

Research on Gas Drainage Technology of Long-distance Bedding Directional Borehole in Huoerxinhe Coal Mine

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Abstract

The Long-distance bedding directional borehole of gas drainage technology can effectively solve the gas control problem in the coal seam excavation working face under complex geological conditions. According to the phenomenon of gas overrun in the main roadway of No.3 coal seam in Huoerxinhe Coal Mine, the gas outburst control measure is adopted to pre-evacuate the gas by the long-distance bedding directional borehole. The results show that the gas content of test point decreases from 13.81m³/t to 7.81m³/t after 25 days of gas drainage by long-distance bedding directional borehole, and the gas pre-pumping rate is about 43.30%. The driving speed of the main transport roadway is 1.48 times that of the traditional ordinary drilling drainage measures, and the tunneling efficiency indicators have not exceeded. Through the application of this measure, it is confirmed that the long-distance bedding directional borehole can effectively reduce the drilling hole construction amount and increase the gas extraction rate compared with the traditional ordinary drilling hole, and effectively eliminate the danger of protruding, and realize the safe and rapid excavation of the coal mine roadway.

Keywords

Coal mine; Long-distance bedding directional borehole; Gas extraction; Excavation face; Field test.

1. INTRODUCTION

The Shanxi Huoerxinhe coalmine area is 71.3947 km², and the main mining is No.3 coal seam which is a single thick coal seam. The average thickness is 5.65m, and the average dip angle is 5°. According to the mine gas emission characteristics, the mining face gas mainly are from the No.3 coal seam. At present, the depth of the main roadway excavation area is about 536m, and the coal seam gas content measured at 104m away from the No.14 contact lane is 11.51m³/t. It is found that when the roadway is excavated normally, the gas concentration of the backflow wind varies greatly, and the maintenance gas concentration is generally between 0.3% and 0.5%. The gas concentration of production classes is generally between 0.4% and 0.8%. The average gas emission rate is about 6.2m³/min in the tunneling face. The gas emission of coal wall is about 3.33m³/min, and the gas emission rate is about 2.87m³/min. No gas drainage is carried out in the heading face of the mine, only ventilation was adopted to solve the gas emission. However, with the gradual extension of the roadway to the deep, coal seam gas content is growing, ventilation can not completely solve the digging gas emission, and occasionally gas close to the phenomenon of overrun. While the main transport roadway normal tunneling, the return air gas concentration has a big change, and the average gas emission is about 6.2m³/min.

It can be seen that it urgent needs to control and manage the main transport roadway driving face gas drainage.

The Long-distance bedding directional borehole of gas drainage technology can effectively solve the gas control problem in the coal seam excavation working face under complex geological conditions [1-5]. In view of the current situation of the short effective extraction length of the bottom-drawing roadway through the layer drilling in Zhaozhuang Coal Industry, Lv Gaolei et al. [6] explored the construction technology practice of the through-layer directional long-drilling hole. The gangue ratio of directional long boreholes is increased to 1:0.51, and the flow rate of 100-meter boreholes is increased by 1.35 to 2.5 times. Liang Yujian [7] applied the directional long drilling technology to extract gas in the 1208 working face of Sima Mine, and the gas extraction rate was increased by 1.7 times, and remarkable application results were achieved. Therefore, this paper mainly adopts the technology of gas drainage with the directional long boreholes to carry out the application in the tunneling face of the main transport roadway in Huoerxinhe No.3 coal seam. During the test, the directional drilling rig (ZYWL-6000DS type crawler type full hydraulic drilling rig) which is independently developed by the China Coal Science and Industry Group Chongqing Research Institute Co., Ltd. is used to carry out the construction of long borehole gas drainage.

