

# Study on Pre Pumping and Outburst Elimination Technology of "one hole and two elimination" in Bedding Directional Long Drilling

Benqing Yuan<sup>1,2,3,\*</sup> Yongjiang Zhang<sup>1,3</sup>

<sup>1</sup> Chongqing Research Institute CO., Ltd of China Coal Technology Engineering Group, Chongqing, China

<sup>2</sup> Anhui University of Science and Technology, Huainan 232001, China

<sup>3</sup> National Key Laboratory of Gas Disaster Monitoring and Emergency Technology, Chongqing, China

**Abstract.** Aiming at the problem of gas control in the working face and the roadway to be excavated at the same time due to the small construction length of bedding borehole under the condition of the occurrence of soft coal, a technology of "one hole and two elimination" pre-drainage to eliminate gas outburst by using air screw motor drilling was put forward, and the field test was carried out in the 17102(3) working face of Pansu Coal Mine. The results show that this technology can effectively control the borehole trajectory, ensure the uniform and reasonable range of borehole outburst elimination, solve the problems of long gas treatment cycle caused by the construction of gas treatment roadway, improve the effective drainage time of borehole, ensure enough time and space for gas treatment, and be beneficial to the mining and replacement of mine.

## 1 "One hole two elimination" technology principle

"One hole two elimination" technique is to use the roadway drivage face side has the construction site, the rig directional construction some bedding boring (generally more than 200 m), bedding near borehole control with mining face mining areas and with digging coal roadway stripe area (Fig.1), then use bedding directional borehole extraction control area of coal seam gas drilling. In order to solve the problem of small control range of short drilling, many drilling holes, long moving time during construction, short extraction time, uncontrollable deviation of drilling holes resulting in drilling holes can not be uniformly distributed in the coal seam according to the design, and relieve the tension of extraction and mining replacement[1-3].

## 2. Engineering geological condition

The 17102(3) working face of Pan-San Mine is located in Dong-si Mining Area with elevation of -680~-724m. The mining strike length of the working face is 1820m(including 1048m solid section), the dip width is 200m, the 13-1 coal thickness is 3.2~4.7m, the average thickness is 4.0m, the average dip Angle is 8°, and the measured gas pressure is 2.8MPa. The gas content is 8.4m<sup>3</sup>/t, and the permeability coefficient of coal seam is 0.022m<sup>2</sup>/(MPa<sup>2</sup>·d).

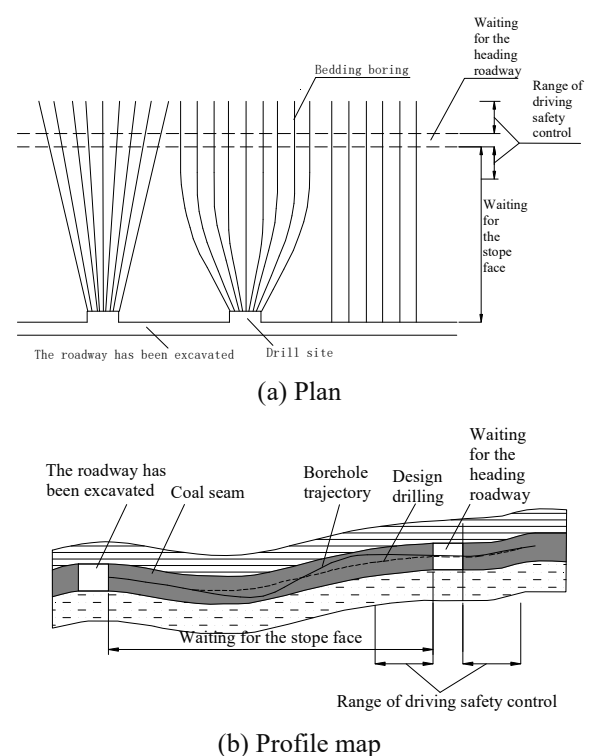


Fig. 1 Schematic diagram of "one hole and two elimination" drilling layout

17102(3) track grooves are goaf tunneling roadways. In order to solve the problem of gas outburst on the coal working face and transportation grooves at the same time after tunneling is completed, 17102(3) track grooves are considered as the drilling site to drill long boreholes into

