Research on mining of medium thick coal seam under pedal condition based on fuzzy evaluation

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Abstract. In a coal mine, the 15# coal seam is first exploited, and the 6# coal above the 15# coal is not exploited, so the 6# coal seam above the 15# coal belongs to the kicking mining. It is necessary to judge the feasibility of the coal seam. On the basis of the analysis of the coal seam occurrence conditions in this mine, the factors affecting the kicking of 6# coal seam are analysed, and the feasibility of the 6# coal bed kicking feasibility is preliminarily judged by using the ratio discrimination method, the "three band" discriminant method, the surrounding rock balance discrimination theory and the mathematical statistics analysis method, and the fuzzy evaluation algorithm is used for the 6# mining. The feasibility of the implementation of coal mining is further demonstrated. The analysis results show that it is feasible to implement comprehensive mechanized coal mining in 6# coal seam.

Keywords: Mining above hollow; Fuzzy evaluation algorithm; Medium and thick coal seam.

1. Introduction

With the development of social economy, coal resources are playing a more and more important role in the development of our country. The progress of mining technology makes some more complicated mining problems can be solved. Some mines raise the upper limit of mining by reducing the retained waterproof pillar, and some of the mines have already finished the better coal seam, leaving some poor coal seam in the upper part of the mine. In order to prolong the service life of the mine, the mine has to go back to the mine. The above Goaf of coal seam, it will face the problem of overhead mining. A lot of experts and scholars at home and abroad have studied the kicking mining [1, 2]. The coal mining sequence of the Bai Jia Zhuang coal mine in Xi shan mining area has successfully exploited the abandoned 6# coal above the 8# coal goaf. Under the current technical conditions, special measures should be taken to promote economic exploitation and reasonable exploitation [3, 4]. Based on the conditions of each coal seam in a mine, this paper makes a theoretical analysis on the safety of the kicking mining in the two-mining area of 6# coal mine, and then makes a reasonable analysis and judgement on the feasibility of the kicking.

2. Project overview

6# coal mining in a coal mine, the average coal thickness is 1.86M, the roof is sandy mudstone or mudstone, the floor is sandy mudstone, it belongs to the large coal seam, and the lower 15# coal in the

lower part of the two-coal mining area of 6# coal is mined by long wall caving method, which has already formed a large range of goaf, resulting in the formation of coal in the upper group. There are 3 drilling holes in the two-mining area of 6# coal, namely ZK301 borehole and D368 borehole GJ01. The distance between 6# coal and 15# coal seam in the two-mining area of 6# coal is about 103.3 ~ 113.3m, with an average of 108.3m. The drilling parameters are detailed in Table 1.

Table 1. List of borehole parameters

Borehole marking	Borehole elevation	6# coal	15# coal
ZK301	1109.748	906.318	797.898
D368	1088.70	921	807.70
GJ01		934.26	831.56

3. Analysis of influence factors of kicking mining

The key factors affecting the mining of the top coal are the mining height, the interval between the lower coal seam and the thickness and nature of the main rocks.

3.1. Mining height

The mining height of the lower coal seam is the fundamental factor that affects the failure degree of the overburden and the height of the caving. The larger the mining height is, the larger the space of mining will be. The smaller the probability of the overburden structure may be balanced, the more serious the overburden will be. 15# coal has a maximum mining height of 3.5m, and it has little threat to the recovery of 6# coal two mining area.

3.2. Coal mining method

The mining method is an important factor that affects the failure height of overburden. The 15# coal in the coal mine is processed by long wall method and the filling method is used to treat the goaf. When the caving method is used to treat the goaf, the overlying strata in the stope usually form "three zones", and when the filling method is used to treat the goaf, it is generally only caused by the cracking of the overlying rock, and the subsidence of the roof is smaller than that of the whole caving method, and the subsidence of the roof varies with the height of the mining.

3.3. Seam interval

Theoretical research and production practice of upward mining of coal seam have proved that enough interval is an important condition for upward mining. The distance between 6# coal and 15# coal seam are from 103.3 to 113.3m, with an average of 108.3m. The larger the interval between the upper and lower coal seam is, the smoother the upper coal seam moves, and the smaller the various deformation values such as tilt and curvature are, the more favorable for upward mining.

