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Prediction study on gas emission of the first face in the 11-2 coal seam in Liuzhuang Coal Mine

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Abstract

According to the geological exploration about gas information in Liuzhuang Coal Mine, the gas pressure during well construction parameters, and the actual gas emission from tailgate and track trough, the author calculated and got the gas content of the first coal face; combining with coal mining conditions and coal bed methane occurrence conditions, the authors selected the gas emission coefficient from rock k_1, the gas emission coefficient from pre-drainage tunnel k_2, the gas emission coefficient from residual coal k_3 and a series of other forecast parameters, and used sub-source prediction method to calculate the gas emission from mechanized mining face and the adjacent layer. Finally, the author got the total gas emission about the first coal mining face in the 11-2 coal seam in Liuzhuang Coal Mine, which provides a theoretical basis for the gas control in Liuzhuang Coal Mine.

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*keywords:*Gradient of the gas content; sub-source prediction method; gas emission; predict

1. Introduction

The purpose of gas emission prediction is that mine ventilation system design to meet up to the maximum capacity requirements of mine gas emission. Currently, there are two ways to prediction method about the gas emission from work face: sub-source prediction method and statistical prediction. The former calculate the gas emission from work face according to the source of gas emission and the

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different emission laws from different source, combined with coal mining conditions and parameters of gas occurrence in coal seam. It adapts to the various mining methods for prediction the gas emission from work face. It can obtain a high prediction accuracy if you can select a reasonable forecast parameter. Statistical prediction requires the mining working face we will predict has the same or similar conditions with the sample face in mining method, conditions of coal seam, geological conditions of gas. Otherwise, the prediction accuracy is difficult to guarantee.

We use sub-source prediction method to predict gas emission in working face. The method is summed up by Fushun Branch of China Coal Research Institute on the basis of the study results at home and abroad, and investigated by testing the suitability of the proposed conditions of coal mine gas emission prediction. This method has been drafted by the Institute of Fushun Coal Branch in 2005, and publishes by the State Administration of Production Safety Supervision. Now it has become the industry standard. It releases in February 2006 and implements in May 2006. The standard calculates the amount of gas emission according to the source of gas emission law, and combines with coal mining conditions, coal seam gas content. Therefore, the key to reduce the amount of prediction error is to accurately determine the gas content of coal seam gas emission.[1]

2. Overview of the First Face

The level of belt trough of the first face in the11-2 coal seam in Liuzhuang Coal Mine of New Set Group is -790m~-825 m, the design length is 2030m, the level of the drainage lane is -840m. Now it has been the construction 925m, the gas emission is 0.43~1.81m^3/min. The level of track trough of the first face is -746~-775 m, the design length is 2030m. Now it has been the construction 1420m (Table 1.), the gas emission is 0.31~1.01m^3/min. The length of the work face is 210m.

The length of the work face is 210m, and the dip angle of the coal seam is 10°～20°, the average coal thickness is 3.8m. The mining method used longwall retreating methoed, full-seam mining, the roof used caving method to manage.

Track trough: bolting with wire mesh adding cable bolting, the clear width and height of the trapezoidal are 4.6m and 3.5m, the net section is 16.1m^2; the excavation width and height is 4.8m and 3.6m, the net section is 17.28m^2. The partial roadways with large pressure are supported with the U-type arch in arched, of which the net section is 15.2m^2.

Transport trough: The partial roadways with large pressure are supported with the U-type arch in arched, of which the net section is 18.95m^2, of which the net section is 17.31m^2. The partial roadways are supported with wire mesh adding cable bolting in echelon form, and its clear width and height are 5m and 3.5m, the net section is 17.5m^2.

3. Determine the Gas Content of Coal Seam in the First Work Face[2]

According to the gas information during geological exploration and the gas pressure we got during well construction in Liuzhuang Coal Mine, combined the actual gas emission from transport trough and driving track trough in the first face in 11-2 coal seam, we determine the gas content gradient integrated relationship as following:

$$W = 11.623 \times \ln H - 73.02 \qquad (1)$$

In the formula:

W——the gas content in coal seam, m^3/t;

H——The thickness of the overburden, m.

When the level of the first work face during -746m and -825m, we can calculate that the gas content W $=4.81m^3/t$ if we take 809m as its level.