\* Corresponding author: 2012156@cqccteg.com

the coal working face and transportation grooves for regional pre-drainage and outburst elimination, that is, "one hole and two elimination".(3) The design length of the transport route is 1,820m, of which 1,048m in the western section is located in the solid section of the outburst danger zone. In the solid section, 100m area is selected as the "one hole and two elimination" test area. However, directional drilling of bedding borehole is difficult, the borehole trajectory is difficult to effectively control, and the gas treatment period is long caused by the construction of gas treatment roadway, etc., which are difficult problems for the implementation of "one hole and two elimination" technology.

### 3. Drilling equipment technology

#### 3.1 Drilling equipment

##### 3.1.1 Rig equipment

ZDY6000LD (F) type crawler full hydraulic tunnel drill produced by Xi'an Coal Research Institute is selected as the construction rig, as shown in Fig 2.



**Fig.2** ZDY6000LD (F) model crawler type hydraulic tunnel drill for coal mine

##### 3.1.2 Drilling assembly

###### 1) Drilling BHA

Φ108mm drill bit + 73/83mm outer screw pneumatic motor + 81mm outer screw non-magnetic drill pipe + 81mm outer screw probe pipe + insulation sub + 81mm non-magnetic drill pipe + top 73mm auger pipe, as shown in Fig. 3.



**Fig.3** Drilling BHA

###### 2) Run a casing assembly

Φ92mm steerable bit + 73-40mm integrated large hole auger. The 92mm steerable bit is shown in Fig. 4.



**Fig.4** Φ92mm guided open and close drill bit

##### 3.1.3 Air screw motor

Air screw motor surface smooth type outside diameter 73mm, spiral type outside diameter 85mm, length 4 ~ 4.4m, front deflection 1.25 ~ 1.5°, as shown in Fig.5.



**Fig.5** Air screw motor (flat)

##### 3.1.4 Wireless measuring system

Wireless measurement system transmission distance is not less than 500m, the transmission rate is as high as 50bps, the measurement time is about 40s, the measurement accuracy: Angle ±0.2°, azimuth Angle ±1.2°, tool facing Angle ±1.2°. This is shown in Fig. 6.



**Fig.6** Wireless measuring system (outside hole part)

##### 3.1.5 Lubricating and cooling devices

The hydraulic oil lubrication device improved by the foam generator lubricates and cools the motor to ensure the normal operation of the motor. The main structure includes storage tank, storage hydraulic oil, pressure gauge, communication pipeline, circulation pipeline, gate valve, flowmeter, flowmeter pipeline, structural support, etc., as shown in Fig. 7.



