High efficiency extraction technology and application of bedding directional long borehole along in Coal Roadway

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Abstract. In view of the occurrence conditions of coal seam groups in most mining areas in China, the protective layer mining mode is mainly adopted to carry out gas treatment in regional coal seam. In this paper, based on the pressure relief mining of the protective layer, the principle, type and geological conditions of the co-mining mode of the protective layer coal and gas under the condition of coal seam group are analyzed. In Taoyuan Coal Mine, there are some problems such as frequent handling, low efficiency, difficult to control the drilling track, poor drainage effect, etc. The directional long drilling hole is used instead of bottom drainage roadway to reduce the moving time of drilling rig. According to the coal seam characteristics of Taoyuan Coal Mine, the directional drilling rig and other equipment suitable for Taoyuan Coal Mine are selected, and the directional long drilling technology is studied, A total of 13 directional long boreholes have been constructed in the inner section of Ⅱ8223 machine roadway, with a total length of 2336m, a lower screen pipe of 2249m, a cumulative coal slag discharge of 480.17t, and an equivalent diameter of 442mm. By January 14, 2020, 78577m³ has been pumped by directional long boreholes, with an average pumping concentration of 15% ~ 100%, and an average net pumping volume of 0.05m³/min ~ 0.40m³/min. It saves the construction of floor drainage roadway, reduces the amount of drilling work for gas control, saves 6 million yuan of gas control investment in the inner section of Ⅱ8223 machine roadway, shortens the time for reaching the standard of drainage for 2 ~ 3 months, effectively alleviates the tension of mine production replacement, and realizes safe, economic and efficient mining.

1. Introduction
Most mining areas in China have the mining conditions of coal seam groups [1]. In order to reduce the gas pressure and content of the adjacent high gas and outburst coal seam or to eliminate the outburst danger of the adjacent coal seam, the coal seam or rock stratum first mined becomes the protective layer. The protective layer above the high-gas outburst coal seam is called the upper protective layer, and the lower protective layer is called the lower protective layer. Due to the mining operation of the
protective layer and the simultaneous extraction of the pressure relief gas, the outburst danger area of the adjacent high-gas and outburst dangerous coal seam can be transformed into low-gas coal seam or no outburst danger area, and the high-gas or outburst coal seam is called the protected layer [2].

Under the mining action of the first coal seam, the adjacent coal seam shows obvious pressure relief characteristics on the macro level, and on the micro level, it will cause the decrease of in-situ stress, movement deformation, fracture development and increase of permeability coefficient of the adjacent coal seam. In general, the adjacent coal seam is the main coal seam of the mine, and its gas occurrence is abundant and gas disaster is serious. Especially when it is far away from the first coal seam, it is necessary to carry out gas extraction under the pressure relief state, that is, carry out pre-mining extraction of the adjacent coal seam to reduce the gas pressure and gas content of the adjacent coal seam. On the one hand, it can improve the safe mining degree of the working face of the first coal seam. On the other hand, it can completely eliminate the outburst risk of adjacent main mining seam and create conditions for safe mining of main mining seam [3].

On August 1, 2009 promulgated the regulation on prevention and cure of coal and gas outburst and promulgated on October 1, 2019 implementation of the prevention and cure of coal and gas outburst rules are put forward in the outburst prevention work adhere to the "leading regional outburst prevention measures, local outburst prevention measures complement" principle, and clearly put forward regional outburst prevention measures shall give priority to adopt protective layer mining technology, thus protective layer mining technology in the outburst prevention work.

Based on the pressure relief mining of the protective layer, the paper analyzes the principle, type and geological conditions of the co-mining mode of the protective layer coal and gas under the condition of coal seam group.

2. Project overview

Il 8223 working face is located in the second stage of Il 2 mining area, the upper section is the second level Il 8221 goaf and Il 8222 working face, right to the north of 5-6 exploration line, left to the boundary of Il 2 mining area; the corresponding lower protective layer is the goaf of working face Il 1027 and working face Il 1029. The working face elevation is -567.2-665.2m, the design strike length is 1292-1366m, the average is 1329M, the inclined length is 185-193m, the average is 189m, and the coal seam reserve is 563700 t. The Il 8223 working face is located in the outburst danger area. The protective layer mining measures have been taken in the middle section of the working face. The mining effect of the protective layer has been investigated and the effective protection boundary has been delimited. The middle section of Il 8223 machine roadway is located in the effective protection range of protective layer and has been constructed in place. In the unprotected area of the inner section of the machine roadway, it is planned to adopt floor through layer drilling to pre extract strip gas from coal roadway.

3. Directional drilling rig equipment and technology

3.1. Selection of directional drilling rig

1. Selection of directional drilling rig

According to the existing conditions, ZDY12000LD directional drilling rig is selected for the test, as shown in Fig. 1, which can meet the requirements of directional drilling. The torque of the drilling rig reaches 12000n·m, and the feeding and pulling force reaches 250kN, which has certain accident handling capacity.
2. Directional bit selection

The air screw motor directional drilling in soft coal seam puts forward special requirements for the rock breaking ability and directional function of the bit. On the one hand, it is required that the coal chip particles cut down are small and easy to be discharged by compressed air; on the other hand, the bit is required to have the directional function of opening branch with screw motor. The drilling bit with a diameter of 113mm for hydraulic screw motor and a Φ 108mm bit for opening and closing.

3. Other

According to the drilling needs, the special large hole tail water is designed and equipped with large hole high-pressure rubber hose. Considering the requirement of slag discharge, the screw nipple is designed according to the bit position. In order to meet the cooling and lubrication requirements, a cooling and lubricating device is equipped. In addition, in order to observe the drilling air supply parameters, a flowmeter is installed to monitor the flow and air pressure, as shown in Fig. 2-4.