Table 1. The tables of absolute gas emission from the first face in the 11-2 coal seam in tailgate and track trough

Date	The belt trough in 11-2 coal seam				The track trough in 11-2 coal seam			
	Gas Concentration (%)		The absolute Emission (m^3/mim)		Gas concentration (%)		The absolute Emission (m^3/mim)	
	Face	Return	Face	Return	Face	Return	Face	Return
28/12	0.11	0.14	0.31	0.44	0.06	0.08	0.31	0.43
29/12	0.10	0.14	0.28	0.44	0.06	0.08	0.31	0.43
30/12	0.10	0.14	0.28	0.44	0.08	0.10	0.41	0.54
31/12	0.10	0.14	0.28	0.44	0.08	0.10	0.41	0.54
1/1	0.14	0.16	0.46	0.57	0.09	0.13	0.44	0.67
2/1	0.13	0.14	0.42	0.50	0.13	0.16	0.64	0.82
3/1	0.15	0.16	0.49	0.57	0.11	0.14	0.54	0.72
4/1	0.17	0.18	0.56	0.64	0.12	0.13	0.59	0.67
6/1	0.16	0.17	0.52	0.60	0.10	0.12	0.49	0.62
8/1	0.16	0.18	0.52	0.64	0.10	0.12	0.49	0.62
9/1	0.18	0.20	0.59	0.71	0.12	0.14	0.59	0.72
10/1	0.14	0.16	0.46	0.57	0.10	0.14	0.49	0.72
11/1	0.25	0.26	0.79	0.89	0.09	0.12	0.42	0.59
12/1	0.20	0.22	0.63	0.75	0.16	0.16	0.76	0.79
13/1	0.18	0.19	0.57	0.65	0.09	0.12	0.42	0.59
14/1	0.16	0.17	0.50	0.58	0.11	0.16	0.52	0.79
15/1	0.14	0.16	0.44	0.55	0.12	0.14	0.57	0.69
16/1	0.16	0.17	0.50	0.58	0.11	0.12	0.52	0.59
17/1	0.12	0.14	0.38	0.48	0.13	0.14	0.61	0.69
18/1	0.15	0.16	0.47	0.55	0.13	0.14	0.61	0.69
19/1	0.15	0.16	0.47	0.55	0.12	0.14	0.57	0.69
21/1	0.14	0.14	0.43	0.49	0.15	0.14	0.64	0.64
22/1	0.13	0.14	0.40	0.49	0.14	0.14	0.60	0.64
24/1	0.14	0.14	0.43	0.49	0.12	0.12	0.51	0.55
26/1	0.29	0.29	0.90	1.01	0.11	0.12	0.47	0.55
27/1	0.22	0.25	0.68	0.87	0.12	0.12	0.51	0.55
29/1	0.19	0.19	0.59	0.66	0.12	0.13	0.51	0.60
30/1	0.17	0.17	0.53	0.59	0.20	0.20	0.86	0.92
1/2	0.19	0.19	0.58	0.65	0.30	0.31	1.23	1.37
3/2	0.25	0.25	0.76	0.86	0.30	0.30	1.23	1.32
5/2	0.18	0.18	0.55	0.62	0.40	0.41	1.64	1.81
6/2	0.26	0.28	0.79	0.96	0.26	0.26	1.06	1.14
7/2	0.22	0.23	0.67	0.79	0.23	0.23	0.94	1.01
8/2	0.19	0.19	0.58	0.65	0.20	0.21	0.82	0.92
9/2	0.20	0.20	0.61	0.69	0.20	0.20	0.82	0.88
10/2	0.22	0.23	0.67	0.79	0.23	0.23	0.94	1.01

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar.

4. Prediction of Gas Emission Amount

During mining the first work face in the 11-2 coal seam, because of mining relief the pressure, the gas will emit to the first work face from the overlying the coal seam 13-1,13-2 and the under cover coal seam