3.4. Rock properties and interlayer structure between coal seams

Interlayer rock mechanical properties and interstorey structure affect the failure height of overburden to a certain extent. The roof of 15# coal seam is sandy mudstone and mudstone. The floor is sandy mudstone and mudstone, and individual is siltstone. The filling method is used to deal with the goaf. The overlying strata will easily form a balance structure in the fracture subsidence. The coal seam on the balance structure will sink slowly, which is beneficial to the upper seam mining.

3.5. Dip angle of coal seam

The dip angle of coal seam mainly affects the spatial form of deformation and failure of overlying strata. The dip angle of 15# coal seam is 3~14 degrees, and the gangue in the goaf is accumulated on the ground. Due to the support of coal pillar, the backwardness of the roof will roll along the bottom of the coal seam bottom to the low end of the working face, and underneath the slope to be filled with the

gangue, and the fall is not sufficient, which helps the coal pillar to realize the force state of the coal seam, thus it is beneficial to the kicking of the coal seam in the 6# coal seam.

4. Feasibility determination of kicking mining

Because the problem of kicking mining is very complicated, and it is closely related to the geological conditions, the law of change and the mining technology of the concrete engineering, it must be judged by comprehensive analysis on the basis of detailed analysis of the specific engineering geological conditions. The following uses the "three band" discriminant method, the surrounding rock balance method, the ratio discrimination method, the mathematical statistics analysis method and the mining time interval to carry on the feasibility analysis to the 6# coal two mining area of the coal mine.

4.1. "Three band" discriminant method

The principle of the "three belt" discriminant method is that when the upper coal seam is located in the caving zone caused by the mining of the lower coal seam, the overall structure of the upper coal seam will be seriously damaged, and the coal seam in the upper part of the coal seam is hard to be mined again.

The compressive strength of overlying bedrock in 15# coal seam is 30.4 to 46 Mpa and belongs to medium hard rock. The actual thickness of 15# coal seam is 2.8 to 3.5m, with an average of 3.0m. The height of the upper three bands is calculated as follows:

15# coal seam caving zone and water guide fracture zone formula:

$$H_m = \frac{100M}{4.7M + 19} \pm 2.2 \tag{1}$$

$$H_{li} = 20\sqrt{M} + 10 \tag{2}$$

H_m is the caving zone; H_{li} is the water diversion fracture zone; M is the total thickness of mining.

Therefore, the height of 15# coal caving zone is 6.9 to 11.3m, and the height of water flowing fractured zone is 44.64m. According to drilling parameters, the distance between 6# coal and 15# coal seam is from 103.3 to 113.3m, with an average of 108.3m, within the two-coal mining area of 6# coal.

After 15# coal mining, 6# coal is located above the water flowing fractured zone. That is to say, the coal seam only moves in a whole way, and the integrity is not destroyed, so it can be used for goto mining. According to the "three zones" discriminant method, the result of discrimination is that 15# coal will not affect the mining of upper 6# coal after mining.

4.2. Surrounding rock balance method

A formula for calculating the equilibrium height of surrounding rock for goto mining:

$$H_p = \frac{M}{K - 1} + h_p \tag{3}$$

M for coal seam mining height; K for breaking coefficient, take 1.1; h_p for rock layer thickness.

The necessary balance of rock mass is 71.6m. The spacing between 6# coal seam and 15# coal seam is 103.3~113.3m, with an average of 108.3m, indicating that the mining of lower 15# coal seam has no effect on the upper 6# coal seam.

4.3. Ratio K discriminant method

After 15# coal seam mining, the most basic condition to ensure 6# coal seam safety is to ensure that 6# coal is in the sinkage zone of 15# coal. When the lower part of a coal seam is exploited, the ratio K is used to distinguish it:

$$K=H/M \tag{4}$$

H is the vertical distance between the upper and lower coal seam; M is the mining height and m of the lower coal seam.

The interval between 15# coal and 6# coal is H=103.3 to 113.3m, and the maximum mining height of 15# coal is 3.5m, which is K=29.5 to 32.4. According to the production practice of pedal mining, it is proved that when the ratio K is greater than 7.5, the lower coal seam will not affect the normal production and preparation of the upper coal seam. The calculated results are far greater than 7.5. Therefore, the kicking is feasible.

