Application of full-section gas extraction drill in zhao zhuang coal mine

Gao Yong, Xu Pengbo
Xi’an Research Institute, China Coal Technology and Engineering Group Corp, Xi’an, Shaanxi 710077, China

Abstract: In order to solve the coal mine gas extraction from whole section fan-shaped hole fast construction technical problems, through to walk type crawler drilling rig structure and the design of the hydraulic system, developed a whole section of roadway fan in mine gas extraction hole drill, the Angle of institution by hydraulic motor driven rotary gear reducer to feed within a cross section of 360° fuselage quickly adjustable Angle, reduce the assistant time of drilling construction, the hydraulic system controlled by single action, the operation is simple and reliable. Field tests show that the drill has strong structural stability, easy to move, and is a monolithic crawler drill that can be applied to the construction of gas extraction borehole with large inclination Angle and full section.

1. Introduction
With the expansion of coal mining scale and the increase of mining depth, the problem of coal mine safety production becomes more and more prominent, especially the mining of coal seams with low permeability, soft, high gas content and outburst risk. The adoption of bottom suction tunnel perforating hole can effectively improve the gas extraction effect, reduce the gas content of coal body, and realize safe and efficient tunneling of roadway [1-4]. At present, gas in adjacent strata is often extracted by perforating holes in coal mines in China. In general, a special drilling site is set every 30 ~ 50 m in the bottom rock roadway or coal roadway, and 5 ~ 10 boreholes are arranged in a radial pattern of fan shape. The drilling depth is generally not more than 150 m, and the inclination Angle is mostly within the range of 30° ~ 150° [5]. The pre-extraction of gas in the bottom drainage hole requires the drill to move the drill once to complete the construction of all the gas extraction holes in a section. The hydraulic system must be safe and reliable to prevent the hidden dangers caused by the construction of large Angle drilling holes.

ZDY3600LQ type coal mine crawler full hydraulic tunnel drilling machine is a kind of full hydraulic tunnel drilling machine with medium and low speed, high torque, which can carry out full section gas extraction drilling.

2. Rig structure and parameters
The ZDY3600LQ drill can be used for drilling through layer holes. It can go by itself through the crawler and has strong adaptability to the roadway. On the basis of studying the construction characteristics of full-section drilling in bottom suction roadway, the ZDY3600LQ roadway fan gas extraction drilling rig is designed by using the optimal design method, which meets the construction requirements of full-section perforating drilling in bottom suction roadway [6-11].
The structure of the drill is shown in figure 1. It is composed of main engine, stabilizing device, tracked vehicle body, motor pump set, fuel tank and control console. All parts are connected by high pressure rubber hose and bolts, with compact structure and high reliability.

![Figure 1 Schematic diagram of rig structure](image)

1 - The host; 2 - Stabilizing device; 3 - Tracked vehicle body; 4 - Motor pump set; 5 - Tank; 6 - Console

The ZDY3600LQ type crawler full hydraulic tunnel drilling machine is mainly applicable to the construction of underground suction tunnel hole in coal mine, which meets the requirements of full-section drilling, convenient Angle adjustment and strong adaptability of technology. The main performance parameters of the drill are shown in table 1.

| Name                              | Parameter | Value                  |
|-----------------------------------|-----------|------------------------|
| Rated torque                      | /N m      | 3600 ~ 800             |
| Rated speed                       | / (r/min) | 70 ~ 260               |
| Main shaft Angle                  | /°        | 0 ~ 180                |
| Rated feed/pull force             | /kN       | 80 / 80               |
| Feeding Stroke                    | / mm      | 1250                   |
| Maximum walking speed             | /(km/h)   | 2                      |
| Climbing ability                  | /°        | 15                     |
| Rated power                       | /kW       | 55                     |
| Drill pipe diameter               | / mm      | 73 / 89                |
| Machine quality                   | / kg      | 8000                   |
| Transportation state dimensions   | / m       | 3.2 x 1.25 x 2.25      |

3. Industrial test
The ZDY3600LQ drilling rig passed the performance test in March 2017 at the national safe production xi 'an exploration equipment testing and inspection center, and all the indexes met the design requirements. The field industrial test is located in the north return air suction lane, west wing, 2 pan district, zhaozhuang mine, shanxi jincheng anthracite mining co., LTD.

