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Research Article

Assessment of Risk Tendency of Coal Bursting Pressure in Deep Outburst Seam

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In order to analysis the mechanism of coal bursting pressures of deep coal seams and take effective methods to identify, monitor, and control coal bursting pressure, this paper takes 21101 working face of No. 2 coal seam in Dongpang Coal Mine as an example. Risk identification is carried out for the hazardous and harmful factors of coal bursting pressure in coal seam 21101 in Dongpang Coal Mine, and each influencing factor is classified. The hierarchical structure model of the influencing factors of coal bursting pressure in coal seam protruding deep in Dongpang Coal Mine is established in combination with expert opinions, and the weight of each level index is calculated by MATLAB software. The results show that the 21101 working face of No. 2 coal seam in Dongpang Coal Mine has strong impact risk, and the main risk factors include geological structure, impact resistance of coal and rock, mining stress, inducing factors, and emphasis degree of impact risk. According to the results, the corresponding safety measures are put forward to prevent the damage caused by coal bursting pressure in advance and ensure the high quality and safe production in the mine. The qualitative and quantitative methods are used to make the evaluation process more reasonable and scientific. The method could effectively analyze the main factors affecting coal bursting pressure and put forward corresponding safety measures for the main risk factors.

1. Introduction

The mining depth of China's coal mines increases at a speed of 8 m ~10 m per year [1], and some mining depths have even exceeded 1000 m. In recent years, with the increasing mining depth and mining intensity of coal mines in China, the frequency of coal bursting pressure and the harm degree of coal bursting pressure have increased significantly, which has become one of the major disasters that pose a great threat to coal mine safety production [2]. Coal bursting pressure refers to a violent failure of coal, rock, and rock in the shaft or around the working face due to elastic deformation, resulting in the instantaneous release of potential energy. It is often accompanied by the phenomena such as throwing out of coal and rock, air wave, and violent sound. This phenomenon is extremely destructive and has a very wide range of destruction, which is almost complete destruction after its

occurrence [3]. According to the current occurrence of coal bursting pressure accidents, the occurrence of coal bursting pressure is uncertain, with almost no warning before occurrence, and is characterized by instantaneous, sudden, wide damage range, large destructive power, etc. Therefore, it is difficult to predict the occurrence time, place, and other factors of this accident [4].

2. Literature Review

The study of coal bursting pressure in China began in the early 1870s. Its application technology and related theories are based on the research of Australia, the Soviet Union, Poland, and other countries and have been widely applied in the 1980s [5]. Lai et al. [6], on the basis of studying the structural characteristics of overburden of steep extrathick coal seam, obtained the comprehensive evaluation function

of structural instability of coal and rock based on the emergence and prevention of coal bursting pressure in the process of combining of two coal seams. Dou and others [7] from the angle of the strength analyzes the causes of rockburst, by reducing the static load of coal and rock and mineral earthquake-induced dynamic load, increasingly induced the critical stress to control the occurrence of rockburst, and puts forward the end unloading blast in the top technology and directional hydraulic roof crack technology. The distributed Secom microseismical monitoring system developed by Dou et al. [8] of the China University of Mining and Technology can obtain real-time monitoring data at both the working face site and the monitoring laboratory. The comprehensive monitoring "stress field-vibration field" early warning system developed by Jiang et al. of the University of Science and Technology Beijing [9] is able to detect the impact low pressure in the fault area and monitor and give early warning at the same time.

There are few researches in this field abroad. Taussig [10] summed up the actual situation and experience of coal bursting pressure in South Africa for decades and believed that the mechanism of coal bursting pressure could be better explained from the perspective of energy. Bieniawski et al. [11, 12] obtained the bursting liability theory based on the stress-strain test experiment of coal based on many field data records and field investigations. Zubelewicz applied the catastrophe theory in his numerical simulation study of coal bursting pressure and regarded the sudden jump of coal and rock from the stable deformation state to the shock and instability state as the catastrophe instability process [13]. Salamon [14] and Brady and Brown [15] developed the stiffness theory proposed by Cook [16] to analyze and calculate the impact of multiple ore pillars. Zhang et al. studied the damage characteristics of the gas-containing coal under the conditions of different loading and unloading rates by experiment [17, 18].

