Research on screen pipe hole protection technology of large diameter directional long drilling hole

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Abstract. In order to solve the problems of serious hole collapse and poor gas drainage effect of large diameter directional long borehole in roof under complex geological conditions, based on the gas geological conditions of 32 coal seam in Zouzhuang coal mine, the research on hole protection technology of full hole under large diameter directional long borehole of roof under complex geological conditions was carried out. The construction efficiency was improved by 32\%, the drilling hole forming effect was good, and the gas drainage effect reached the expectation.

1. Introduction
Gas disaster is one of the most serious disasters in coal mine production. Gas drainage is the fundamental measure to solve the gas disaster in coal mine. The results show that the large diameter directional long borehole drainage technology can effectively change the gas flow field in the goaf, weaken the gas emission intensity in the goaf, and has the advantages of high gas drainage concentration, low operation cost of drainage system, good comprehensive control effect and remarkable economic benefits. In recent years, with the improvement and upgrading of large diameter directional long drilling equipment and technology, it has gradually become an important technology to solve the gas disaster in working face safely and efficiently. With the increase of mining depth, the mine gas geological conditions become more and more complex, which brings many problems to the large diameter directional long drilling construction. After the completion of drilling construction, the problem that gas cannot be extracted due to hole collapse often occurs. Taking the 32 coal seam of Zouzhuang coal mine as the research object, the field test and Research on the technology of screen pipe protection in the whole process of large hole diameter long drilling hole was carried out, which effectively solved the problem of large diameter directional drilling hole forming, and improved the construction efficiency and gas drainage effect.

2. Project overview
The 3303 working face of Zouzhuang coal mine mainly adopts 32 coal seam with coal thickness of 1.78m–3.20m, with an average of 2.44m. the coal thickness changes little and the coal seam is relatively stable. The overall evaluation of the geological conditions of the working face is medium, and the overall
strike of coal (rock) layer is near NW~SE and tends to ne. The dip angle of coal (rock) bed is 10~26° with an average of 15°.

The geological structure of 3303 working face is medium. According to the analysis of exploration data and roadway actual exposure data, there are 5 faults with large drop within the working face construction scope. The roof of coal seam is sandstone and mudstone, and the boreholes are arranged in stable sandstone.

3. Directional drilling construction

3.1. Directional drilling construction equipment

(1) Selection of directional drilling rig

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

![Fig. 1 ZDY12000LD directional drilling rig](image-url)

(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 phenomenon of holding air and not returning slag occurs in both the Φ113mm directional bit for liquid drive screw motor and the Φ108mm openable and closing bit. The analysis shows that the common characteristics of these two kinds of bits are that there is only one large nozzle, the pressure air provided by air motor drilling is not high, and the bit position is easy to be blocked by pulverized coal.

According to the needs of drilling, special large hole water convenience is designed and equipped with high-pressure rubber hose. 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 rate and air pressure.

3.2. Construction parameters of directional drilling

(1) Construction parameters

According to the research results of "three zones" theory and gas diffusion seepage theory, and the practical experience of gas prevention and control in coal mine, the directional long drilling hole is selected in the mining fault zone. The drilling straight stage is located within 20m of the roof of 32 coal
seam, and the horizontal distance from the air roadway is 10m, 20m and 50m. The construction parameters of directional drilling are shown in Table 1, among which 4# hole is large diameter directional drilling.

**Table 1. Construction parameters of directional drilling**

| Number | Azimuth /° | Degree inclination /° | Hole depth /m | Screen pipe diameter /mm | Screen pipe length /m |
|--------|------------|-----------------------|---------------|--------------------------|----------------------|
| 1#     | 7          | 18                    | 540           | 50                       | 536                  |
| 2#     | 13         | 18                    | 525           | 50                       | 520                  |
| 4#     | 21         | 18                    | 552           | 108                      | 521                  |

(2) Construction situation

In 3303 working face of Zouzhuang coal mine, the large diameter 4# hole is designed with an opening angle of 18° and an azimuth of 21° to the left. From 24m to 84m, the dip angle changes continuously, and from 84m to 141m, the azimuth changes continuously. The bending strength of the two sections is relatively large, so the directional construction is completed and the composite drilling technology is adopted to ensure that the borehole wall is smooth. The design total hole depth is 531m, and the actual construction total hole depth is 552m. The dip angle and azimuth of other sections are very stable without great change.

4. Screen pipe hole protection technology

4.1. Drilling and opening

During the rotary drilling, the rotary speed shall not exceed 20 rpm, so as to ensure that the parameters such as inclination angle and azimuth will not change in the early stage of drilling, and the later measurement data basically have no deviation from the design.

