2011

Pressure Relief Gas Extraction based on Strata Movement of Mined upper Protective Seam

Haifeng Weng
China University of Mining and Technology, China

Yuanping Cheng
China University of Mining and Technology, China

Qingwei Zhai
China University of Mining and Technology, China

Publication Details

H. Wang, Y. Cheng and Q. Zhai, Pressure Relief Gas Extraction based on Strata Movement of Mined upper Protective Seam, 11th Underground Coal Operators' Conference, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2011, 343-347.

PRESSURE RELIEF GAS EXTRACTION BASED ON STRATA MOVEMENT OF MINED UPPER PROTECTIVE SEAM

Haifeng Wang, Yuanping Cheng and Qingwei Zhai

ABSTRACT: Consensus on protective seam mining technology to solve the problems of coal and gas outburst has been reached. For upper protective seam mining, the effect of pressure relief and permeability in the lower protected layers is determined by the distance between the seams. If the distance is small, the effect of pressure relief and permeability on the lower protected seams is better, but there will be more relief gas flows to the working faces of the protective seam, and gas control of the working faces will be more difficult.

INTRODUCTION

Most high gas coal seams in China have low permeability. The Huainan mining area for example, has a permeability coefficient of 2.5×10^{-5}~2×10^{-4} md (0.001~0.008 $m^2/(MPa^2.d)$) (Zhao and Liao, 2007) and the gas extraction of the original coal seam is very poor. Protective seam mining is a kind of pressure relief gas extraction technology. Through protective seam mining, the pressure relief and permeability increases in the adjacent coal seams, and thus gas extraction is improved (Cheng, 2009; 2007; 2003). Protective seam mining is divided into upper and lower protective seam mining. Mining the upper protective seam will not damage the mining conditions of the protected seams, so mining the upper protective seam should be preferred (SACMS, 2007; 2009). The pressure relief and permeability increase in the protected seams is determined by the distance between the seams (seam spacing). The smaller the distance, the better. Close range upper protective seam mining is ideal for regional gas extraction technology. However, there are some problems in application. The most significant problem is that if gas cannot be extracted quickly from the protected seam it will flow into the working faces of the protective seam, and cause a great security risk.

APPLICATION BACKGROUND

Huainan Xinzhuangzi Mine coal seam C13 is a seam in which many coal and gas outburst dynamic phenomena have happened. There is a thin and unstable coal seam C14 on top of the seam C13, and the coal seam histogram is shown in Figure 1. The seam C14 is planned to be adopted to protect the seam C13 and eliminate its outbursts. A test working face in the upper protective layer of C14 has a coal thickness of 0.1 to 1.2 m, average 0.6 m, and mining height 1.5 m. There is no outbursts potential for seam C14, and the gas content is 6 m^3/t. The average thickness of coal seam C13 the underlying protected seam is 6.2 m, the average gas pressure is 4.6 MPa, and the average gas content is 14.9 m^3/t. In this geological block, the distance between seams C14 and C13 is the 14 ~ 20 m, with an average of 18 m.

MOVEMENT AND FRACTURE EVOLUTION OF COAL-ROCK MASS IN FLOOR

After mining of an upper protective seam the floor strata will move up under integrated stresses, and floor heave will appear in the goaf (Qian and Liu, 1984). According to the simulation and field tests and previous research, the floor strata affected by mining can be classified as floor heave fracture zone and floor heave deformation zone, as shown in Figure 2. The lower limit of the floor heave fracture zone is 15~25 m below the goaf, the fracture in the zone are mainly bedding fractures parallel to the seam and penetrating fractures vertical and skewed to the seam. The penetrating fractures connect the coal seams within the fracture zone and the goaf, the relief gas can flow into the protective seam goaf along the fracture. If the protected seam is in the zone, it is called the close range upper protective seam mining. The lower limit of the floor heave deformation zone is 50~60 m below the goaf, the fracture in the zone are mainly bedding fracture and penetrating fracture are lacking. The protected seam in the zone will expand

National Engineering Research Centre for Coal and Gas control, China University of Mining and Technology, Xuzhou, Jiangsu 221008, China, ypcheng620924@163.com

and deform, the permeability of the coal seam will increase, which will create favorable conditions for gas extraction. The number of fractures decreases as seam spacing increases.