2. LONG-DISTANCE BEDDING DIRECTIONAL BOREHOLE CONSTRUCTION AND PROGRAMING

The head of the main transport roadway constructs two main hole, drilling hole in the roadway head is 1.6m high, and the two holes control the coal roadway. Drilling length is 400m, horizontal and vertical direction to open branches, the hole spacing is 4m. And drilling layout parameters are shown in Table 1 and Figure 1. The main transport roadway driving face distance from the 14th contact lane 104m construction of the first group of hole spacing 4m of ordinary drilling, investigation completed 80m after the construction of the second group of hole spacing of 3m of the second group of ordinary drilling. After the completion of the second group ordinary drilling and extraction test, the gas content in the coal seam is measured after excavation 80m (distance:14m, contact hole:264m, maximum gas content:13.81m³/t), construct directional bedding drilling, construct two main holes, open the hole with eight branches, control 5.3m coal seam gas and the entire coal thickness with each branch length of 24~114m.

Table 1. The drilling arrangement parameter

Hole number	1#	2#	Total
Aperture orientation	0°	0°	
Target azimuth	0°	0°	
Opening height	1.6m	1.6m	
Final hole diameter	94mm	94mm	1088m
Main hole length	400m	400m	
Branch hole length	Branch hole length	Branch hole length	

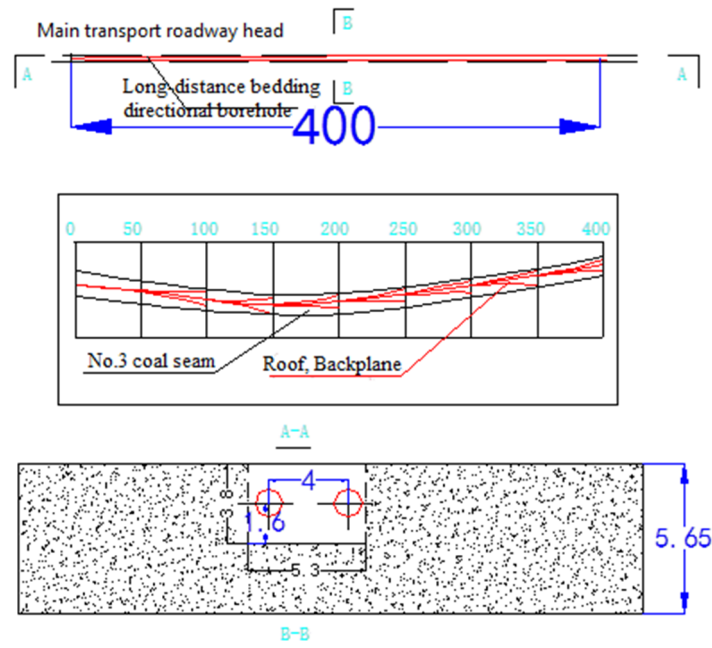


Figure 1. Long Directional Drilling schematic arrangement

3. LONG-DISTANCE BEDDING DIRECTIONAL BOREHOLE GAS DRAINAGE EFFECT

3.1. Statistical Analysis of Gas Extraction Capacity

The directional long boreholes are constructed in front of the main transport roadway heading face. The observation time are from February 29, 2016 to March 24, 2016. The drilling gas concentration is above 71% after pumping 25 days, and the drilling single hole standard gas extraction rate is above $0.77\text{m}^3/\text{min}$. The statistical results are as shown in Table 2.

From the Figure 2 and Figure 3, the drilling gas extraction concentration of Huoerxinhe coalmine main transport roadway heading face is very high, the single-hole gas concentration is above 70%, and the single-hole pure gas extraction volume is 3.73 times that of the ordinary single hole pure gas extraction, which successfully eliminates the gas emission anomaly and effectively eliminates the danger of coal and gas outburst. While the negative pressure of gas drainage in drilling section farther away from the location of hole drilling begins to decay. The drilling gas extraction volume is reduced, and the residual gas content is large. It is verified that the distribution of negative pressure along the long direction is gradually reduced.

