Study on the co-mining mode of coal and gas in protective layer of coal seam group

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Abstract. In view of the occurrence conditions of coal seam groups in most mining areas in China, the protective layer mining mode is mainly adopted to carry out gas treatment in regional coal seam. In this paper, based on the pressure relief mining of the protective layer, the principle, type and geological conditions of the co-mining mode of the protective layer coal and gas under the condition of coal seam group are analyzed.

1. Introduction

Most mining areas in China have the mining conditions of coal seam groups [1]. In order to reduce the gas pressure and content of the adjacent high gas and outburst coal seam or to eliminate the outburst danger of the adjacent coal seam, the coal seam or rock stratum first mined becomes the protective layer. The protective layer above the high-gas outburst coal seam is called the upper protective layer, and the lower protective layer is called the lower protective layer. Due to the mining operation of the protective layer and the simultaneous extraction of the pressure relief gas, the outburst danger area of the adjacent high-gas and outburst dangerous coal seam can be transformed into low-gas coal seam or no outburst danger area, and the high-gas or outburst coal seam is called the protected layer[2].

Under the mining action of the first coal seam, the adjacent coal seam shows obvious pressure relief characteristics on the macro level, and on the micro level, it will cause the decrease of in-situ stress, movement deformation, fracture development and increase of permeability coefficient of the adjacent coal seam. In general, the adjacent coal seam is the main coal seam of the mine, and its gas occurrence is abundant and gas disaster is serious. Especially when it is far away from the first coal seam, it is necessary to carry out gas extraction under the pressure relief state, that is, carry out pre-mining extraction of the adjacent coal seam to reduce the gas pressure and gas content of the adjacent coal seam. On the one hand, it can improve the safe mining degree of the working face of the first coal seam. On the other hand, it can completely eliminate the outburst risk of adjacent main mining seam and create conditions for safe mining of main mining seam[3].

On August 1, 2009 promulgated the regulation on prevention and cure of coal and gas outburst and promulgated on October 1, 2019 implementation of the prevention and cure of coal and gas outburst rules are put forward in the outburst prevention work adhere to the "leading regional outburst prevention measures, local outburst prevention measures complement" principle, and clearly put forward regional...
outburst prevention measures shall give priority to adopt protective layer mining technology, thus protective layer mining technology in the outburst prevention work.

Based on the pressure relief mining of the protective layer, the paper analyzes the principle, type and geological conditions of the co-mining mode of the protective layer coal and gas under the condition of coal seam group.

2. Pressure relief principle of protective layer mining

After the mining of the protective layer, the surrounding coal strata move towards the goaf, the rock mass above the goaf falls down and forms natural caving arch, and the rock mass above and below the goaf expands towards the goaf and forms cracks, resulting in changes of stress, permeability, gas pressure and displacement of the coal and rock mass above and below the goaf[4]. The details are shown in Fig.1 and Fig.2.

![Fig.1 Gas parameters change during the mining process of the protective layer](image1)

![Fig.2 Schematic diagram of the distribution of stress and deformation within the mining influence range of the protective layer](image2)
1-Surface subsidence curve; 2-Abutment pressure curve; 3- Normal rock deformation curve along the plane; 4-Caving zone; I - Fully exploit the pressure relief zone; II、II ′- Support relief zone; III、III ′-Abutment pressure concentration area; IV、IV ′-Floor compression zone; V、V ′-Floor uneven uplift area; VI-Uniform uplift of floor; IJCKL-Mining area, EFGH- Full pressure relief zone; ABCD- Unloading area

In the pressure relief zone delineated by the pressure relief Angle of the rock, the ground stress decreases, and the vertical direction of the coal seam presents expansion deformation. In the coal stratum, not only new cracks are generated, the original cracks will also open and expand, making the coal seam permeability increase by tens to hundreds of times. As the strata between the protective layer and the protected layer expand and deform in the vertical layer after unloading, some strata in the parallel layer contract and deform, leading to the communication of fractures in the original rock layer and providing a channel for the flow of the desorption gas to the goaf. The pressure relief of the protective layer improves the gas discharge capacity, and the continuous emission of gas causes the gas pressure to drop and the mechanical strength of coal to increase. Pressure relief is the basis of other factors and plays a decisive role.