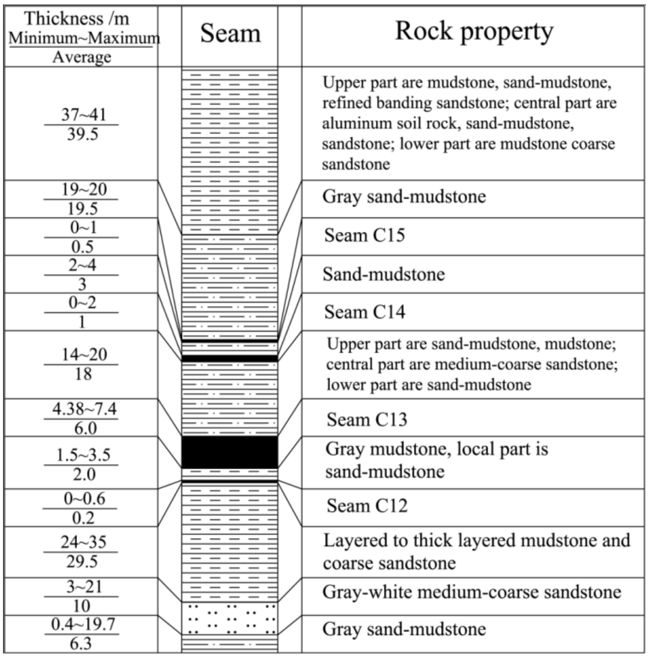

Figure 1 - Coal seam histogram of Xinzhuangzi Mine

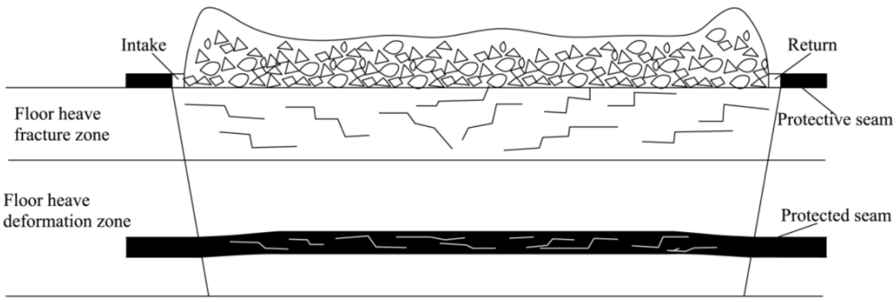

Figure 2 - Fracture zones of floor stratum

Coal seams will expand and deform when moving up, which is the macroscopic performance of fracture development. The greater expansion deformation, the more significant will be the permeability increase, and the stronger the gas desorption effect. The typical vertical deformation curve of the close range lower protected seam is shown in Figure 3, which was obtained from an adjacent Xieyi Mine working coal seam C13. It can be seen from the figure, in the upper protective seam mining period, the compression deformation of the protected seam C13 occurs first and then expansion deformation. The maximum relative amount of compression deformation is 1.14‰, and the maximum relative expansion deformation is 4.00‰.

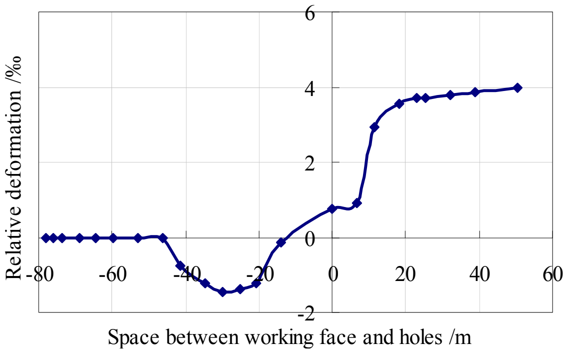

Figure 3 - Typical vertical deformation curve of the close range lower protected seam

RELIEF GAS MIGRATION LAWS AND EXTRACTION EFFECTS OF LOWER PROTECTED SEAMS

Gas release and migration trends of lower protected layers

In the process of close range upper protective seam mining, favourable pressure relief and permeability increased of the lower protected seams can be obtained (Yu, 1992). Under the common effect of the negative pressure of ventilation in the working faces of the protective seams and high-pressure gas in the protected seam, much relief gas from the protected seams flows into the faces of the protective seams along the penetrating fractures. When the spacing is less than 10~15 m, the desorption gas emission rate of the lower protected seams can reach over 80% (SACMS, 2006). If a large amount of gas of the lower protected seams flows into the working faces of the protective seams, it will cause a great security risk, or even cause mining to be stopped. So during close range exploitation of the upper protective seams, effective face ventilation ways and related extraction measures must be selected. Using negative pressure of ventilation and extraction could change the gas migration direction, and ensure safe mining of the protective seams.