3.1. overview
Because of the high gas content, the soft and broken coal seam and the poor permeability of coal seam No. 3 coal seam in Zhaozhuang Coal Mine, the borehole collapse often occurs in the borehole along the coal seam, which causes the shallow depth of borehole and restricts the control of coal seam gas. The
gas drainage problem in actual production process can be effectively solved and the driving speed can be improved by using floor drainage through seam drilling. The lithology of roof and floor of 3 # coal seam is summarized in Table 2.

| Lithology               | Thickness /m | Lithologic description                                      |
|-------------------------|--------------|-------------------------------------------------------------|
| Mudstone, sandy mudstone| 4.80         | Dark grey, even with thin seam                                |
| 3 # Coal                | 4.55         | Black, block-based, semi-bright                              |
| Mudstone, sandy mudstone| 7.20         | Deep ash, gray and black even clip thin coal seam            |
| Fine-medium grained sandstone | 2.10   | Off-white, feldspar quartz mixed sandstone                   |
| Sandy mudstone          | 2.38         | Dark grey, grey black                                       |
| Limestone               | 2.42         | Gray, rich in flint                                         |

As can be seen from the table, the strata with perforation holes are relatively complicated, and the general hardness coefficient is $2 \leq f \leq 8$. A total of 12 groups of boreholes are designed in the drilling field, with 4 boreholes in each group. The layout of boreholes is shown in figure 2, and the design parameters of boreholes are shown in table 3.

| Number | Hole height (m) | Azimuth (°) | Angle (°) | Deep hole (m) | Coal section (m) |
|--------|-----------------|-------------|-----------|---------------|------------------|
| 1      | 4               | 180         | 54        | 36.7          | 30.1-36.2        |
| 2      | 3.5             | 180         | 46        | 42.3          | 35.0-41.8        |
| 3      | 3               | 180         | 40        | 49.4          | 41.1-48.9        |
| 4      | 2.5             | 180         | 34        | 58            | 48.5-57.5        |

Form a complete set of drill pipe combination for Φ 73 mm * 1000 mm flat drill pipe, drill bit for 113 mm Φ three-wing just postures bit, 113 mm Φ three-wing tire postures PDC bit, Φ 96 mm ball tooth in the streets.

3.2. conventional drilling stage
Normal wear layer hole drilling phase matching assembly to Φ 73 mm * 1000 mm flat drill pipe and Φ 113 mm three-wing just postures bit, 113 mm Φ three-wing postures PDC bit, total construction 20 drilling, hole ratio of 100%. Drilling information is shown in table 4.
Table 4. Statistical table of drilling during conventional drilling

| Number of drilling (a) | Construction period (shift) | Pore forming proportion (%) | Total penetration (m) | Average drilling efficiency (m/h) |
|------------------------|----------------------------|-----------------------------|-----------------------|----------------------------------|
| 20                     | 21                         | 100                         | 745.2                 | 23.6                             |

This phase before eight holes are \( \Phi 73 \text{ mm} \times 1000 \text{ mm} \) flat drill pipe and \( \Phi \) three wing just postures bit with 113 mm, total penetration of 289.2 m, took 10 construction divisions, an average of 18.9 m/h drilling efficiency, and found that the bit loss is serious, the average loss every shift a bit. So behind 12 hole are replacing \( \Phi 73 \text{ mm} \times 1000 \text{ mm} \) flat drill pipe and \( \Phi 113 \text{ mm} \) three-wing tire postures bit, total footage of 456 meters, when 11 construction divisions, the average penetration rate reached 27.4 m/h, significantly improved its drilling efficiency, also significantly lower bit loss.