11-1 in different levels. According to the gas occurrence situation in the coal seam, there are three sources which the gas emits from: the mining layer, the adjacent layer and the gobs of coal. The gas of the adjacent layer and the gobs of coal emit to the work face by the ways of gob face during the production process, therefore, we can roughly divided into two sources of gas emission: the gas emit from the mining layer and the adjacent layer. In practice calculations, the part of gas emit from enclosing rock is often used gas emission coefficient to add into the gas emission from extraction layer. According to the integrated histogram formation of the central district east II coal mining area, there are 17-1, 16-1, 14, 13-2, 13-1 coal seam cover the 11-2 coal seam, and there are 8, 9 coal seam under the 11-2 coal seam. The spacing between them are all greater than 70m. According to the gas emission rate curve with different spacing between adjacent layers, the gas emissions from the adjacent layer the first layer to the first work face can be ignored. [2]

5. Determination of the Forecast Parameters and the Prediction[3]

The level of belt trough of the first face in the11-2 coal seam in Liuzhuang Coal Mine of New Set Group is -790m~-825 m, the design length is 2030m, the level of the drainage lane is -840m. Now it has been the construction 925m, the gas emission is 0.43~1.81m^3/min. The level of track trough of the first face is -746~-775 m, the design length is 2030m. Now it has been the construction 1420m, the gas emission is 0.31~1.01m^3/min. The length of the work face is 210m.

According to the mining conditions of the first work face and the conditions of gas occurrence, it determines the forecast parameters as following.

The gas emission factor of the enclosing rock: k_1=1.2 ;

The gas emission factor when we use the roadway to pre-discharge gas: k_2 =0.89 ;

The gas emission factor of the residual coal: $k_3 = \frac{1}{\eta}$

—percentage extraction, if it is fully-mechanized face, we take as 95%, it is that =0.95, and k_3 =1.053.

The original gas content of the mining layer: As the face is mined in the way of full high extraction, the gas emission from the coal seam have a greater change during the mining process, according to gas gradient in the district (H take 809m), we determine integrated that the face value of the gas content in 11-2 coal seam: w_0 =4.81m^3/t;

The residual gas content during the coal ship out from the work face: the same coal mine field to take w_c =2 m^3/t;

The thickness of the coal seam in mining m_0 =3.8m.

The driving speed of the heading face: the speed of full mechanized roadway is 500m/month, and the speed of f blast-winning is 150m/month.

The statistics data of Huainan and other mining area indicate that the maximum imbalance factor of gas emission are usually between 1.3 to 1.8, and generally it takes 1.5; it must consider the maximum gas emission of the face when we determine the production of the work face and design the ventilation system, it is say that it should be multiplied by a factor of 1.5 times based on the prediction parameters because of the imbalance factor of gas emission.

5.1. Gas emission prediction of fully mechanized coal face

We can calculate the gas emission in advance for the mining coal seam as following:

$$q_1 = k_1 \cdot k_2 \cdot k_3 \cdot \frac{M}{m}\left(w_0 - w_c\right) \quad (2)$$

In the formula:

q_1 —the gas emission for the mining coal seam, m^3 /t;

k_1 —the gas emission factor of enclosing rock, it takes K_1＝1.2;

k_2 —the gas emission factor of residual coal, if $k_2 = \frac{1}{\eta}$ (η is the mining rate of the work face), and η is 95% for comprehensive Shearer, that k_2＝1.053;

k_3 —The gas emission factor when we use the roadway to pre-discharge gas: if $k_3 = \frac{(L - 2h)}{L}$ （L — the length of the coal face, it takes 210m; h —the equivalent width of coal wall gas emission in excavation roadway, m）, according to the determination of Fushun Branch, the coal of Huainan mining area is bituminous coal, and h can be calculated use the formula $h = 0.808\ T^{0.55}$（T — the failure time of methane emissions from coal wall, d）, if T takes 150 days, and we can get h＝12.71m and substitute it into the formula k_3, we get K_3＝0.88;

M —the thickness of coal seam, it takes 3.8m;

m — mining height, it takes 3.8m;

w_0 —the original gas content in coal seam, it takes 4.81m^3/t;

w_c —the residual gas content, it takes 2 m^3/t;

$$q_1 = 1.2 \times 1.053 \times \frac{3.8}{3.8} \times 0.878 \times (4.81 - 2) = 3.12 m^3/t \quad (3)$$

5.2. Gas emission prediction of adjacent layers

The gas emission prediction of adjacent layers can be calculated using the following formula:

$$q_2 = \sum_{i=1}^{n} \frac{m_i}{m} k_i \cdot w' \quad (4)$$

In the formula:

q_2 —The gas emission for the adjacent coal seam, m^3 /t

m_i —The thickness of adjacent coal seam, m;

w' —The gas content of adjacent coal seam, m^3/t;

k_i — The gas emission rate of adjacent coal seam, %.