Table 2. Long bedding directional borehole gas extraction test data

No.	Date	1# hole			2# hole		
		Gas concentration(%)	Mixed flow(m^3/min)	Extraction volume (m^3/min)	Gas concentration(%)	Mixed flow(m^3/min)	Extraction volume (m^3/min)
1	February 29th	89	1.52	1.35	90	1.47	1.32
2	March 3th	90	1.27	1.14	88	1.34	1.18
3	March 7th	85	1.44	1.22	81	1.51	1.22
4	March 10th	80	1.11	0.89	83	1.06	0.88
5	March 13th	78	1.10	0.86	79	1.05	0.83
6	March 19th	75	1.08	0.81	76	1.04	0.79
7	March 24th	72	1.07	0.77	71	1.20	0.85

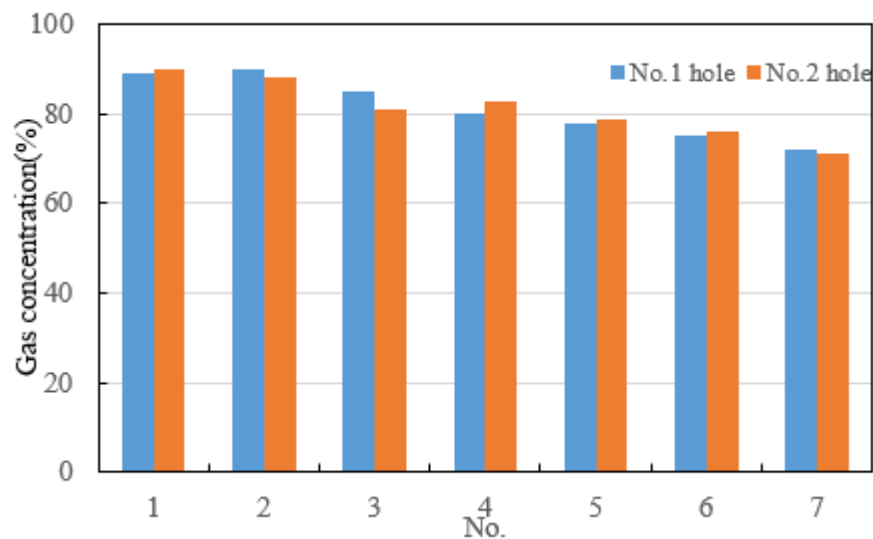


Figure 2. Long bedding directional drilling gas extraction concentration

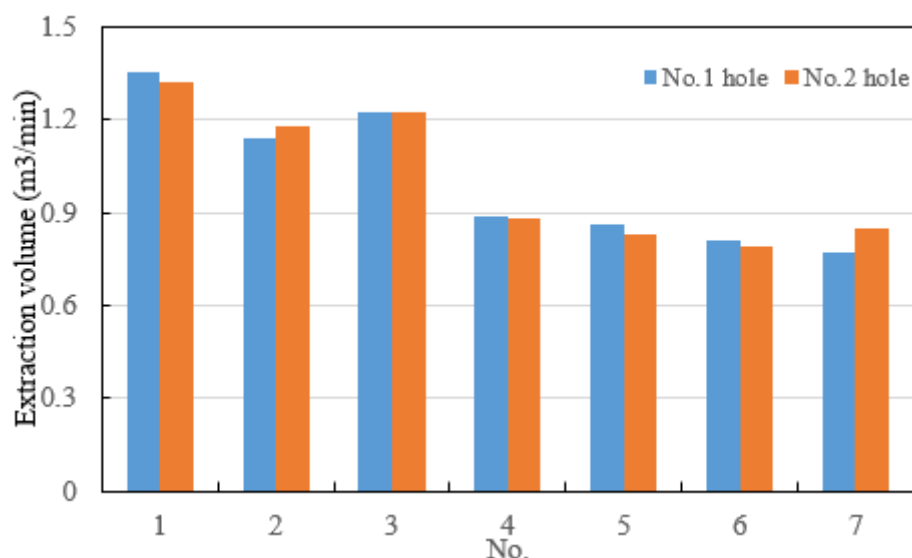


Figure 3. Pure gas drainage capacity with long bedding directional drilling

3.2. Analysis of Gas Content Change

The average thickness of the main transport roadway No.3 coal seam is 5.52m, and the gas content of the original coal seam is $13.81\text{m}^3/\text{t}$, and the length of the drilled hole is 400m. It is calculated that the coal seam gas reserves in the front area of the main roadway face is controlled by the directional long drilling in this area to be about 16,500 tons and the coal seam gas reserve is controlled to be $227,900\text{ m}^3$.