In general, 90% of the gas in the protected layer still remains in the coal seam and has not been released after the remote protective layer is mined. If the gas in the protected layer is not extracted at the same time, it may not be enough to eliminate the outburst risk of the protected layer. Especially in the case of large interval between layers and hard rock in the middle, natural gas discharge is difficult, pressure relief effect is not obvious, should cooperate with gas extraction; Although there is no problem that is not enough to eliminate the prominent danger in the process of close distance protective layer mining, if not extracted, a large amount of gas from the protected layer will flood into the protective layer working face, which will also pose a major safety hazard.

Protective layer according to the occurrence conditions, the use of protective layer pressure, the role in the formation of the stress reducing area and layout of the fracture zone gas extraction project, to be protective gas extraction, cause the protective gas extraction, outburst dangerous disappear, realize the gas in the condition of low gas safe and efficient mining of coal seam, at the same time to realize the coordinated development of coal and gas and mining.

3. Protection layer selection principle
There are many kinds of classification methods for the protective layer. According to the different positions of the protective layer, it can be divided into three mining methods: upper protective layer, middle protective layer and lower protective layer from the perspective of gas prevention and control. At the same time, according to the different vertical distance h between the protective layer and the protected outburst coal seam, it can be divided into short distance, medium distance and long distance protective layer (short distance protective layer h ≤10m, medium distance protective layer 10m < h < 50m, and long distance protective layer h ≥50m).

When choosing coating, coating should be preferred, no conditions, also can choose under cover, but under the mining protective layer, may damage the protective layer mining conditions, namely the cover layer is generally located in the protective layer formed after mining fissure zone and bending subsidence zone, caving zone can not be located in the protective layer formed after mining.

When the protective layer is mined in close proximity, the thickness of interlayer rock is small. If a large amount of gas is not pumped, it will flood into the working face of the protective layer and threaten production safety. When the protective layer is mined at a distance, only the protective layer is loosened to relieve pressure. If the gas is not extracted at the same time, may not be enough to eliminate the danger of outburst of the protective layer. Therefore, it is necessary to adopt the prevention and control measures of mining the protective layer and extracting the pressure relief gas at the same time when the coal seam group is outburst mining. The concrete principle is to choose the non-outburst dangerous coal seam as the protective layer. When several coal seams in the coal seam group can be used as protective layer, the coal seam with the best protective effect should be exploited first. When all coal seams in the
mine are in danger of outburst, the coal seam with less outburst danger can be selected as the protective layer. If the dangerous and serious coal seam is highlighted and the recoverable coal seam can not be mined as a protective layer, the adjacent unamiable thin coal seam or rock strata can be selected as a protective layer for mining[4].

4. Classification of patterns

4.1. Classification
Coal and gas co-mining, that is, coal mining and gas treatment to achieve three synchronization: synchronous planning, synchronous design, synchronous mining; Gas control and production organization should be considered as a whole, and the process management should be synchronized, so as to realize the safe and efficient mining of high gas seam in low gas state. At the same time, the gas is treated as clean energy and high quality chemical raw material to achieve the maximization of extraction and utilization. The essence of coal and gas co-mining is the pressure relief mining of the protective layer and the supporting gas control mode, which is mainly applicable to the occurrence of coal seam groups and the mining conditions of the protective layer, and can be used to prevent and control outburst in a large area continuously and regionally, and can also be applied to local outburst prevention measures.

It is required that all protective layers above 0.5m must be mined, and all outburst coal seams with protective layer mining conditions must be first mined to relieve pressure and eliminate outburst. It is necessary to exhaust all the gas and put forth great efforts to carry out gas treatment measures by means of drilling[4].

According to different protective layer and protective layer vertical distance from the roadway layout, mining sequence and the perspective of extraction method, based on the basic principle of protective layer mining will open coal mining with gas protection layer mode for the next segment on the protective layer mining unloading extraction mode, protective layer mining unloading extraction model, intermediate key stratum mining unloading extraction models three child.

From the perspective of preventing the influence of mining, the top-down sequential mining (upper protective layer mining) is a more scientific mining method. The mining and extraction mode of the upper protective layer is to solve the problems of the large amount of gas gushing from the working face of the protective layer and the outburst elimination of the underlying protective layer, which mainly includes two ways of extracting the pressure gas from the protected layer, namely, up-hole drilling through the layer in the form of floor roadway network and borehole drilling without coal column along the roadway[6].