Positive effects of Y-ventilation on the safe mining of the close range upper protective seams

The Y-ventilation is a "two-intake and one-return" ventilation. The leaking air of the goaf does not flow through the upper corner, gas accumulation in the upper corner can be eliminated completely, and then the gas overflow problem can be solved. In addition, there are two inlet air tunnels for the Y-ventilation, and the total air quantity is more than that of U-ventilation. With the same gas concentration, the gas emission capacity is higher than that of U-ventilation. In summary, the Y-ventilation is more suitable for the working face of the close range upper protective seams than is U-ventilation.

Effect of gas extraction on the relief gas migration direction

To ensure safety of the working faces of the protective seams and reduce the gas contents of the protected seams, boreholes must be drilled to form a new free space for rapid desorption and flow of gas. Through sunction of the boreholes, the flow direction of relief gas of the protected seams can be changed. Under normal circumstances, the technique of grid-type penetrating boreholes from the floor roadway is used to extract the relief gas in the lower protected seam, as shown in Figure 4. First the floor roadway needs to be constructed under the protected seam along the strike, and then a set of equally spaced boreholes are made at regular intervals in the roadway. Each set shows a fan-shaped arrangement of boreholes that should cross the protected seams, with hole diameters not less than 90 mm.

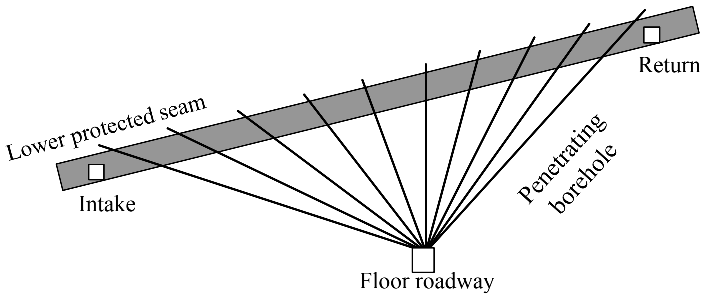

Figure 4 - Layout inclination diagram of the grid-type penetrating borehole in floor roadway

The negative pressure of the penetrating borehole causes the relief gas of the protected seams to flow into the boreholes along the bedding fractures; however, it can flow into the goaf of the protective seams along the penetrating fracture. The gas flow direction is determined by the frictional drag formed by gas flow in the cracks and the negative pressure of the borehole extraction. The permissible negative pressure range of the free space (protective seam goaf and the boreholes) changes little, so the flow direction is mainly determined by the frictional drag (Wang, *et al.*, 2010).

To control the relief gas of the protected seams flowing to the boreholes, valid borehole spacing must be selected to reduce the frictional drag in the fracture and improve the sealing quality of the boreholes, thus a certain negative pressure extraction capacity within the holes can be gained. The gas flow with the best extraction effect is shown in Figure 5. Most of the protected seam gas is extracted from the boreholes. According to the theoretical analysis and field test results, in close range upper protective seam mining process, the borehole spacing should be less than or equal to the layer spacing. The layer spacing of the test was 12 m, and for the sake of reliablity, the grid-type penetrating borehole spacing was designed for 10 m.

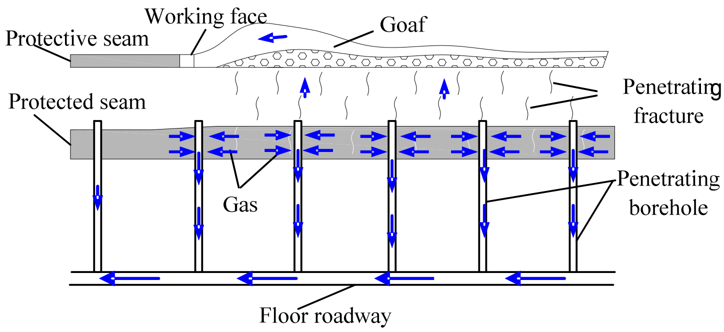

Figure 5 - Extraction effect for relief gas by penetrating borehole

When the seam spacing is smaller and the gas reserve is larger within the protected seams, some gas will flow into the protective seam goaf. If there is a large amount of gas influx and it has an impact on the mining safety of the protective seam, a high level drainage roadway needs to be used for gas extraction. In the mining process of the protective seam working of face 62114, besides the grid-type penetrating boreholes, a high level drainage roadway was used for gas extraction.