The value of k_i can be selected according to the thickness of exploitation seam and the gas emission rate curve of different space between adjacent layers (Figure 1). The curve is obtained based on the

determination results of Yangquan, Beipiao and Huainan mining area in China, and it is verified, therefore it has a higher fitness.

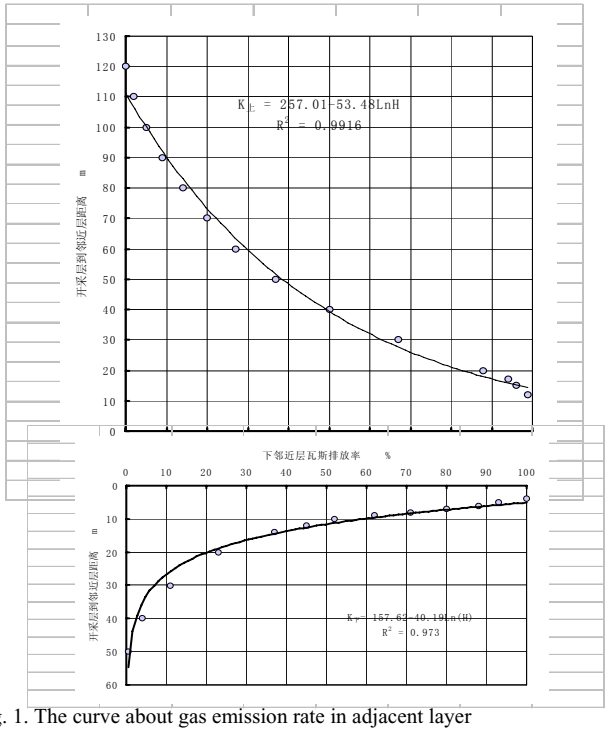

Fig. 1. The curve about gas emission rate in adjacent layer

5.3. Gas emission prediction of the first work face

The gas emission of the first work face is equal to the gas emission from the mining coal seam and the adjacent coal seam. Therefore,

$$q = q_1 + q_2 = 3.12 + 0.96 = 4.08\ m^3/t$$

According to the above prediction methods and parameters, we predict the gas emission of the first work face, and the results are shown in Table 2 while it is First Face First Mining Area and uses a one-time full-high-mechanized coal mining.

Table 2. The predictions of gas emission in the first coal faces

Mining method	Coal thickness (m)	Daily output (t)	Absolute gas Emission (m^3/min)			Relative gas emission (m^3/t)	The peak (m^3/min)
			Working seam	Adjacent seam	Total		Total
Fully mechanized	3.8	8172	17.71	5.45	23.16	4.08	34.74

Note: The peak value is taken the maximum when the gas emission is not balanced, and they are all multiplied by the coefficients 1.5

6. Conclusions

According to the geological exploration about gas information in Liuzhuang Coal Mine, the gas pressure during well construction parameters, and the actual gas emission from tailgate and track trough, the author calculated and got the gas content of the first coal face 4.81m^3/t; combining with coal mining conditions and coal bed methane occurrence conditions, the authors selected the gas emission coefficient from rock, pre-drainage tunnel, residual coal (k_1, k_2, k_3) and a series of other forecast parameters, and used sub-source prediction method to calculate the gas emission from mechanized mining face and the adjacent layer. Finally, the author got that the total gas emission about the first coal mining face in the 11-2 coal seam is 4.08 m^3/t, which provides a theoretical basis for the gas control in Liuzhuang Coal Mine.

After calculation, when the production of the first face is 2.452Mt / a (if there are 300 work days in a year, the daily output are 8172t), the absolute gas emission from the mining coal seam are 17.71m^3/min, and it takes 76.47% of the total gas emission; the absolute gas emission from the adjacent coal seam are 5.45m^3/min, and it takes 23.53% of the total gas emission. The data shows that the main gas emission of the work face comes from the mining coal seam. When the mining face fast forward and the gob area is gradually increasing, or when the thickness of adjacent coal seam and the layer spacing changes, especially it uses tilt the long arm-type to mining the lower, it will be significantly changed to the gas emission of the work face.

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