4.4. Mathematical statistics analysis method

Based on some examples of coal mining in China, the empirical formula for the interval between the top and bottom two layers of coal is obtained:

$$H>1.14M+4.14+Ms \tag{5}$$

M for the lower coal seam height; M_S for the upper coal seam thickness. The maximum height of the lower coal seam is 3.5m and M_S the average is 1.86m. The spacing of the layer must be 10m, while the interval between the 15# coal and the 6# coal is 103.3 to 113.3m, which meets the mining conditions.

4.5. Mining time interval

The upper coal seam mining should be carried out after the strata movement stability caused by the mining of the lower coal seam. According to the practice experience of domestic kicking, it is known that:

$$t=0.1K+3 \tag{6}$$

t is the interval of mining time of upper and lower coal seam; M is the height of the lower coal seam.

According to the condition of coal seam, H=103.3~113.3m, M=3.5m, K=29.5~32.4, the interval between 15# coal and 6# coal is more than 6.24 months.

In fact, the time interval between the exploitation of 15# coal and 6# coal in the coal mine is more than 1 years.

5. Fuzzy evaluation analysis

Weight is the core of the whole fuzzy evaluation, and the data is processed to get the evaluation level. The weight is determined, and the process of quantitatively describing different indicators in multiple indicators is described in the same way. Weight is the weight that indicates the importance of each evaluation index (or evaluation item), indicating the different functions of each evaluation index in the whole. First, determine the evaluation factor U = {U_1, U_2..., Un}, in which U_1 is high, U_2 is layer

spacing, U_3 is coal seam dip, U_4 is coal mining method, U_5 is the rock property and structure of coal seam, n=5; then the evaluation grade Z = {Z_1, Z_2, ... For Z_m}, Z_1 is in accordance with Z_2 and Z_3 is not consistent, m=3. Then the membership function of each evaluation factor corresponding to each evaluation factor is obtained through fuzzy evaluation algorithm, and membership degree is composed of membership matrix:

$$R=\begin{bmatrix} v_1 & w_1 & Q_1 & J_1 & H_1 \\ v_2 & w_2 & Q_2 & J_2 & H_2 \\ v_3 & w_3 & Q_3 & J_3 & H_3 \end{bmatrix} \tag{7}$$

V is the subordinate function of mining height each evaluation grade; W is the subordination function of layer spacing; Q is the subordinate function of coal seam angle; J is the subordinate function of coal mining method; H is the membership function of the rock structure in the coal seam.

Then the weight distribution of each evaluation factor is set up, and the matrix A:

$$A = (a\%\ b\%\ c\%\ d\%\ e\%) \tag{8}$$

The evaluation matrix is obtained based on membership function and weight matrix:

$$B = R^* A^T = \begin{bmatrix} Z_1 \\ Z_2 \\ Z_3 \end{bmatrix} \tag{9}$$

According to the maximum membership degree principle, it is found that the height of the 15# coal seam caving zone is 8.24m, the height of the water guide fissure zone is 50.43m, the distance between the 6# coal and the 15# coal seam is 108.3m, which can be exploited by the kicking.

6. Conclusion

The results show that the maximum height of the overlying rock fracture zone after 15# coal mining in the coal mine is 44.64m, indicating that 6# coal is above the fracture zone; the mining impact multiple (K) value is 29.5~32.4, far greater than that in the mining practice, and the actual time interval between 6# coal and 15# coal is more than 1 years, which is more than the reasonable time interval required by 6.24. Therefore, the two-mining area of 6# coal can be mined.

Based on the fuzzy evaluation algorithm, the weight is determined and according to the maximum membership degree principle, it is concluded that the height of 15# coal seam caving zone is 8.24m, the height of water guide fissure zone is 50.43m, the distance between 6# coal and 15# coal seam is 108.3m, which can be exploited in kicking.

The comprehensive theoretical calculation and analysis can be used to form the 6# coal two mining area from the holistic mining scheme is feasible in theory, it can be normally excavated, can effectively improve the recovery rate of coal resources and prolong the service life of the mine.

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