However, it is worth noting that although many scholars and scientists have put forward relevant theoretical research and published many related works, few can really achieve the effect of monitoring and prevention. The fuzzy level index evaluation method used in this paper is a combination of the qualitative and quantitative methods, which can effectively analyze the main factors affecting coal bursting pressure and put forward corresponding safety measures for the main risk factors, so as to prevent the harm caused by coal bursting pressure in advance and ensure the high quality and safe production in mines.

3. Methodology

3.1. Determination and Classification of Evaluation Indexes.
The generation of ground pressure impact is caused by a comprehensive combination of various reasons. For a large multielement and multilayer system, it is often necessary to establish a multilayer fuzzy evaluation model [19, 20] to solve the problem. In order to solve the problem of multilevel complex system, the analytic hierarchy process (AHP) can be used to determine each index. Usually, the problem is decomposed into different indicators, and these indicators

TABLE 1: Grading standard of the impact evaluation index.

Evaluation index	Classification	Standard	Scale
	I(C_1)	No impact	>500
I_1 dynamic failure time	II(C_2)	Weak impact	50-500
	III(C_3)	Strong impact	≤500
	I(C_1)	No impact	<2
I_2 elastic energy index	II(C_2)	Weak impact	2-5
	III(C_3)	Strong impact	≥5
	I(C_1)	No impact	<1.5
I_3 impact energy index	II(C_2)	Weak impact	1.5-5
	III(C_3)	Strong impact	≥5

are classified hierarchically for selection, forming a multilevel model, so as to finally make the problem boils down to the determination of the relative important weight value of the lowest level relative to the highest level or the arrangement of relative advantages and disadvantages (see Table 1).

As there are too many grading and quantifying standards for all indicators, only the grading standards for impact evaluation indicators are taken as an example [21].

According to the hierarchy establishment rule, the evaluation indexes are sorted in order according to the size of the scope, and then, the indexes are graded. The top level is the total indexes, such as the research object and content. The second layer is the overall evaluation index, such as the important influencing factors of the research object. The last layer is the refinement of the total evaluation index layer, that is, the refinement of each important research factor into several factors that affect it. Sometimes layers of structure are added or deleted depending on the overall goal.

a_{ij} is the comparison result of importance between element I and element J. Table 2 lists the 9 importance levels and their assignments given by Santy. The matrix formed by pairwise comparison is called the judgment matrix. The judgment matrix has the following properties:

$$a_{ij} = \frac{1}{a_{ji}}. \tag{1}$$

3.2. Single Ranking and Consistency Check.
If CR < 1, the maximum characteristic root of the judgment matrix is denoted as W after normalization. If CR < 1, then it can pass the consistency test and is considered acceptable. Otherwise, the elements of the matrix must be changed again and the scale should be reperformed according to Table 1 until CR meets the consistency condition. Where RI needs to query in Table 3, the calculation of CR is shown as follows:

$$CI = \frac{\lambda_{max}}{n-1}, \tag{2}$$

$$CR = \frac{CI}{RI}. \tag{3}$$

In equation (2), max is the largest eigenvector and n is the order of the judgment matrix ($n \geq 1$).

TABLE 2: 1-9 scale.

Scale	1	3	5	7	9	2, 4, 6, 8
Factor importance	Both are equally important	Element I is slightly more important	Element I important	Factor I is very important	Factor I is extremely important	The two are in between

3.3. Steps of Fuzzy Comprehensive Evaluation Method.

The fuzzy comprehensive evaluation method is a kind of evaluation method based on fuzzy mathematics. According to the principle of fuzzy relation synthesis, some fuzzy and difficult quantitative factors are quantified. According to the membership degree theory, fuzzy mathematics is used to carry out an overall evaluation on the complex system affected by various indexes.