During the main transportation roadway driving face driving process, the cumulative statistics of the residual gas content determination are 8 times. Combining with downhole determination of the directional control region long boreholes in driving working face of the main transportation roadway, the average gas drainage volume of the single hole extraction is about $0.252\text{m}^3/\text{min}\cdot\text{hm}$, the total extraction volume is about $98,700\text{ m}^3$ for 25 days, the residual gas content of coal seam is between 5.64 and $7.83\text{m}^3/\text{t}$, as shown in Table3.

From the Table3, it can be seen that the long-distance bedding directional borehole measures significantly reduces the coal seam gas content in the heading face of the main transport

roadway in the Huoerxinhe coalmine, and the residual gas content in the coal seam decreases gradually along the drilling direction.

Table 3. Determination of gas content during the directional control region long boreholes driving

Drilling section	Original gas content(m^3/t)	Residual gas content(m^3/t)	Extraction rate(%)
45~55m	13.81	5.81	57.93
95~105m	13.81	5.64	59.16
145~155m	13.81	7.32	46.99
195~205m	13.81	7.83	43.30
245~255m	13.81	7.61	44.90
295~305m	13.81	7.59	45.04
345~380m	13.81	7.81	43.45

3.3. The Long-distance Bedding Directional Borehole Drilling with Long Construction Quantity Analysis

Taking the main transport roadway excavation 400m for example, the ordinary drilling rig construction is carried out to drainage, then each digging 80m need to construct a cycle, each cycle drilling footage 200m. The gas content drops to the target gas content $8\text{m}^3/\text{t}$, and it takes 5 cycles. According to the ordinary drilling construction quantities in January 2016, the comparison of comprehensive advance rate between the long-distance bedding directional borehole and the ordinary drilling is as shown in Table4.

From the Table4, the integrated tunneling is the slowest when using the ordinary drilling drainage. While the comprehensive excavation speed of long-distance bedding directional borehole is the fastest, and the average monthly drilling footage is 133m. And it is proved that the long-distance bedding directional borehole can effectively reduce the construction amount of drilling holes.

Table 4. Comprehensive advance rate

Classification	The ordinary drilling		The long-distance bedding directional borehole
	Hole spacing 4m	Hole spacing 3m	
Drilling work amount	1000m	1000m	1088m
Extraction time	at least 95 days	at least 70 days	25 days
Drilling construction time	5 days	5 days	8 days
Normal advance speed	7 m/day	7 m/day	7 m/day
Comprehensive advance speed	76 m/month	90 m/month	133 m/month

4. SUMMARY

(1) The gas content of the main transport roadway driving face decreases from $13.81\text{m}^3/\text{t}$ to $7.81\text{m}^3/\text{t}$ after 25 days by the implementation of the ordinary borehole gas drainage, long-distance bedding directional borehole gas drainage test, and the gas pre-pumping rate is about 43.30%.

(2) With using the ordinary drilling drainage, the integrated tunneling is the slowest. While the comprehensive excavation speed of long-distance bedding directional borehole is the fastest, and the average monthly drilling footage is 133m.

(3) Through the application of the long-distance bedding directional borehole in the main transport roadway of Huoerxinhe coalmine, it is proved that the long-distance bedding directional borehole can effectively reduce the construction amount of drilling holes and improve the gas extraction rate compared with the traditional ordinary drilling holes, so as to achieve the purpose of effectively eliminating the outburst danger and finally reduce the construction quantity of drilling, save the economic costs to achieve the safe and rapid excavation of the coal mine roadway.

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