**Fig.7** Lubricating device

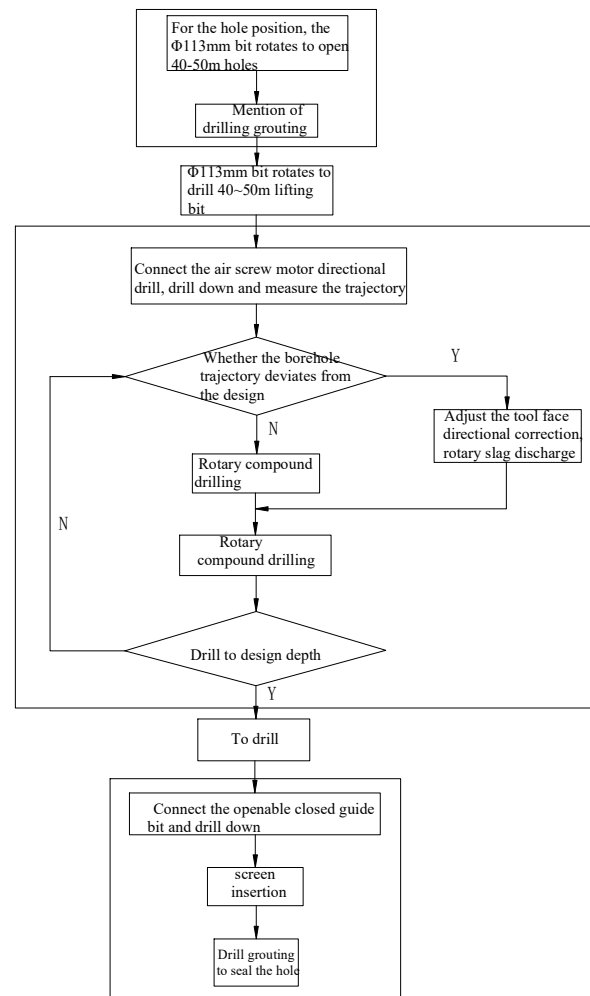
### 3.1.6 Air compressor

The construction of bedding drilling adopts the process of pressing air and discharging slag, and the air pressure in the tunnel system is low. In order to ensure that the air pressure of drilling meets the requirements of drilling construction, the MLGF17/12.5-132G air compressor is selected, with an exhaust capacity of 17m<sup>3</sup>/min and an exhaust pressure of 1.25MPa.

## 3.2 Technical parameters

### 3.2.1 Construction technology

The construction technology of bedding directional drilling for soft coal seam is shown in Fig. 8. In view of the stress concentration area in the open hole section (generally 0~50m) of the construction area, the coal seam is extremely broken. Rotary drilling and grouting treatment are adopted in this section to ensure the stability of the open hole section<sup>[4]</sup>. For some coal seams are loose and broken, and collapse holes are easy to occur. The coal seams in local hole sections are wet, and it is difficult for directional drilling to discharge slag. Therefore, rotary composite drilling should be the main method to ensure normal drilling<sup>[5]</sup>.



**Fig.8** Construction process of directional long drilling along bedding

### 3.2.2 Key parameter

#### 1) Drilling tools

Φ108mm drill bit + 73/83mm external spiral pneumatic motor + 81mm non-magnetic drill pipe under spiral + 81mm external spiral probe pipe + insulation sub + 81mm non-magnetic on spiral + 73mm auger string.

#### 2) Drilling parameters of air screw motor

Rotary drilling speed of 80~120r/min, air volume of more than 400m<sup>3</sup>/h; The air volume of sliding directional drilling is more than 500m<sup>3</sup>/h; When the air volume is lower than 400m<sup>3</sup>/h, the rotary sweeper can fully discharge slag.

#### 3) Directional drilling

The rotary composite drilling is the main method, and the sliding directional drilling is the auxiliary method. The directional drilling is 2~3m, and the rotary sweeping hole is used to drain the slag, and then the directional and rotary sweeping hole is continued to be repeated, so as to ensure the smooth inside the hole and the construction safety.

#### 4) Finish the hole of screen tube

Adopt Φ89mm openable closed guide bit + A73mm integrated large hole auger drill, among which openable

closed guide bit ensures the smooth running into the hole during the second trip and the reliable opening during the running of the screen.

After the completion of directional drilling, connect the openable closed guide bit and the large hole drill pipe to drill again. When the drilling reaches a predetermined depth, stop drilling and insert the hole protection screen pipe from the large hole drill pipe. When the screen pipe pushes the openable closed guide bit position at the bottom of the hole, open the head of the drill and the screen pipe can enter the hole through the drill bit. After the screen is in place, start pulling out the drill pipe, leaving the screen in the hole and the bit and drill pipe out of the hole. After the hole shielding screen tube is placed into the hole, 15~20m outside the hole is covered with PVC pipe.

#### 5) Drilling and sealing holes

The hole sealing process of "two plugging and one injection" was used to seal the hole. The hole sealing depth was 20m, polyurethane plug was used in the range of 5m at the orifice and bottom of the hole, and grouting capsule was used for high pressure grouting at the middle 15m, with the grouting pressure not less than 2MPa.