(i) Step 1: establish evaluation indicators

All indicators can be represented by a set C, and the set of its subfactors is.

(i) Step 2: determine index weight

Any evaluation index has a corresponding weight, and these corresponding weight coefficients constitute the weight vector. So, the weight vector corresponding to R_i is, and the corresponding weight vector for R is.

(i) Step 3: carry out fuzzy evaluation on a single index

If the element C_{ii} in C_i corresponds to the membership of the first element in the comment set is A_{J1}, then the evaluation vector corresponding to rim exists; thus, the evaluation matrix of a single index can be obtained.

$$M = \begin{Bmatrix} M_{i1} \\ M_{i2} \\ \vdots \\ M_{in} \end{Bmatrix} = \begin{pmatrix} m_{11} & m_{12} & \cdots & m_{1n} \\ m_{21} & m_{22} & \cdots & m_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ m_{n1} & m_{n2} & \cdots & m_{nn} \end{pmatrix}. \quad (4)$$

(i) Step 4: establish a multilevel evaluation model

For the first-level comprehensive evaluation, the weight of R_i to the corresponding is; therefore, the first-level comprehensive evaluation results can be obtained as follows:

$$B = W_i * M_i, \quad (5)$$

$$B = \begin{pmatrix} B_1 \\ B_2 \\ B_n \end{pmatrix}. \quad (6)$$

4. Results Analysis and Discussion

4.1. Overview of No. 2 Coal Seam in Dongpang Mine.

The specific location of the mine is located in Shishang Village

TABLE 3: RI values of mean random consistency index.

r_1	1	2	3	4	5	6
RI	0	0.23	0.60	0.88	1.09	1.19

of Neiqiu County, with perfect connection between east, west, and north. To the east is the auxiliary belt of the third level, to the west is the transport roadway of the north wing, to the south is the 21001 mining face, and to the north are two relatively developed fault zones. This working face is used as a main mining area of Dongpang Mine, with ground elevation of 93.26 m and working face elevation of -420 m ~ -500 m. The characteristics of No. 2 coal seam are as follows: the thickness of the coal seam is 5 m ~15 m, the average thickness is 10 m, the dip angle of the coal seam is 6° ~16°, the average dip angle is 11°, the lower fault of the working face is developed, the floor is undulant, and it is strongly influenced by the structure. The stress concentration is obvious. The longwall receding coal mining method is the main mining method of the working face at present.

The geological structure of the No. 2 coal seam is complex, in which faults are the main ones, and there are many normal faults, which are mainly at high angles. There are 30 faults with a drop of 5-20 m, accounting for 51.7%, and 28 faults with a drop of 20 m and more than 20 m, accounting for 48.3%. Due to the large number of faults, it is necessary to pay attention to the geological hazards with fault influence when mining.

4.2. Risk Identification of Face Impact Ground Pressure.

Common risk identification methods include the Delphi method, brainstorm method, expert survey method, scenario analysis method, financial statement method, interview method, hypothesis and condition analysis method, and WBS plan flow chart method.

Based on the risk identification method based on expert investigation, this paper conducts a risk analysis on 21101 working face of No. 2 coal seam in Dongpang Mine. According to the experience of professionals and the actual situation, the main risk factors in this mine are as follows:

(1) Mine geological factors

Most experts believe that the impact energy, the elastic energy index, dynamic damage time, and unidirectional compressive strength are used to measure impact tendency of coal and rock, coal and rock mechanics characteristics are measured through coal and rock impact bias, only keep 1 item, the coal rock impact bias than coal and rock mechanics features easy to quantify, so keeping the coal rock impact bias. Based on expert opinions, mine geological factors indexes are determined to be four, namely, geological
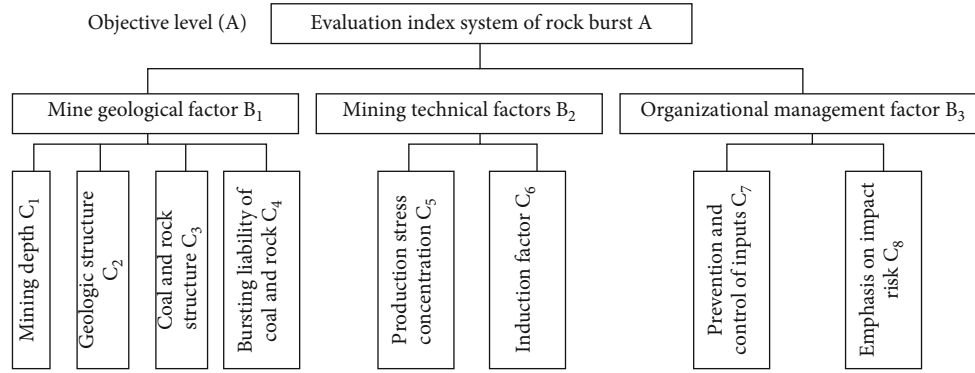
Figure 1: Evaluation index system of coal bursting pressure.

Table 4: Mining depth classification.

Evaluation index	Classification	Standard	Scale
Mining depth C_1	I	<350	0
	II	350-500	1
	III	>500	3

structure, mining depth, coal and rock flushing tendency, and coal and rock structure.

(2) Mining technical factors

Experts believe that roadway and working face are pushed forward, and roadway tunneling, mining procedure, and mining method are all stress concentration caused by mining in the abatement pressure zone. Therefore, two indexes of mining technical factors can be determined, namely, inducing factor and mining stress concentration.

(3) Organizational management factors

According to expert opinions, there are two indicators of organizational management factors for ground pressure impact, namely, the investment of funds for prevention and treatment and the importance of its risk.

4.3. Establish a Risk Assessment Index System. According to the results of index comparison and selection, an index evaluation chart can be established for No. 2 coal seam. The system includes 3 first-level indexes and 8 second-level indexes, as shown in Figure 1.

4.4. Classification and Quantification of Each Indicator. Using the method of classification standard quantification, the mine impact risk degree and each index are quantified into three grades: first grade (no impact risk), second grade (medium impact risk), and third grade (strong impact risk), and the impact ground pressure index of 21101 working face of Dongpang Mine is classified.

4.4.1. Mine Geological Factors

(1) Mining Depth. See Table 4 for the classification of mining depth index obtained by searching data. The deeper the coal

seam is, the greater the elastic potential energy is, and the higher the grade of coal bursting pressure danger is. The mining depth of 21101 working face is 420~500 m, so the mining depth index is level II with medium impact risk and index score 1.

(2) Geological Structure. Refer to the classification of geological structure complexity stipulated in The Geological Code for Mines, and see Table 5 for the classification of geological structure indexes. The average strike length of working face is 1392.7 m, the average tilt length is 241.9 m, and the maximum tilt length is 272.8 m. The geological structure is complex, which is mainly manifested as faulted structure, fault development at the lower part of the working face, and uneven floor, which is strongly affected by the structure. Therefore, the geological structure of 21101 working face is grade III, with strong impact risk and index score of 5.

(3) Coal and Rock Structure. Referring to the classification of roof bursting liability in The Method for The Classification and Index of Roof Bursting liability, the coal and rock structures are classified according to the bending energy index UQW of the roof and the condition of the floor of the coal seam, as shown in Table 6. The second coal seam of the main mining, with a thickness of 5 m ~15 m and an average thickness of 10 m, is a hard siltstone. The bending energy index of the roof measured in the laboratory is 24.56 kJ, and the floor of the coal seam is also relatively hard. Therefore, the coal and rock structure of the 21101 working face is grade II, moderately dangerous, and the index score is 2.