The mining pressure relief and extraction mode of the lower protective layer is to solve the problems of gas emission from the working face of the protective layer and the pressure relief and extraction of the protected layer when the mining method of the lower protective layer is adopted in the occurrence condition of the coal seam group[7]. Be protective layer pressure relief gas extraction is the use of protective layer mining on the cover to protect coal seams under the pressure, the effect caused by the construction and use have been completed by protective layer bottom lane construction grid extraction from drilling method (protective layer mining roadway under extraction), ground extraction from mining Wells, large diameter directional borehole extraction, extraction from the high pumping, roof to high drilling extraction way one or multiple joint extraction was protective layer of pressure relief gas, so as to achieve the purpose of protective layer prominent risk elimination.

For three layers and three layers above the coal seam occurrence condition, as shown in Fig.3, in the middle of the first mining key protective layer (2) of coal seam, the protection of 1, under the protection of coal seam 3, 4, 5 coal seam, the key protective face USES "six lane", namely, return air lane, transportation lane, 2 coal floor lane 2, 2 high coal seam drainage, 5 coal floor lane, achieve "a knife to the middle, up and down all liberation", namely the initial mining the middle layer gas control mode. After completion of the key layer 2 coal seam mining, the protective layer mining sequence can be as follows: first of all key protection layer at the top of the 1 coal seam mining, and then according to the distance with the key protective order, from small to large key protective layer 2 coal seam at the bottom
of the coal bed mining, for example: after mining 1 coal seam, and then in turn mining no. 3, 4, 5 coal seams; The mining sequence of the protected layer can also be as follows: mining the coal seam below the key protective layer in the order of the distance from the key protective layer from small to large, and then mining the coal seam above the key protective layer. The mining sequence of the protected layer can be varied, following the principle that at least one layer above and below the protected layer adjacent to the coal seam is already mined. In this way, in the process of mining the protected layer, the mined coal seam and each roadway and borehole can be used to extract gas, and can also be used to transport the equipment needed for mining, the coal has been produced, so as to fully ensure the safety of coal production, can also improve the utilization rate of the roadway.

Fig.3 Gas management model of first mining intermediate layer

In this paper, the supporting technology of the three seed models of the protective layer coal and gas co-mining model is not fixed in one seed model, and can be applied in other sub-models. At the same time, for the protective layer of the first mining face where the coal seam is protruding, gas control is the priority among priorities. The tunneling face mainly adopts the construction roof and floor gas drainage roadway to drill through the layer, and the pressure relief and anti-permeability technology can be used to realize effective outburst prevention and efficient gas extraction. Coal mining working face with the major mining area in front of the bedding borehole extraction technology and high extraction from the extraction technology of mining, roof to borehole extraction technology, the old man buried tube extraction technology of goaf gas extraction, extraction from the high extraction technology in recent years, the trend of the roof borehole extraction technology by high directional drilling (in conde lane) gradually replaced extraction technology.

4.2. Patterns features
The gas treatment mode based on pressure relief mining of protective layer has the advantages of regional treatment and continuous mining.

The pressure relief effect of protective layer mining on the protected layer is very uniform, which is a basic guarantee measure to ensure the long-term stability of coal enterprises.

In the mining process of the protective layer, the technology of protecting the roadway without coal pillar is adopted to realize the large-scale continuous mining of the protective layer working face, and the driving along the goaf retaining roadway and the comprehensive mining working face are carried out simultaneously, which eliminates the safety impact of coal pillar on the outburst coal seam, and solves the problem of the increase of the regional ground stress of the reserved coal pillar, which is not conducive to the reduction of the outburst risk.
5. Applicable geological conditions

Protective layer mining is an effective way of regional large-scale outburst control, which is suitable for outburst mining coal seam group conditions. According to different coal seam gas conditions, different mining methods can be adopted.

When the coal seam group exists in the outburst mine and there is no outburst dangerous coal seam with thickness of 0.5m or more in the effective protection vertical distance, in addition to the situation that the outburst coal seam is too close to threaten the safety of the working face of the protective layer or may damage the outburst coal seam mining, the protective layer must be mined first and the protected outburst coal seam must be extracted at the same time. This article is "prevention and control of coal and gas outburst fine". The content of the compulsory provisions of the regulations.

In principle, the coal seam with less outburst risk is selected as the protective layer when there are existing conditions of coal seam group in the mine and all coal seams have outburst risk. However, before mining, the protective layer needs to take measures to prevent outburst in the area of pre drainage coal seam gas and test the effect.

6. Conclusion

This paper systematically summarizes and analyzes the gas control mode of protective layer mining coal and gas CO mining under the condition of coal seam group occurrence, mainly including the mining principle of protective layer, the selection principle of first mining protective layer, mode classification and applicable geological conditions, which has guiding significance for the safe mining of coal seams with the condition of coal seam group occurrence.

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