EFFECT ANALYSIS

Ventilation and gas extraction of the protective seam working faces

During mining of the protective seam working face 6214, proper gas extraction measures were taken to ensure working face safety. The amount of air distribution to the working face was about 1500 m^3/min, gas concentration below 0.6%, and the gas emission by ventilation 4-9 m^3/min.

In the protective layer mining period, a total gas extraction was 21 520 000 m^3. Three-quarters of the total gas extraction occurred by penetrating boreholes in floor roadway, by high level drainage roadway and by ventilation. The remainer one quarter was removed by other means. According to the analysis of the results, the relief gas extraction rate of the protected seams in protection range should reach 77.5%, the gas pressure of the protected seams reduces from 4.6 MPa to 0.34 MPa, and the gas content from 14.9 m^3/t to 3.3 m^3/t. This level of reduction in the gas should completely eliminate outbursts of the protective seams.

Outburst elimination verification in drivage face of lower protected layers

In protection range the gate road excavation work was carried out safely. From the field records, the maximum weight of drilling cuttings "*S*" was 3.2 kg/m, the maximum cuttings desorption index K_1 was 0.28 ml/g·$min^{1/2}$. These values were far less than their outburst critical values. The gas concentrations of the drivage face were all less than 0.3%. The above three indicators can fully show that the gas content and pressure of the coal seam C13 had a significant decline through the mining of the coal seam C14 and corresponding gas extraction, which completely eliminated outbursts of the coal seam.

CONCLUSIONS

1) The lower limit of the floor heave fracture zone was 15~25 m below the goaf. The penetrating fractures connected the coal seams within the fracture zone and the goaf, and the gas of the protected layer in the zone had the tendency to flow into the protective seams.

2) In the process of close range upper protective seam mining. Gas control measures with a combination of extraction and emission ias necessary. The borehole spacing for relief gas extraction of the lower protected seams should be less than or equal to the seam spacing. If necessary, the roof high level drainage roadway extraction can be used.

3) Through the close range upper protective seam mining and protected seam extraction, the relief gas extraction and emission rate of the protected seams in protection range reaches 77.5%, the gas pressure reduces from 4.6 MPa to 0.34 MPa, and the gas content from 14.9 m^3/t to 3.3 m^3/t. This reduces the coal seam gas content, and completely eliminates outbursts of the protected seam C13.

ACKNOWLEDGEMENTS

The authors are grateful to the National Foundation for the Youth of China (No.50904068 and No.51004106) and National Basic Research Program of China (973 Program, No. 2011CB201204).

REFERENCES

Cheng, Y P, Fu, J H and Yu, Q X, 2009. Development of gas extraction technology in coal mines of China, *Journal of China University of Mining and Technology*, 26(2), pp 127-139.

Cheng, Y P and Yu, Q X, 2003. Application of safe and high-efficient exploitation system of coal and gas in coal seams, *Journal of China University of Mining and Technology*, 32(5), pp 471-475.

Cheng, Y P and Yu, Q X, 2007. Development of regional gas control technology for Chinese coal mines, *Journal of Mining and Safety Engineering*, 24(4), pp 383-390.

Qian, M G and Liu, T C, 1984. *Mine Ground Pressure and Its Control*. China coal industry press: Beijing.

State Administration of Coal Mine Safety, 2006. *Basic Index of Coal Mine Gas Drainage*. China coal industry press: Beijing.

State Administration of Coal Mine Safety, 2007. *Safety Regulations in Coal Mine*. China coal industry press: Beijing.

State Administration of Coal Mine Safety, 2009. *Technical Criterion of Protective Coal Seam Exploitation*. China coal industry press: Beijing.

Wang, H F, Cheng, Y P, Wu, D M and Liu, H Y, 2010. Gas emission and parameter optimization of gas extraction in mining face of short distance protective seam, J*ournal of coal science and Technology*, 35(4), pp 590-594.

Yu, Q X, 1992. *Gas Control in Coal Mine*. China University of Mining and Technology press: Xuzhou.

Zhao, G and Liao, B C, 2007. Current status and prospect of CMM development and utilization in huainan coal mining area, *China Coalbed Methane*, 4(4), pp 12-15.