(4) Bursting Liability of Coal and Rock. The test results of bursting liability of no. 2 coal seam in main mining show that the dynamic failure time of coal is 300 ms, the impact energy index is 6.11, the elastic energy index is 7.99, and the unidirectional compressive strength is 9.97 MPa. Combined with Table 7, it can be seen that the coal and coal bursting pressuring liability of this working face belongs to grade III, with strong impact risk and index score of 5.

4.4.2. Mining Technical Factors

(1) Mining Stress Concentration. Mining in working face is carried out in sequence according to coal seam distribution,

TABLE 5: Classification of geological structure.

Evaluation index	Classification	Standard	Scale
Geologic structure C_2	I	Tectonic in development	1
	II	Structure development	3
	III	Structure well developed	5

TABLE 6: Structural classification of coal and rock.

Evaluation index	Classification	Standard	Scale
Coal and rock structure C_3	I	UWQ ≤ 15, fragile floor	0
	II	15 < UWQ ≤ 120, harder floor	2
	III	UWQ > 120, hard floor	4

TABLE 7: Classification of coal and coal bursting pressuring liability.

Evaluation index	Classification	Standard	Scale
Bursting liability of coal and rock C_4	I	DT > 500, WET < 2, KE < 1.5, RC < 7	0
	II	50 ≤ DT < 500, 2 ≤ WET < 5, 1.5 ≤ KE < 5, 7 < RC < 14	3
	III	DT ≤ 50, WET ≥ 5, KE ≥ 5, RC ≥ 14	5

TABLE 8: Classification of mining stress concentration.

Evaluation index	Classification	Standard	Scale
Stress concentration factor in mining C_5	I	Reasonable mining sequence / No pillar of coal near the working face / All cavitation effects	1
	II	Reasonable mining sequence / There are a few pillars of coal near the working face / The caving method is generally effective or the filling method is adopted	3
	III	Unreasonable mining sequence / There are many coal pillars near the working face / Coal pillar support method	5

TABLE 9: Classification of inducible factors.

Evaluation index	Classification	Standard	Scale
Mining inducement factor C_6	I	Inducement factor is little, the roof comes to press small	1
	II	There are many inducing factors	3
	III	There are many inducing factors, the roof to pressure	5

TABLE 10: Governance investment classification.

Evaluation index	Classification	Standard	Scale
Control investment C_7	I	Good support effect / Reasonable investment in governance	1
	II	The supporting effect is general / Insufficient management input	3
	III	Poor support effect / Less or no investment in governance	5

TABLE 11: Classification standard of shock risk attention degree.

Evaluation index	Classification	Standard	Scale
	I	Very strong sense of impact prevention	1
		Master the law of rock strata movement	
Emphasis on impact risk C_8	II	Strong awareness of impact prevention	3
		Master certain laws of rock transportation	
	III	Weak awareness of impact prevention	5
		Not mastering the law of rock transport	

TABLE 12: Judgment matrix of criterion layer evaluation index.

Judgment matrix A	B_1	B_2	B_3	W	λ_{max}	CR
B_1	1	2	4	0.571		
B_2	1/2	1	2	0.286	3.001	0.001 < 0.1
B_3	1/4	1/2	1	0.143		

TABLE 13: Judgment matrix of mine geological index.

Judgment matrix B_1	C_1	C_2	C_3	C_4	W_1	λ_{max}	CR
C_1	1	1/5	1/2	1/5	0.075		
C_2	5	1	3	1	0.393	4.004	0.001 < 0.1
C_3	2	1/3	1	1/3	0.138		
C_4	5	1	3	1	0.393		

TABLE 14: Judgment matrix of mining technical indicators.

Judgment matrix B_2	C_5	C_6	W_2	λ_{max}	CR
C_5	1	1/2	0.333	2.0	0
C_6	2	1	0.667		

TABLE 15: Judgment matrix of organizational management indicators.