4.2. Directional drilling footage

After rotary drilling, directional drilling was carried out with Φ120mm bit and mud pulse equipment. The footage of 6 round teams and 2 small teams was 552m, and the average drilling footage was 28m. The drilling was lifted and reamed at the final hole. During directional drilling, ensure that there is no large angle up, down hill and negative angle. After each group of directional footage, punch holes in time, drain out the rock powder in the drill, enhance the accuracy of drilling measurement data, find out the position with large bending strength of the drilling hole, and mark it clearly. When expanding the hole, the hole is swept back and forth for many times, so as to ensure the smoothness of the screen pipe under the borehole.

4.3. Drilling, reaming and punching

After the completion of drilling construction and lifting, use the Φ153mm guiding bit (guiding 120mm) and variable diameter reaming to reach the final hole depth. It takes 8 small shifts and the average drilling footage is 69m. The hole is expanded by a Φ193mm drill bit for 26m. When using a Φ153mm pilot bit for reaming, for the measuring section with large change in total bending strength, the hole shall be swept back and forth for several times to ensure smooth drilling.

After reaming, punch the hole every 30m of drill pipe to ensure that the rock powder in the hole is drained. For the section with large change in total bending strength, the hole should be swept back and forth for many times and punched for a long time to ensure smooth and clean drilling.

4.4. Screen pipe hole protection technology

Replace the gripper and rotator slip, and lower the Φ108mm steel screen pipe with drilling rig clamping and pushing method. The total depth of the lower screen pipe is 521m, which is completed in four small teams, with an average of 130m in each shift. Because the screen pipe is too heavy, it needs 4~6 people to separate the two sides of the screen pipe to make sure that the screen pipe is not loose. Install the
screen pipe to ensure that the screen pipe thread is full, and then cycle until the end. The required materials are shown in Table 2.

After the completion of screen pipe running, the diameter of Φ146mm under the hole changes into 127mm casing 2m, and the bag is tied to the 127mm casing to prevent the bag from being worn during casing running. Then, the 146 casing is 22m and the total sealing length is 24m. The grouting volume is 0.75t and the pressure is 1.2MPa. Finally, the stubble is pulled out.

Table 2. Materials required for screen pipe hole protection process

| Name                                | Number |
|-------------------------------------|--------|
| Φ108mm steel screen pipe            | 550m   |
| Φ108mm steel screen coupling        | 550m   |
| Φ113mm steel screen seeker          | 1      |
| Φ108mm gripper slip                 | 4 sets |
| Φ108mm chuck slip                   | 4 sets |
| Φ146mm bushing                      | 25m    |
| Φ146mm to Φ127mm casing             | 2m     |
| Large aperture pouch                | 1 set  |

5. Field application effect
The actual drilling depth of 1# hole is 540m, and the depth of lower screen pipe is 536m. The actual drilling depth of 2# hole is 525m, and the depth of lower screen pipe is 520m; the actual drilling depth of 4# hole is 552m, and the depth of lower screen pipe is 511.5m.

Table 3. Construction period of large diameter directional drilling and ordinary drilling

| Working procedure      | Number | Total shifts | Number of people | Total time /h |
|------------------------|--------|--------------|------------------|---------------|
| Drill hole             |        |              |                  |               |
| 1#                     | 21     | 3            | 168              |               |
| 2#                     | 23     | 3            | 184              |               |
| 4#                     | 20     | 3            | 160              |               |
| Reaming and punching   |        |              |                  |               |
| 1#                     | 9      | 6            | 72               |               |
| 2#                     | 2      | 6            | 16               |               |
| Put in screen pipe     |        |              |                  |               |
| 1#                     | 2      | 6            | 16               |               |
| 2#                     | 4      | 6            | 32               |               |
| Sealing hole           |        |              |                  |               |
| 1#                     | 1      | 4            | 8                |               |
| 2#                     | 1      | 4            | 8                |               |
| 4#                     | 1      | 4            | 8                |               |
| Total time             |        |              |                  |               |
| 1# + 2#                | 400 hours (16 days and 16 hours) |               |
| 4#                     | 272 hours (11 days, 8 hours)     |               |

Through comparison, the total construction time of 1# hole, 2# hole and 4# hole is 400 hours (16 days and 16 hours) and 272 hours (11 days and 8 hours) respectively. Compared with hole 1# and hole 2#, the total time of hole 4# saved 128 hours (5 days and 8 hours), and the total time decreased by 32%.

6. Conclusion
According to the theory of "three zones", combined with the actual situation of the working face, it is analyzed and determined that the drilling straight keeping stage of large diameter directional drilling in roof is within 20 m of roof of 32 coal seam. By comparing and analyzing the labor cost and construction period cost of large diameter roof directional drilling and ordinary roof directional drilling under the
same conditions, the large diameter roof directional long drilling is more efficient for gas control in mining face.

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