4	2.35×10^3	0.25	8.90	35
II coal	1.74×10^3	1.54×10^3	0.30	2.50	39
Mudstone	1.28×10^4	2.65×10^3	0.24	6.00	29
Sandstone	1.32×10^4	2.35×10^3	0.25	8.60	35
Sandy Mudstone	1.17×10^4	2.50×10^3	0.24	7.50	29
III coal	1.33×10^3	1.47×10^3	0.33	2.80	39
Sandstone	1.32×10^4	2.30×10^3	0.25	8.50	33
IV coal	1.50×10^3	1.50×10^3	0.33	2.60	39
Sandstone	1.35×10^4	2.55×10^3	0.25	8.20	35

COMSOL simulation software was used to analyze the distribution and variation of stress and displacement [6]. The coal seam was regarded as an elastic-plastic ideal body and the deformation of coal seam obeys the Drucker-Prague yield condition during the simulation process. At the same time upper boundary was changed to free boundaries and fixed the boundary of the left and right and the lower.

3. Stress and displacement characteristics of protected layer

Stress concentration occurs in the floor coal and rock along the coal seam strike in front of working face during the mining period and advance of working face. The back of working face has been mined out thus caused the process of roof spanning to re-compaction and it provides a larger free face for the movement and deformation of floor coal and rock to develop a space conducive deformation[7]. Stress tensor distribution of coal and rock strata showed in Fig.1. The displacement of protected layer showed in Fig.2.

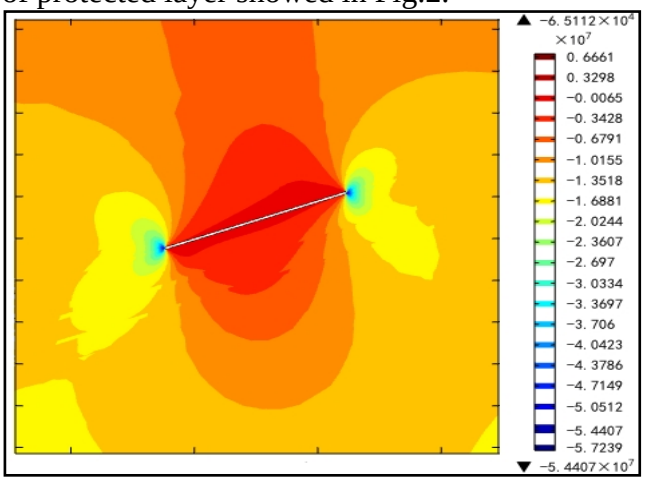

Fig.1 Stress distribution of coal and rock strata

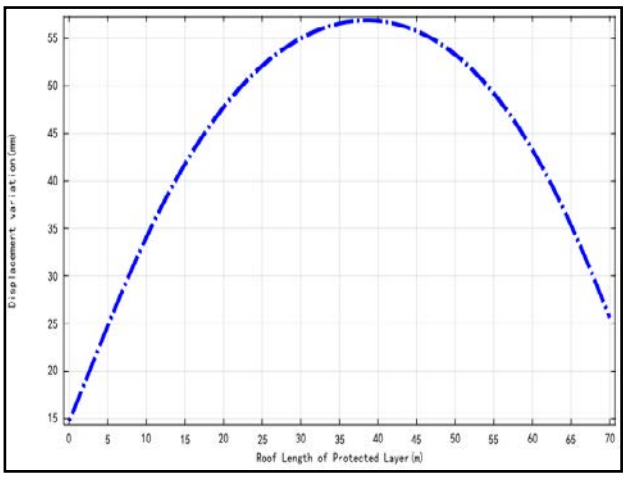

Fig.2 Displacement variation of protected layer

As shown in Figure 1 the distribution of inclined stress along working face of coal seam floor presented gradient changes and with the characteristic of closer to the mined out area with greater

variation range and gradually weakens with the increase of distance from the mined out area. The stress of floor coal seam in the middle of the mined out area decreases the most and showed obvious "U" distribution. The stress decreases the most equate to the pressure relief degree is the greatest and the stress distribution presents an obvious "arch" distribution.

As shown in Figure 2 the greatest degree of pressure relief and displacement variation of protected layer in the middle of the mined out area. At the same time displacement of roof and floor of protected layer distributes "arch" along the coal seam tendency. The displacement of protected layer test face could be reach to 15-57 mm.

4. Gas overflow of coal seam under mining influence

Weak gas permeability layers of coal seams existed in the coal measures strata which can become the channel of interlayer gas flow and forming gas cross-flow field when under the mining influence. Gas overflow effect of coal seams produced through gas overflow field under the action of pore pressure gradient [8].

Stress of short-distance outburst coal seam group redistributed after the mining of protective seam. At the same time reduced the stress of protected seam and expands and deforms so that fully relieves the pressure of protected coal seams. Crack passage expansion in floor coal and rock strata simultaneous derivation of transverse and vertical intersecting cracks [9]. Adsorbed gas of protected layer desorbed and pour into protective seam working face through interlayer fissures formed pressure relief and increased permeability and flow.

5. Gas prevention of protective seam working face in close outburst coal seam group

5.1 Measures optimization

Protective seam working face of experimental mine take measures of gas pre-drainage of III、IV、V coal seam and buried pipes in corner tube extraction during mining. The length of pre-drained drilling holes through layers is difficult to reach the design requirements because of the complex geological conditions so that caused difficulty to discharge slag and ensure the quality of drilling holes. The poor permeability of coal seam and the difficulty in guaranteeing the quality of borehole sealing lead to the unsatisfactory effect of drilling and extraction through seam. The prevention and control technology of working face by buried pipe pumping could be obvious effective only in local area of upper corner. In order to achieve gas prevention and control of protective seam working face by the key of extract pressure relief gas from adjacent seams efficiently.