Judgment matrix B_3	C_7	C_8	W_2	λ_{max}	CR
C_7	1	1/3	0.25	2	0
C_8	3	1	0.75		

and roof caving is treated with caving method. The caving effect of the roof is good. However, affected by roadway and coal pillar near working face in later mining period, a large amount of elastic energy is easily stored in the roof and coal body, resulting in the increase of impact risk. Therefore, the mining stress concentration factor of this working face belongs to level II, with medium impact risk and index score of 3. The classification of mining stress concentration factors is shown in Table 8.

(2) Inducing Factors. Due to its special geographical location, there are many uncontrollable factors in mining. In addition, the fracture of the roof and floor and high stress migration will also increase the impact risk during the initial and periodic incoming pressure of the working face. Therefore, the

inducement factors of 21101 working face belong to level III, strong shock risk, and index score 5. The classification of inducible factors is shown in Table 9.

4.4.3. Organizational Management Factors

(1) Input of Governance. Equipped with acoustic emission and other advanced instruments and equipment, the mine also has a large input in monitoring and forecasting, and problems can be detected in the first time at each working face. The site is equipped with much international advanced equipment. To sum up, the management investment in the 21101 work surface is in place, belonging to the first level, with no impact risk and index score 1. See Table 10 for the classification of governance input evaluation indicators.

(2) Emphasis on Impact Risk. This mine has a special department for flood prevention, which also has perfect data for the preplan and prediction of ground pressure impact, and often carries out safety education for the staff. However, due to the lack of professionals, the company is planning to add professionals to grasp the law of rock strata movement. Therefore, the impact risk of the 21101 working face is regarded as level 2, with medium impact risk and index score of 3. See Table 11 for the evaluation index grades of shock risk attention degree.

4.5. Index System Weight. The AHP method is used to judge the importance of the weights of criteria layer indexes, mine geological indexes, mining technical indexes, and organizational management indexes, and the scale method of 1-9 and its reciprocal are used to judge the element values of matrix, as shown in Table 12–15.

4.6. Single-Factor Membership. According to the interim Provisions on Safe Mining of Coal Seam under coal bursting pressure, Coal Mine Safety Regulations and relevant research results of coal bursting pressure, a safety check list is compiled and the safety evaluation results of Yanbei Coal Mine are referred to. The ratio method was used to determine the single-factor membership degree (the distribution function of simulated probability theory was used as the membership degree). The membership degree results are shown in Table 16.

4.7. Comprehensive Evaluation Results of Fuzzy Hierarchy Method. Through the above analysis, grade determination, and grading, the first- and second-level indexes can be evaluated for No. 2 coal seam. Meanwhile, the evaluation results

Table 16: Membership degree of each factor.

Factor		Membership
Mine geological factor	Mining depth	(0.000 0.500 0.500)
	Geological structure	(0.000 0.250 0.750)
	Tectonic coal and rock	(0.000 0.000 1.000)
	Bursting liability of coal and rock	(0.000 0.500 0.500)
Mining technical factors	Production stress concentration	(0.111 0.333 0.556)
	Inducing factors	(0.000 0.500 0.500)
Organizational management factor	Control investment	(0.000 0.667 0.333)

can be calculated to evaluate the degree of coal bursting pressure hazard of the No. 2 coal seam.

(1) Comprehensive evaluation of first-level indicators

According to formula (4), the indicators of mine geology are as follows:

$$M_1 = \begin{pmatrix} 0 & 0.5 & 0.5 \\ 0 & 0.25 & 0.75 \\ 0 & 0 & 1 \\ 0 & 0.5 & 0.5 \end{pmatrix}, \tag{7}$$

$$W_1 = (0.075 ; 0.393 ; 0.138 ; 0.393), \tag{8}$$

$$B = W_i * M_i = (0.000 ; 0.332 ; 0.667). \tag{9}$$

In the same way, we can get the following: mining technical indicators and organizational management indicator $B_3 = (0.000, 0.688, 0.312)$.

