Research on Evaluation and Prevention of Impact Risk of Hard and Thick Coal Seam

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Abstract: In order to prevent and control the rockburst of the hard and thick coal seam in 22 panels, the laboratory tested the impact propensity of coal seams and roof rock layers. It used the comprehensive index method and microseismic monitoring to evaluate the risk of medium rock burst 3# coal seam in 22 panels. Anti-scouring countermeasures are proposed, including regional anti-scouring, local anti-scouring, danger zone relief, anti-scouring effect inspection and safety protection, etc., which provide reference for mines with similar conditions.

1. Introduction

According to the statistical analysis of a large number of rock-bursting mines in China, the coal seam with impact risk usually has a thick and hard roof rock layer. From the point of view of the mechanism of occurrence, the thick hard roof is easier to store elastic energy, which creates energy conditions for the occurrence of rockburst. Especially under the joint influence of huge thick hard roof and faults, rockburst disasters are often characterized by strong destructiveness, frequent occurrence, suddenness and severity. Once it occurs, it will directly cause significant economic losses and casualties. Therefore, many experts and scholars have begun to carry out a lot of research work on fault rockburst, and have obtained many research results [1~5], but it needs further study on the hard thick coal seam anti-scouring. Therefore, this paper focuses on the study of impact risk assessment and prevention measures under the conditions of hard roofs in huge thick coal seams, which has far-reaching significance for the prevention of rock burst.

2. Research plan

2.1. Overview of the test area

Cuimu Minefield is located in the Beiwan-Sun Temple Temple exploration area at the east end of Linyou District in Yonglong mining area. The 3# coal seam is located in the middle of the lower coal-bearing section of the Yan'an Formation, with a burial depth of 314.42~777.03m. The thickness of the coal seam is 0.35~34.20m, the average coal thickness is 16.89m, and the maximum recoverable thickness is 32.55m.

The test area is 22 panels, with an average coal thickness of 12.52m. The roof of 3# coal seam is mostly siltstone and fine-medium grain sandstone with a maximum thickness of 12.76m. The bottom plate is gray-brown aluminum-bearing mudstone or aluminum-bearing powder-fine sandstone, with a...
thickness of 0.2~18.3m.

2.2. Research plan
First, it tests the impact tendency of coal and rock samples in 22 panels. The coal seam mainly tests four indexes, such as dynamic failure time $D_T$, elastic energy index $W_{ET}$, impact energy index $K_E$ and uniaxial compressive strength $R_c$. The rock layer mainly tests the block density, uniaxial tensile strength and elastic modulus, and calculates the bending energy index $U_{WQ}$. Then, according to mining technology factors and geological factors, it used comprehensive index method and microseismic monitoring to comprehensively evaluate the impact risk of 22 panels, and put forward targeted countermeasures against erosion.

3. Impact propensity test
According to the specification, it tests impact tendency of the 3# coal seam coal sample and roof rock sample in the 22 panel of Cuimu Coal Mine. The test results of 3# Coal seam impact tendency identification, one samples is strong, the other is weak. The 3# Coal Seam Roof Rock Impact Tendency Appraisal Results is weak.

So it can be seen that 22 panel 3# coal seam has a strong impact tendency and 22 panel 3# coal seam roof rock layer has a weak impact tendency.

4. Impact risk assessment

4.1. Comprehensive index method evaluation
The comprehensive index method is to analyze the occurrence of rockburst, and to separate the corresponding mining technology and geological conditions on the impact of rockburst. On this basis, it determine the influence weights of various factors, and then combine them to establish a comprehensive index method for risk assessment of rock burst.

Assessment index of dangerous state of rockburst impacted by geological factors of working face $W_{t1}$:

$$W_{t1} = \frac{\sum_{i=1}^{n_t} W_i}{\sum_{i=1}^{n_t} W_{i_{\text{max}}}}$$

The geological factors mainly include seven factors, which are the history of occurrence of rockburst at the same level (number of times), mining depth, the distance of the hard and thick rock layer in the overlying fissure zone from the coal layer, the characteristic parameters of the thickness of the roof rock layer within 100 m above the coal layer, the ratio of the stress increment caused by the structure in the mining area to the normal stress value, uniaxial compressive strength of coal and elastic energy index of coal.

In the formula: $W_{t1}$—burst pressure risk index determined by geological factors; $W_i$—$i$-th geological factor evaluation index; $W_{\text{imax}}$—the maximum index of the $i$-th geological factor; $n_t$—The number of geological factors.

Evaluation index $W_{t2}$ of the dangerous state of rockburst affected by mining face technical factors.

$$W_{t2} = \frac{\sum_{i=1}^{n_t} W_i}{\sum_{i=1}^{n_t} W_{i_{\text{max}}}}$$
In the formula: $W_{t2}$—burst pressure risk index determined by mining technology factors; $W_i$—Ith evaluation index of mining technology factors; $W_{imax}$—the maximum index of the i-th mining technology factor; $n_2$—Number of mining technical factors.

The mining technology factors include six factors, which are the relationship between the working face and the adjacent goaf, the length of the working face, the width of the coal pillars, the thickness of the bottom coal, the distance between the stop line and the goaf, the distance from the working face or head to the fault. The evaluation results are shown in Table 1.

| Influencing factors          | Evaluation index($W_{t1}, W_{t2}$) | Comprehensive Evaluation Index/($W_{t1}, W_{t2}$)$_{max}$ | Shock hazard level          |
|-----------------------------|-------------------------------------|-------------------------------------------------------|----------------------------|
| Geological factors          | 0.57                                | 0.67                                                  | Moderate impact hazard     |
| Mining technical factors    | 0.67                                |                                                       |                            |

The evaluation showed that the impact risk index of the 22-face mining face was 0.67, and the risk status of rockburst was rated as medium impact risk.

