Application of Pre-extraction Drilling in Anti-burst of Low Permeability Coal Seam

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Abstract. In order to eliminate the outburst danger of coal seam with low gas permeability and consider the economic cost of anti-burst measures, the gas pre-extraction coal seam gas prevention technology in the coal roadway excavation process is studied to relieve the coal seam pressure and gas content. The pressure is reduced, and the gas content of the coal body is reduced to 8m³/t within the allowable excavation range. The maximum gas cuttings Smax of the gas is reduced to less than 6kg/m after the anti-burst effect test, which effectively eliminates the prominent danger of the coal seam. During the implementation of the regional anti-burst measures, it can assist the gas release from the gas release, reduce the gas content of the coal seam, release the gas potential of the coal body, and strictly implement the regional defense according to the requirements of the two “four-in-one” anti-burst measures. The comprehensive anti-burst measures supplemented by the sudden measures and the local anti-burst measures eliminate the prominent danger of the coal seam and ensure the safe excavation of the coal roadway.

1. Introduction

In the process of coal mining, with the longitudinal extension of mining and the increase of mining intensity, the gas content and ground stress of coal seams increase, and the outstanding risk increases, which poses a serious threat to the safe production of mines. Therefore, it is economically applicable. The anti-burst measures are particularly important for ensuring mine safety production. The local anti-burst measures such as the original gas release hole and the shallow hole loose blast hole can not effectively solve the anti-burst problem [1-2], and the implementation cost of the pre-extracted coal seam gas in the large-area tunnel of the floor rock is too high. According to years of field practice experience, regional gas drainage measures can more effectively eliminate the outburst and prevent sudden out, local anti-burst measures can be supplemented to implement [3]. The 1# and 3# coal seams of the Weijiadi coal mine in Jingyuan Mining Area of Gansu Province have outstanding
dangers, but each coal seam does not have the conditions for mining protective layers. Due to cost control problems, large-area rock penetration drills have not been implemented. Holes, mainly through the coal seam roadway excavation strip pre-drilling holes for coal seam outburst and anti-burst problems. After the effectiveness test of the regional measures is effective, the gas release holes are applied to the local high gas area to supplement, so that the risk of protruding the low gas permeability protruding coal seam is greatly reduced until the sudden elimination, effectively ensuring the safe production of the mine.

2. Test area overview

2.1. Overview of the work surface

The upper part of 1302 is the 2102 fully mechanized caving face with the end of mining, the F3 fault in the northwest, the Shimen protection coal pillar in the west of the second mining area in the east, the 2104 fully mechanized mining face in the southwest, and the original three in the south and northeast. The coal seam is 0.8m recoverable boundary of the third coal seam in the west. The working face is 932m long, with a width of 168m, an area of 156,576m², industrial reserves of 908,000 tons, and recoverable reserves of 772,000 tons. The working face elevation is 1170m~1100m, corresponding to the ground elevation of 1598~1608m; The coal dust is explosive and the explosion index is 31.64%; the coal seam has a tendency to spontaneous combustion, and the spontaneous combustion period is 4-6 months.

2.2. Work area highlights risk area division

According to Article 48 of the Regulations on Prevention of Coal and Gas Outburst, the maximum protection distance of the protective layer on the gently inclined and inclined coal seam is not more than 50m, the dip angle of the coal seam of the 1302 working face is $\alpha=10^\circ$, and the spacing of the 1# and 3# coal seams is taken as the upper protective layer measure, and the 1112 goaf can play a certain protective role on the coal seam of the 1302 working face. Take the protective layer toward the relief angle $\delta_5=56^\circ$, the upper boundary safety relief angle $\delta_4=75^\circ$, and the lower boundary safety relief angle $\delta_3=75^\circ$. Calculate the three coal seams in the plane to be protected relative to the 1112 goaf.

Towards the offset:

$$L = \frac{H}{\tan\delta_5} = \frac{31}{\tan 56^\circ} = 20.9$$  \(1\)

Tend to the upper boundary offset:

$$L_1 = H \times (\text{ctg}\delta_4 - \tan\alpha) \times \cos\alpha$$
$$= 31 \times (\text{ctg} 75^\circ - \tan 10^\circ) \times \cos 10^\circ$$
$$= 2.8 \text{m}$$  \(2\)

The tendency to lower the boundary offset:
\[ L = H \times (\text{ctg} \delta_{3} + \text{tg} \alpha) \times \cos \alpha \]
\[ = 31 \times (\text{ctg} 75^\circ + \text{tg} 10^\circ) \times \cos 10^\circ \]
\[ = 13.6 \text{m} \]  

(3)

Compared with the plane position of the 1112 mined-out area, the 1302 working face is 43m in the outer section of the return airway, which is 57m away from the 1112 protection range. The difference is 11m (43m+14m) from the 1112 protection zone. ~ 153m, that is, the distance from the 1112 protection range is 167m (153m+14m); the back section of the return wind lane and the 1302 eye are in the original coal seam. Therefore, the 1302 return air duct and the cut-eye are in the prominent dangerous area.