(2) Comprehensive evaluation of second-level indicators

According to Table 9, the weight vector of the criterion layer is

$$W = (0.571, 0.286, 0.143), \tag{10}$$

$$M_1 = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \end{bmatrix} = \begin{pmatrix} 0.000 & 0.332 & 0.667 \\ 0.037 & 0.444 & 0.519 \\ 0.000 & 0.668 & 0.312 \end{pmatrix}, \tag{11}$$

$$B = W_i * M_i = (0.012, 0.413, 0.575). \tag{12}$$

(3) Evaluation results

According to the calculation results, the membership degree of "no shock risk, medium shock risk and strong shock risk" on the working face of 211101 in this mine is (0.012, 0.413, 0) According to the principle of maximum membership, the working face has a strong shock risk. Therefore, eight factors, including geological factors, mining technology factors, and organizational management factors,

should be considered in the selection of preventive measures for coal bursting pressure in the future.

This result is only a prediction of ground pressure impact on the working face, which belongs to a section with complex structure. The specific implementation plan and relevant safety plan have to be determined according to the evaluation of professional engineers and the actual situation on the site for a long time.

4.8. Risk Control Measures. In the No. 2 coal seam of Dongpang Mine, we know through risk analysis that the factors mentioned above have a great tendency of coal bursting pressure and should be the key control object of No. 2 coal seam of Dongpang Mine. In order to ensure the safety in the process of mining in the later stage, risk prevention is mainly carried out from the following aspects, and corresponding control measures are formulated.

(1) For geological structure, the structure of No. 2 coal seam is relatively developed and has a great impact, and the danger level is level 3. Therefore, prevention should be paid close attention to. Prevention method is as follows: (1) Due to the complex geological structure, the structure is more developed, so the best way is to the section of accident prevention and monitoring. (2) The bottom plate belongs to the hard bottom plate, but the bottom plate is uneven, and it is easy to cause accidents. So the prevention can be taken to the floor grouting treatment, the floor reinforcement and flatness adjustment

(2) For the inducement factors, the geological structure of the No. 2 coal seam is more complex, the fault structure is more developed, and the roof pressure from the inducing factors is larger, which belongs to the third-level danger level. Therefore, in the mining process, it is necessary to reinforce and strengthen the roof of the roadway by adding u-shaped supports and link the adjacent two supports by pulling rods. The top and top of the supports can be strengthened by adding roadway wood, and then grouting can be carried out to increase the designed thickness

(3) For workers' understanding of ground pressure impact. Workers do not have enough awareness and attention to the impact of ground pressure, and their awareness of impact prevention is weak.

Therefore, it is necessary to (1) increase the publicity of knowledge of coal bursting pressure, post safety warning signs in the mining area, hold a special conference on coal bursting pressure, and watch the film warning of coal bursting pressure and (2) hire professional engineers, set up the shock pressure safety institute, the workers for the popularization of basic knowledge, including the shock pressure mechanism, the accident occurred when the response measures

5. Conclusion

Taking the No. 2 coal seam project in Dongpang Mine as an example, this paper takes the whole process of roof impact ground pressure accident risk analysis as the research object, applies the evaluation method of fuzzy hierarchical evaluation method, analyzes the results and gives corresponding measures, and mainly draws the following conclusions:

(1) By using the evaluation method of fuzzy hierarchical evaluation method, it is concluded that the working face of Dongpang Coal Mine 211101 has a strong impact risk. The main risk factors include geological structure, coal and rock impact, mining stress, inducing factors, and emphasis on impact risk. The risk level is level 3, which requires timely rectification and prevention

(2) For the major risk factors such as geological structure, the method of drilling pressure relief could be adopted to relieve pressure. Reasonable arrangement ensures the safety of drilling, so as to improve the safety of coal seam in the mining process

(3) The fuzzy hierarchy index evaluation method used by several typical factors, but with the increase of mining depth of coal seam, coal bursting pressures become uncertain influence factors, and there was a cross between these factors, so to some extent, restricted by some objective factors, the need to further improve on science

Data Availability

The underlying data supporting the results of my study can be found in generated during the study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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