4.2. Microseismic monitoring and evaluation

Through statistics of the microseismic monitoring data during the roadway excavation and working face mining of Cuimu coal mine, there are more than 10 driving roadways and four working faces. The number of vibrations of roadway excavation and working face mining in Cuimu coal mine are 23885 and 2582 respectively.

It is that the impact danger of roadway excavation and working face mining is relatively large, with weak impact to medium impact accounting for 47.48% and 44.85%, respectively, and the accuracy of the experimental results is also verified.

5. Countermeasure

5.1. Regional anti-scouring measures

5.1.1. Pre-injection of coal seam.

Before mining, according to the monitoring of impact hazards, coal seam injection can also be selected outside the range of 100 m in front of the leading working face. The water injection holes are arranged in the two along the working face of the working face or the solid coal gang of the driving tunnel (the coal pillars in the goaf and the near side of the fault are not hit). Make adjustments, staggered from the large-diameter pressure relief drilling. The number of drill holes is determined according to the thickness of the coal seam. The drill holes are constructed parallel to the inclined direction of the coal seam. The diameter of the drill holes is 45 to 90 mm.

5.1.2. Roof pre-splitting blasting.

For the hard roof, the roof blasting pre-cracking measures are taken to cut off the roof to reduce the period of the old roof of the working face to press the step and the intensity of the roof activity, thereby reducing the stress concentration and impact risk of the coal body. The blasting is carried out in the machine roadway and the measure roadway of the working face. A group of blasting holes is constructed every 20m, arranged in a single row. Each roadway is generally arranged with 3 holes, the hole diameter is generally 94mm, and the hole depth is half of the thickness of the suspended ceiling. The layout is as shown in Figure 1.
Figure 1. Schematic diagram of roof pre-splitting blasting

The sealing length must be based on the premise of passing coal, and the sealing length and the amount of charge should be controlled according to the actual hole depth on site. The charge is artificially charged, and the blasting is initiated once, and safety protection measures must be established during blasting. Each group of holes adopts series electric explosion network. The detonator is detonated with a segmented millisecond detonator, the detonator detonates the explosive, the detonation method is forward detonation, and the explosive is coal mine safety water glue explosive.

5.2. Local anti-collision measures

5.2.1. Pressure relief of large-diameter boreholes in coal.
On the basis of the monitoring of the impacting dangerous area in the driving face, on the basis of the pre-drilled pressure drilling, the solid coal gang in the dangerous area and the roadway near the dangerous area is supplemented with pressure relief drilling and pressure relief to further weaken the coal and release the coal Elasticity. The hole spacing of large-diameter boreholes is determined according to the danger zone and coal seam thickness, and controlled a certain range outside the contour of the tunnel. The diameter of the borehole is generally 133mm. After using large-diameter boreholes for pressure relief, the danger zone is again tested for impact hazards using drill cuttings, etc. If the hazards continue to exist, further measures should be taken to eliminate them.

5.2.2. Pressure relief blasting of coal body.
When measures such as large-diameter coal borehole pressure relief have been adopted for the excavation face, and the face is still at risk of impact, drill holes can be made between the original pressure relief holes for blast pressure relief. Pressure relief blasting is implemented in the flume, and pressure relief blasting is performed on the solid coal gang. After blasting, it also use the drill cuttings method to check the pressure relief effect to determine the dangerous state of impact. If there is still a risk of rockburst in the pressure relief blasting range, further measures are taken until the risk of rockburst is removed.

5.3. Relieve the impact danger zone
During the mining process of the working face, after pre-pressure relief measures are taken, if there is still a risk of impact, it must be taken measures to eliminate the danger. Pressure relief is mainly used for large-diameter coal drilling, coal pressure relief blasting, coal seam water injection and roof pre-splitting blasting. It is preferred to use large-diameter coal bore holes for pressure relief. If the effect is not good, other pressure relief measures can be further adopted.

5.4. Inspection of anti-shock effect
After implementing anti-scouring measures, the effect test is carried out by the drill cuttings method and microseismic method. It is judged whether the impact danger is eliminated by comparing the
amount of drill cuttings before and after the measure, the microseismic situation, and so on. If the danger still exists, continue to use anti-shock measures, and then check the effect until the danger is lifted.

5.5. Safety protection against rock burst
It must take special personal protective measures, when persons entering dangerous areas with severe impacts. Support must be strengthened for the roadway in the dangerous area of rock burst. Measures to prevent bottom drums must be taken in case of severe impact on the dangerous area. An excavation face at risk of rockburst must be equipped with a self-rescue system of wind pressure, and a disaster avoidance route should be specified when a rockburst occurs.

6. Conclusion
Laboratory tests show that 3# coal seam has a strong impact tendency in 22 panels, and roof rock laye of 3# coal seam has a weak impact tendency in 22 panels.

It used the comprehensive index method and microseismic monitoring to evaluate the risk of medium rock burst 3# coal seam in 22 panels.

Aiming at the impact risk of 22 panels, anti-scouring countermeasures were proposed, including anti-scouring of coal seam water injection and roof rupture blasting area, coal large-diameter borehole pressure relief and coal pressure relief blasting local erosion control, danger zone relief Impact test, safety protection, etc.

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