### 4. "One hole two elimination" technical characteristics

Existing single unprotected recoverable coal seams in or protective layer for the coal seams, occurrence condition of coal seam bedding directional drilling crossing with mining face and with digging a tunnel gas extraction of elimination technique, solve the end of the alley pumping + layer drilling or bedding combined gas control technology of drilling is large volume, high cost, long cycle, etc. It has the following characteristics<sup>[6]</sup>:

(1) The directional drilling track across the working face can be oriented to ensure that the drilling hole is in the coal seam. Using the air screw motor directional drilling method can solve the problem that the roof or floor drilling is not in place because of the fluctuation of coal seam, which can easily be seen by the conventional rotary drilling, improve the drilling depth and coal seam drilling encounter rate of soft coal seam, realize the precise control of bedding drilling trajectory, and ensure the coverage of drilling to eliminate the blind area of gas extraction.

(2) The screen pipe under the whole hole section of directional drilling can guarantee the gas drainage channel, realize the gas pre-drainage and outburst elimination of the working face and roadway to be excavated, and ensure the safe excavation of the roadway and the safe mining of the coal working face.

(3) It can save the engineering quantity of floor roadway and through layer hole, and reduce the production cost while ensuring the safety of coal roadway excavation and working face mining.

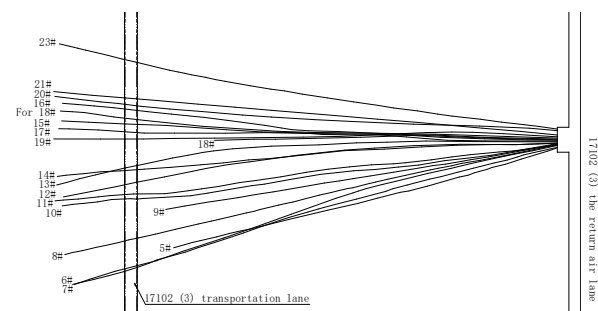
### 5. Application effect

In order to solve the problem of gas outburst elimination in coal working face and transport roadway (return air

roadway) at the same time, reduce the comprehensive cost input of supporting floor roadway and relieve the tension of mine production replacement, 17102 (3) working face with more complex gas and coal seam occurrence conditions was selected for field application of directional long drilling drainage technology along bed in Pansan Mine of Huainan mining area.

### 5.1 Drilling construction

17102 (3) A total of 19 directional long boreholes along the bedding were constructed in the return air roadway (Fig. 9). The completion parameters of the boreholes are shown in Table 1. According to the actual formation conditions of Pansan Mine, the directional long hole diameter of 17102 (3) working face is determined to be  $\Phi 108\text{mm}$ . The boreholes are arranged in two rows, with opening heights of 1.2m and 1.8m respectively. The spacing of each row of holes is 0.6m, and the spacing of the final hole is 5m. The directional drilling construction technology is adopted to realize the drilling construction along the coal seam, improve the coal penetration rate of the long borehole along the bed, basically realize the control of the drilling trajectory, realize the precise directional construction, and the drilling penetration rate of 8 boreholes in the coal seam reaches 100%.



**Fig. 9** Pore drawing of directional drilling construction in bedding

**Table 1** 17102 (3) Construction of directional drilling for bedding in return air roadway

Serial number	Boring number	Aperture /mm	Hole depth /m	Drill encounter rate/%	Sieve tube length /m	Upper and lower deviation /m	Left-right deviation /m
1	23#	108	231	85.54	231	-0.87	-
2	21#	108	224.5	93.7	220	-0.40	-0.7
3	20#	108	225	93.7	214	-1.03	1.9
4	19#	108	225	91.6	220	-0.92	-1.5
5	18#	108	160	100	-	-	-
6	For 18#	108	221	100	220	-1.88	1.4
7	17#	108	223	100	220	-0.61	-2.0
8	16#	108	221	89.6	220	-1.94	-
9	15#	108	221	100	202	-1.55	-
10	14#	108	224.5	100	220	-1.81	-2.1
11	13#	108	222.5	100	220	-1.4	-1.4
12	12#	108	224	100	220	-1.7	-1.9
13	11#	108	224	91.5	220	-2.0	-0.9
14	10#	108	224	100	220	-2.04	2.0
15	8#	108	224	100	218	-1.9	1.1
16	7#	108	227	90.7	220	-1.9	-2.0
17	6#	108	227	93	220	-1.72	-
18	9#	108	170	100	170	-	-
19	5#	108	175	100	171	-	-

## 5.2 Application effect

Based on the failure characteristics of surrounding rock of deep mining roadway in huainan mining area, the grouting pressure of "two blocks and one injection" with pressure grouting and hole sealing method is calculated. According to the results of fluid mechanics and field grouting technology, the  $P_z$  expression of grouting pressure is obtained as follows.

