Research on key technology of high speed auger

XU Pengbo, WU Di
(Xi’an Research Institute, China Coal Technology and Engineering Group Corp., Xi’an 710077, China)

Abstract: In order to solve the problem of hole collapse and low construction efficiency in the process of soft media gas extraction. A full hydraulic drilling machine with high drilling speed, cross belt construction ability and strong process adaptability has been developed. Through the industrial test, the high efficiency of the drilling machine in the construction of soft coal gas extraction hole is verified, and a method of drilling efficiently in the soft broken coal seam is explored.

1. the introduction
Gas control is the fundamental measure to reduce and eliminate the occurrence of gas accidents, and the key and emphasis of gas control lies in the construction of gas extraction borehole. There are more soft coal seams in China, accounting for 42% of total coal production. This kind of coal seam has low strength, fast gas desorption and relatively high gas content, and belongs to coal and gas outburst body. Studies have found that, in the construction of soft coal seam gas extraction, spiral drilling technology has good hole formation effect and is an effective drilling construction method [1-4]. Screw drilling technology is adopted for drilling. When the rotating speed of the drilling machine is high, the powder discharge effect is good, which can effectively reduce the resistance in the hole, thus improving the drilling efficiency and drilling depth [5].

At present, most of the gas extraction RIGS in underground coal mines in China are more suitable for working in tunnels without belt conveyor due to the influence of rig structure and other factors. When drilling in tunnels with belt conveyor, the RIGS cannot effectively work across belts, which reduces the working efficiency and increases the labor intensity of workers.

2. Rig structure and parameters
ZDY2800LG crawler full hydraulic tunnel drill used in coal mine is a full hydraulic tunnel drill with high speed, large torque, which can carry out the construction across the belt. It is mainly suitable for the construction of gas drainage hole across the belt in coal mine. The drill has advanced technical performance, strong process adaptability, safety and reliability, and is easy to move and move.
As shown in Figure 1, the drill rig is in an integral layout. It consists of nine parts: electromagnetic starter, radiator, pump station, hoisting and lifting device, control console, stable Angle adjusting device, main engine, seat and track body. All parts are connected by high-pressure rubber hose and bolts, with compact structure and high reliability.

ZDY2800LG crawler full hydraulic tunnel drill is mainly applied to the construction of gas drainage hole across the belt in underground coal mine, which meets the requirements of high speed, large adjustable range of drilling Angle, flexible operation and strong process adaptability. The main performance parameters of drilling machine are as follows:

Table 1. Basic parameters of ZDY2800LG drill

| Name                  | Parameter          |
|-----------------------|--------------------|
| Rated Torque /Nm      | 2800~400           |
| Rated speed /(r/min)  | 200~800            |
| Pitching Angle /(°)   | -20~20             |
| Maximum feed/pull-out force /kN | 120/160         |
| Give in/out stroke / mm | 1800              |
| Rated power /kW       | 90                 |
| I Ⅱ / Ⅲ pump rate /(ml/r) | 145/28/10      |
| Rig Size /m           | 5130×1200(3380)×2060 |

3. Industrial tests

The field industrial test is located at 3316 auxiliary air return roadway working face in Wangpo Coal mine of Tiandi Technology Co, LTD. The gas emission amount of the main coal seam in Wangpo Mine is 19.22m³/t, which is a high-gas mine. The coal seam on the working face of auxiliary return air roadway in the test area 3316 is no.3 coal, with a thickness of 4.20 ~ 7.89m and an average of 5.82m. The hardness coefficient of coal seam is about F =0.32. The histogram of stratigraphic synthesis is shown in Fig2.
Form a complete set of test pipe for Φ and Φ 100/110 / Φ 63.5 mm Φ 63.5 mm two spiral drill pipe, spiral Angle is 28.5 °, pitch is 100 mm, drill pipe length is 1.5 m and 1 m in two forms, inner concave bit test drill adopts four wings. The drill pipe is connected with hexagonal interpolation, fixed by U-shaped bolt, which can be used for positive and negative rotation construction. The drill pipe and drill bit are shown in Figure 3.

The field industrial test can be divided into two stages according to the progress of the test. The first stage is the stage of getting familiar with the formation, exploring the equipment and drilling tools, as well as the process adaptability; the second stage is the stage of seeking breakthrough in data such as average hole depth and drilling efficiency on the basis of the earlier stage.