The overlying coal seams under II coal including III、IV、V、VI、VII coal seams in which each coal seam has coal and gas outburst dangers and hosts a siderite nodule layer with an average thickness of 8M especially for V coal seam floor. The most effective way of gas extraction is borehole drilling in floor rock roadway but potential being the danger of mis-crossing outburst coal seam. On the other hand there has been many problems for drilling through siderite interlayer such as large amount of drilling work and difficult construction and long construction period.

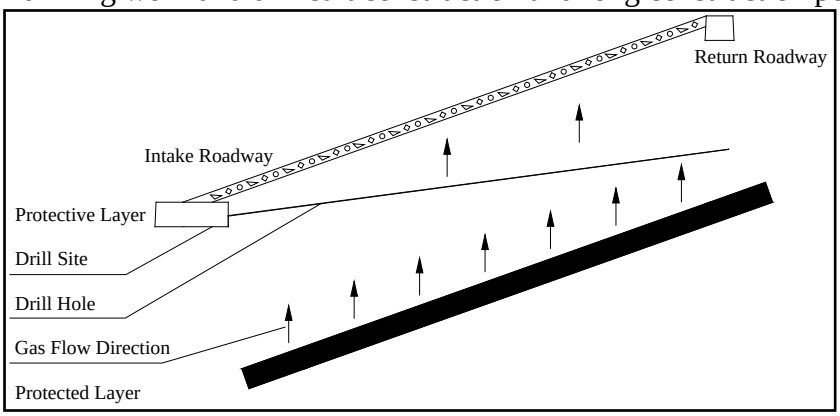

Fig.3 Schematic diagram of gas control technology of protective layer

Intercepting boreholes were arranged between protective layer and protected layer to extract pressure-relief gas based on comprehensive consideration of mining influence of protective seam and gas overflow and field conditions of coal seams. The length and inclination of drilling holes equal to the parameters of working face and distance between final holes determined as 5m. The profile of boreholes showed in Fig.3.

5.2 Effect investigation

Gas drainage volume of boreholes and gas concentration in upper corner and return air roadway of working face were taken as indicators in order to inspect the effects of gas prevention and control of protective seam working face in close outburst coal seam group.

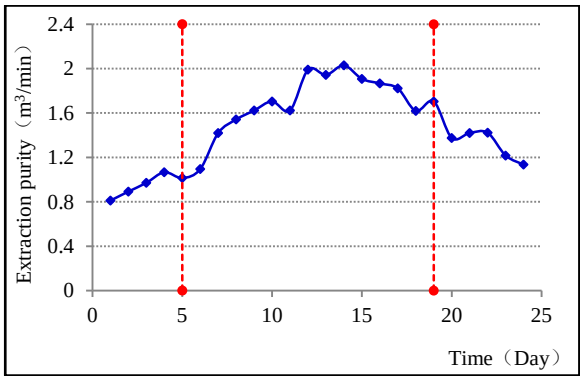

Fig. 4 Change curve of gas extraction

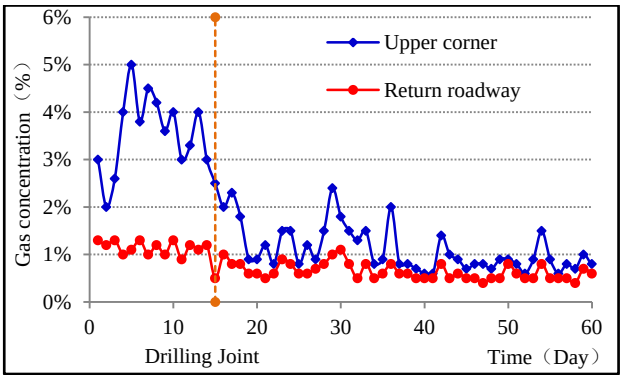

Fig.5 Variation curve of gas concentration in upper corner and return lane of working face

As shown in Fig.4 and Fig.5 gas extraction of prevention and control technical measures of protective seam working face in close outburst coal seam group could be reached to 0.81-2.03m^3/min with an average of 1.47m^3/min and the gas concentration in the upper corner of protective layer working face obviously reduced and the gas concentration in the return air roadway basically less than 1% so that realized the safe opening of working face of protective layer.

6. Summary

The main conclusions of gas prevention and control of protective seam working face in close outburst coal seam group as showed.

(1) The distribution of inclined stress along working face of coal seam floor presented gradient changes and with the characteristic of closer to the mined out area with greater variation range and gradually weakens with the increase of distance from the mined out area. The stress of floor coal seam in the middle of the mined out area decreases the most and showed obvious "U" distribution. The stress decreases the most equate to the pressure relief degree is the greatest and the stress distribution presents an obvious "arch" distribution.

(2) The greatest degree of pressure relief and displacement variation of protected layer in the middle of the mined out area. At the same time displacement of roof and floor of protected layer distributes "arch" along the coal seam tendency. The displacement of protected layer test face could be reach to 15-57 mm.

(3) Gas extraction of prevention and control technical measures of protective seam working face in close outburst coal seam group could be reached to 0.81-2.03m^3/min with an average of 1.47m^3/min and the gas concentration in the upper corner of protective layer working face obviously reduced and the gas concentration in the return air roadway basically less than 1% so that realized the safe opening of working face of protective layer.

Acknowledgments

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