3. Strip zone prevention mechanism

At present, the regional anti-burst measures only have two major categories: mining protective layer and pre-extracted coal seam gas. The mining protective layer is the most effective anti-burst measures. However, the coal seams of the Weijiadi coal mine in Jingyuan Mining Area are 1# and 3# coal seams, which do not have the conditions for mining protective layers. They can only be removed by pre-extracting coal seam gas. Highlight the danger. In the floor rock, the pre-extracted gas in the large area of the tunneling layer is made by the large amount of boreholes in the coal seam in the floor rock to carry out regional pressure relief, releasing the potential of gas. After long time pre-pumping, the gas content of the coal body is reduced and the ground is lowered. Stress, increase coal seam permeability, reduce ground stress and gas pressure gradient, and eliminate coal seam outburst danger [4-7]. However, the Weijiadi Coal Mine in Jingyuan Mining Area has a high cost of pre-extracting coal seams due to the large-area drilling of the underground rock in the construction floor. The method of pre-extracting coal seam gas in the roadway of the coal seam is selected to eliminate the gas. The key factor of gas pre-extraction coal seam gas outburst prevention is the extraction rate, and the gas drainage rate is determined by the coal seam permeability coefficient and drilling construction parameters. By designing large-diameter boreholes, the commonly used diameter is 75-100mm, and a reasonable cloth hole pattern and layout, long-term drainage is carried out to achieve coal seam outburst and anti-burst.

4. Application of anti-burst measures in the area of excavation

4.1. Design and construction of anti-burst drilling in the area of excavation strip

The length of the 1302 return air trough is 980m, and the section of the roadway is semi-circular arch. The anchor net is sprayed and supported, and the section is 4.6m×3.4m. In the process of coal roadway excavation, pre-drilling holes in the excavation strip zone are used to implement the anti-burst measures. The implementation range of the anti-burst in the coal roadway excavation zone: the direction of the strike is 60m, which tends to be 20m in the upper direction and 10m in the lower direction. During the excavation process, a drill field is arranged every 25m, and the drill fields are alternately arranged left and right, as shown in Figure 1. In the drilling field following the working face, the coal seam should be drilled ahead of time to control the drilling site in the area of the coal roadway for gas drainage.

The design parameters of the advanced drilling hole in the coal roadway strip zone are: the diameter of the drill hole is φ94mm, the row spacing between the final holes is 5m, and the final hole is on the sideline and range of the implementation range of the measure. The thickness of the coal seam is calculated according to 5.2m, that is, 7 drill holes are constructed at the opening of the roadway, 4 drill holes are constructed for each upper drill field in the excavation, and 2 drill holes are constructed for each lower drill pit. Always keep the left and right help drilling field measures holes ahead of the working surface is not less than 10m, otherwise it is not allowed to dig.
4.2. Excavation strip pre-drilling drilling effect
The effective length of the pre-drilling hole of the 1302 returning wind tunnel is 11700m, and the accumulated gas is 1.475 million m³, and the gas drainage rate is about 35%. Drilling and sealing holes are tight, the concentration of single gas drainage is above 20%, the negative pressure of extraction is kept above 20kPa, the extraction volume of single drilling is 0.3m³/min, and the gas concentration is kept above 15%.

4.3. Excavation strip pre-drilling hole prevention effect test
In the process of excavation in the 1302 return airway, after the pre-drilling of the coal roadway strip zone is carried out, the test method for the residual gas content of the coal seam and the maximum amount of gas drilled by the Smax anti-burst measures are tested within the allowable excavation range. In the coal roadway excavation strip, a gas content measurement point and a large drill cuttings amount Smax anti-burst effect test test point are arranged at intervals of 5m, and the test test points are staggered in the middle position of the lower hole in the lower trough, into a uniform distribution state, appropriate increase of inspection test points in complex areas of geological structures. The measurement results are shown in Figures 2 and 3.

It can be seen from Fig. 2 that the coal roadway excavation strip pre-drilling gas drainage and anti-burst measures have obvious effects. The residual gas content of all 10 test points is less than 8m³/t, which has been reduced to the critical risk index. It can be seen from Fig. 3 that within the allowable tunneling range after the strip pre-drilling gas drainage, the maximum amount of gas cuttings Smax is within 6kg/m, reflecting that the mechanical strength and ground stress of the coal body are reduced.
The gas pressure is reduced and the outstanding risk is reduced. At the same time as the pre-drilling of the excavation strip, the gas release hole is implemented at the head, the pressure is released, the gas potential is released, the gas pressure of the coal body is reduced, and the coal body is eliminated by the supplement of the local anti-burst measures.

5. Conclusion

(1) The pre-extraction and anti-burst technology of coal roadway excavation technology reduces the gas potential of coal seam, reduces the gas content and gas pressure gradient and greatly increases the drainage rate, effectively eliminating the prominent danger of coal seam.

(2) Under the conditions of regional anti-burst measures, the local anti-burst measures of gas release drilling are simultaneously supplemented, so that the coal body is partially relieved, the gas potential is further released, the gas content is reduced, and the coal seam gas outburst is further reduced.

(3) The pre-extraction and anti-burst technology of coal roadway excavation belt has low construction cost and good gas drainage effect, which can effectively eliminate the danger of coal and gas outburst, improve the excavation speed, and realize the production balance of mine pumping, excavation and mining.

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