### 3.1 Formation exploration stage

This stage adopts Φ 110 / Φ 63.5 mm with 1.5 m long spiral drill pipe Φ three-wing carbide drill 120 mm, a total of complete drilling 51, total penetration of 3135.5 m, the maximum drilling depth of 201 m, the normal comprehensive drilling efficiency reached more than 42 m/h, drilling information see table 2.
Table 2. Statistics of borehole data in exploratory stage of formation

| Number of drilling(a) | Biggest hole deep (m) | Average depth (m) | Average drilling efficiency(m/d) | Hole depth ratio of 100 m (%) |
|-----------------------|-----------------------|------------------|---------------------------------|------------------------------|
| 51                    | 201                   | 78.8             | 190.5                           | 24.1                         |

It can be seen from the table that the proportion of holes, the maximum hole depth, drilling efficiency, and so on are not satisfactory. After exploration, the project team speculated that the three-wing carbide drill bit has poor straightening effect in soft coal drilling, and is likely to enter the top and bottom too early.

Using YZG7 borehole trajectory measuring instrument, the drilling trajectory of one three-wing carbide drill bit and two four-wing inner concave drill bits were repeated tested, and the trajectory trend of these two kinds of drill bits was grasped at the same time.

After 65 meters, the trajectory of no. 1 hole with three-wing scraper bit begins to sink rapidly and contact the bottom plate prematurely, while no. 2 and No. 3 holes with four-wing concave bit have good straightness. Analysis of the reason is that three wing drag bit not well supported in the process of drilling, drilling early by drill pipe is closely connected to provide certain laymen, when after entering certain depth due to the connection between the drill pipe prolapse of accumulative total can't provide bit laymen, drilling easy to early into the floor, four wing between the concave bit with four wings and hole wall formed the good support, so keep good laymen, the team decided to replace the drill bit for concave bit in four wings.

3.2 Efficient drilling stage

At this stage the Φ 110 / Φ 63.5 mm with 1.5 m long spiral drill pipe within 120 mm four-winged Φ concave bit, complete effective penetration drilling 66, effective total footage of 6087 m, average drilling depth of 92.2 m, the average comprehensive drilling efficiency reach 45 m/h, comprehensive drilling rate to a maximum of 60 m/h, daily average speed of 265 m.

3.3 summarize

The ratio of hole formation, average hole depth, average drilling efficiency and ratio of hole depth of 100 meters in three stages of formation exploration, breakthrough seeking and efficient drilling are shown in Table 3:

Table 3. Comparison of borehole data in formation exploration stage and efficient drilling stage

| Phase                        | Pore forming proportion (%) | Average depth(m) | Average drilling efficiency (m/d) |
|------------------------------|------------------------------|------------------|---------------------------------|
| Stratigraphic exploration stage | 65.9                         | 78.8             | 190.5                           |
| Breakthrough stage           | 86                           | 92.2             | 265                             |

It can be seen that the data of formation exploration stage and efficient drilling stage are improving steadily, the average drilling efficiency of efficient drilling stage reaches 265m/d, and the industrial test of ZDY2800LG drilling rig is successfully completed.

4. conclusion

(1) The rig’s capability was tested.

Through the last five months more than 20,000 meters of effective footage fully tested the drill capacity, the high speed of the drill across the belt, the use of a fan cooling hydraulic oil, drilling efficiency significantly improved and other advantages have been fully reflected.

(2) Through the industrial test of drilling RIGS, new techniques and methods for drilling soft coal are explored
Author profile: XU Pengbo (1986-), Born in Xianyang, Shaanxi province, assistant researcher, master degree, mainly engaged in the design and research of hydraulic drilling RIGS, Email: xupengbo@cctegxian.com

References:
[1] Dan Bruner, Jeffrey Smallball. Directional drilling technology of pre-mining gas drainage [J]. China coalbed methane, 2005,2 (2) : 10-13.
[2] Gao Kui, Liu Zegong, Liu Jian, et al. Physical and mechanical properties of structural soft coal and its influence on coal and gas outburst [J]. Chinese journal of safety science, 2013,23 (2) : 129-133.
[3] Xi'an Research Institute of Coal Science Research Institute. Principle and Application of Soft Coal Seam Drilling Technology [R]. Xi'an: Institute of Xi'an, Coal Science Research Institute, 2007.
[4] Shi Zhijun, HU Shaoyun, Yao Ningping. New Technology of gas extraction (discharge) Drilling in Underground Coal Mine [M]. Beijing: Coal Industry Press, 2008.
[5] Wang Yi, LI Qiaoqiao, JIA Mingqun. Application of spiral drilling technology in strong outburst Coal seam of Cedar Tree Coal Mine [J]. Mineral Exploration Engineering (Rock and soil drilling Engineering), 2008, 10:11-13.