3.3. hydraulic hammer drilling stage

The hydraulic dth Hammer, also called hydraulic hammer or hydraulic hammer, is a device for generating impact load in hydraulic impact rotary drilling, the matching drill assembly is 73mm * 1000mm outer leveling drill pipe and 96mm spherical tooth drill bit. The schematic diagram of the hydraulic dth Hammer drill assembly is shown in Fig. 3:

![Fig. 3 Schematic diagram of hydraulic submersible hole hammer and drill assembly](image)

Table 5. Statistical table of drilling during hydraulic hammer drilling

| Number of drilling (a) | Construction period (shift) | Pore forming proportion (%) | Total penetration (m) | Average drilling efficiency (m/h) |
|------------------------|----------------------------|-----------------------------|-----------------------|----------------------------------|
| 12                     | 10                         | 100                         | 377.4                 | 28.3                             |

In this stage, the rotary pressure of the drilling machine decreased from 14MPa to 10MPa, the feed pressure decreased from 12MPa to 10MPa, and the drilling efficiency increased from 23.6m/h to 28.3m/h, which was obviously improved.

4. Conclusion

(1) 3 # coal seam roof and floor for Zhao Zhuang ore formation conditions of complex, using the fan fan gas extraction from whole section of roadway hole drill move convenient, adjustable Angle of the advantages of flexible choice \( \Phi 73 \text{ mm} \times 1000 \text{ mm} \) flat drill pipe and three-wing just postures bit \( \Phi 113 \text{ mm} \), 113 mm \( \Phi \) three-wing tire postures combination of PDC bit can effectively solve Zhao Zhuang mine bottom hole drainage way wear layer construction technical problem;

(2) test later choose \( \Phi 89 \text{ hydraulic DTH hammer and } \Phi 96 \text{ mm button bit technology combination} \), use than a previous \( \Phi 73 \text{ mm} \times 1000 \text{ mm} \) flat drill pipe and three-wing just postures bit \( \Phi 113 \text{ mm} \), 113 mm \( \Phi \) three-wing tire postures technology combination of PDC bit drilling efficiency improved significantly;

(3) through the industrial test, the ability of the drilling rig to construct the bottom suction roadway through the strata in the complex strata of zhaozhuang mine was tested, and an effective construction process method for the bottom suction roadway roof and floor through the strata was also explored.
References

[1] Su Haitao, Li Haitao. Application of preextraction technology of bottom suction through borehole in Changping mine [J]. Coal mine modernization, 2015(3) : 15-17.

[2] Yan Yingjun, Six counties of Miao. Research on progressive screen driving technology [J]. Zhongzhou coal, 2009(12) : 5-6.

[3] Wang Tiejun, Zhao Chuanlong, Dai Huaming, et al. Research status and research of mine gas extraction technology [J]. Shanxi coking coal technology, 2012, 36(6) : 27-30.

[4] Gu Lipeng, Luo Xinrong. New development and problems of gas extraction technology in coal mines in China [J]. Energy technology and management, 2011(1) : 105-107.

[5] Shi Zhijun, Hu Shaoyun, Yao Ningping. New technology of drilling for underground gas extraction [M]. Beijing, coal industry press, 2008.

[6] Song Haitao, Liu Yiyang, Yao Yafeng, et al. Development and application of large Angle multi-hole crawler full hydraulic tunnel drill [J]. Coal engineering, 2014(12) : 126-128.

[7] Yauck. Key technology of ZDY4000LD directional drilling machine [J]. Coal geology and exploration, 2012, 40(4) : 82-85.

[8] Yauck. Development and application of ZDY series full hydraulic crawler drill [J]. China coal, 2012, 38(1) : 68-71.

[9] Pang Hairong, Fan Dong, Yao Yafeng. Development and application of ZDY650S top coal drilling machine [J]. Coal engineering, 2006(11) : 117-119.

[10] Yao Ke, Yin Xinshe, Yao Ningping, et al. Design and application of ZDY4000S full hydraulic drill [J]. Coal engineering, 2006(2) : 77-79.

[11] Shi Lu, Li Haining, Yao Ningping, et al. Stress analysis of drag plate of full hydraulic power head drill [J]. Coal mine machinery, 2011, 32(10) : 117-119.