3.2. Directional drilling construction technology

1. Directional drilling trajectory control

The construction technology of air screw motor directional drilling mainly refers to the directional construction technology of hydraulic motor and air pressure drilling technology in coal mine, and carries out research according to the characteristics of soft coal drilling.

2. Composition of directional drilling system with air screw motor
The air screw motor directional drilling system mainly consists of directional bit, air screw motor, upper (lower) non-magnetic drill pipe, measuring probe pipe, insulating nipple, drill pipe, water, orifice monitor, air compressor and flowmeter, etc., as shown in Fig. 5.

3.3. Directional drilling technology
Like the hydraulic screw motor, the air screw motor is a kind of bottom hole power drilling tool. Its working principle is that the high-pressure air provided by the air compressor enters the hole bottom through the water and the center of the drill pipe. The air screw drives the motor to rotate, so as to drive the drill bit to cut the coal and rock in the hole. In directional drilling, the whole drill string does not rotate, and only the bottom hole screw drilling tool drives the bit to rotate and break rock, and then it extends forward under the action of the feed force.

The reason why the screw drill is used in directional drilling is mainly based on two reasons: one is that during the directional process of the air screw motor, the drill bit rotates to break the rock, but the whole drilling tool does not rotate; the second is that the bent outer pipe is set at the lower end of the air screw motor, which makes the screw drilling tool bend. Under the action of WOB, the bit will produce different lateral forces around the hole wall, so as to realize the deviation drilling.

The drilling trajectory control is mainly realized by changing the direction of the bending angle of the air screw motor at the bottom of the hole (that is, the tool facing angle). In the system, the data of dip angle, azimuth angle and tool face angle are transmitted to the hole monitor in real time for processing, and the actual drilling trajectory is formed and displayed. According to the deviation between the designed trajectory and the actual drilling trajectory, the tool face angle is adjusted to achieve the purpose of adjusting the drilling trajectory or correcting the deviation, and the drilling trajectory is extended along the predetermined direction.

4. The field test
4.1. Test scheme
The drilling site is constructed at J3 + 20m in the middle section of Ⅱ 8223 machine roadway. The drilling field is 8.8m wide and 3.3m high (middle roof). It is developed from the original roadway to the upper side. Seven boreholes are designed. The plane of the middle hole (1# hole) is along the middle line of the roadway. Three boreholes are arranged on both sides with a spacing of 6m. The control roadway is 15m outside the contour line of both sides. The design depth of the drilling hole is 300m. The profile track is located at the bottom of coal seam 82, close to the floor mudstone layer. The opening
position is located in the bottom mudstone with a spacing of 1 m. The drilling hole passes through the mudstone of coal seam floor and is constructed along the direction of roadway coal seam.

Fig. 6 Design of directional bedding drilling for Ⅱ 8223 machine roadway

4.2. Drilling construction
The design spacing of directional bedding boreholes in the inner section of Ⅱ 8223 machine roadway is 6m. The construction of directional bedding boreholes starts from September 26, 2019 and ends on January 13, 2020. Thirteen directional bedding boreholes are constructed, with a work quantity of 2336m. On the inclination of drilling, no less than 15m outside the contour line on both sides of the roadway is controlled. During the drilling construction, there is no abnormal dynamic phenomenon such as spray hole and top drilling. A total of 7 holes have been formed, the engineering quantity is 2336m, the lower screen pipe is 2249m, the accumulated coal slag is 480.17t, and the equivalent diameter of drilling hole is 442mm.

Tab. 1 Borehole parameter table

| Borehole number | Final hole depth | Coal washing quantity | Bottom screen depth |
|-----------------|------------------|-----------------------|---------------------|
| 0#              | 337              | 44.28                 | 195                 |
| L-1#            | 338              | 39.64                 | 203                 |
| L-2#            | 330              | 41.48                 | 190                 |
| L-3#            | 326              | 37.63                 | 224                 |
| R-1#            | 335              | 45.64                 | 201                 |
| R-2#            | 336              | 44.32                 | 202                 |
| R-3#            | 334              | 23.68                 | 204                 |

4.3. The test results
The seven directional boreholes began to be pumped after the completion of the construction. The mine arranged the measurement every day on November 11. The average daily pumping concentration and purity of directional boreholes are shown in Fig. 7 and Fig. 8.

Fig. 7 Average drainage concentration of directional drilling
By January 14, 78577m³ has been pumped by directional long boreholes, with an average pumping concentration of 15% ~ 100%, and an average net pumping volume of 0.05m³/min ~ 0.40m³/min. Directional bedding drilling "replacing roadway with drilling" lays the foundation for the construction mode of one drilling in place, which saves the construction of floor drainage roadway and reduces the amount of drilling work for gas control. Only in the inner section of Ⅱ 8223 machine roadway, the gas control investment of 6 million yuan can be saved, and the machine roadway can be constructed 2-3 months in advance, which effectively relieves the tension of mine production replacement and realizes safety Economic and efficient mining.

5. Conclusion
(1) The test shows that the construction equipment of directional long drilling "replacing roadway with drilling" is stable, the failure rate is low and the construction efficiency is high. In the construction process, the repeated moving of drilling rig is avoided, and the safety risk in the construction process is reduced.

(2) After the construction of directional long drilling hole, more than 40% of the work amount of gas control boreholes can be effectively reduced, more than 6 million yuan of investment in a single drilling site can be reduced, and the gas control and drainage time can be shortened for more than 2 ~ 3 months, which can effectively alleviate the tension of the mine excavation replacement, and realize the safe, economic and efficient mining.

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