In order to test the drainage effect, six drill holes were constructed corresponding to 17102(3) transport lane. The maximum distance from the bedding directional drill was 6.4m, the measured maximum residual gas pressure was 0.35MPa, and the residual gas content was 3.69m<sup>3</sup>/t. After inspection, the extraction within the control range of drilling is up to standard.

17102(3) in the area where bedding directional drilling extraction technology is adopted in the transport roadway, the average driving footage is 9.3m/d. Outburst risk cycle prediction is performed in the roadway driving process, and the maximum prediction indexes for outburst prevention are  $S_{max}=3.5\text{kg/m}$  and  $Q_{max}=2.91\text{L/min}$ . During tunneling, the roadway air distribution volume was 960m<sup>3</sup>/min, and the maximum gas concentration of return air was 0.23%, which realized safe and efficient tunneling.

## 6 Conclusion

(1) The technology innovation of "one hole and two elimination" of bedding long drilling is carried out. One bedding long drilling is carried out, and at the same time, the coal mining face and transportation groove are pre-drained and outburst is eliminated in the region, which saves a lot of engineering work of bedding through drilling.

(2) A good drainage effect was obtained. A total of 322,000 m<sup>3</sup> of gas was extracted from 14 boreholes, the extraction rate was 61.3%, the residual gas pressure was 0.35MPa, and the residual gas content was 3.69m<sup>3</sup>/t. The average gas concentration was still about 50% after 7 months, which was 3-4 times that of conventional drilling.

(3) The directional drilling technology of "one hole and two elimination" bedding long borehole can effectively control the borehole trajectory, ensure the uniform and reasonable range of borehole outpouring elimination, and at the same time can fully discharge slag, ensure the unblocked drainage channel in the borehole, and improve the drainage effect.

(4) "One hole and two elimination" bedding long borehole is constructed in the groove by the track constructed in advance, which solves the problem of long gas treatment cycle caused by the construction of gas treatment roadway, improves the effective drainage time of borehole, ensures enough time and space for gas treatment, and is conducive to the production replacement of mine.

## Acknowledgments

This work is financially supported by National Natural Science Foundation of China (No. 52004005), Anhui

Provincial Natural Science Foundation (No. 2008085QE222), China Postdoctoral Science Foundation (2021M691185), Anhui University of Science and Technology Introduction of Talents Research Fund Project, Scholastic Key Project (No. QN2019113), Patent Transformation and Cultivation Project (No. ZL201907).

## References

1. Chen Jian, Luo Yong. Research on the technology of "one hole and two elimination" pre-drainage to eliminate outburst in bedding long borehole [J]. Mining Technology, 2020,20(5):47-50.
2. ZHANG Jie, WANG Yi, HUANG Hanjing, et al. Research on directional drilling technology of air screw motor in soft coal seam [J]. Coal Science and Technology, 2018, 46(11):114-118.
3. WANG Xian, XU Chao, LIU Fei, JIANG Lei, et al. Key equipment and application effect analysis of ultra-long directional drilling along coal seam [J]. Coal Engineering, 2019, 51(11):46-50.
4. WANG Yong, ZHOU Yan-an, TONG Xiao-zhang. Optimization and Application of Regional Anti-outburst Measures in Pre-pumping Coal Seam Gas [J]. Coal Technology, 2021, 40(02):133-136.
5. LI Yanqing, TANG Yongzhi, TANG Bin, et al. Innovation and development of coal and gas co-mining technology in Huainan mining area [J]. Safety in Coal Mines, 2020, 51(8):77-81.
6. FANG Jun, LI Quanxin, XU Chao, et al. Construction technology and development tendency of gas drainage borehole in soft and outburst seam [J]. Coal Science and Technology, 2018, 46(5): 130-137, 172.