Research on the key technology of narrow split crawler drilling rig

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Abstract: According to the complex construction conditions in China, such as coal mines roadway cross section is small and the space is little, a new type of down hole drill was designed in this paper. In order to improve the mobility under the coal mines, the split type and narrow body structure was adopted in the design drill process, the compact type and more range combined frame with the ability which can construct for more rows level drill holes in the coal roadways and all-round pitching angle drilling in the rock. The industrial test showed that the new type drilling has well application effect in complex conditions with flexible mobility and process adaptability under the coal mines, the workers labor intensity was obviously reduced.

1. Introduction

Underground drilling machine is a key equipment for the exploration and treatment of hidden disaster factors in coal mines, such as gas extraction, water exploration and drainage. According to its overall structure, it can be divided into two categories: split crawling drill and integral crawler drill. With the improvement of the requirement of underground equipment automation in coal mines in China the integral crawler drill has gradually replaced the split crawler drill.

The split-type crawling drill is mainly used in small and medium-sized mines due to its manual relocation, long auxiliary process time and low construction efficiency. However, due to its small size and flexible layout according to drilling field conditions, it is mainly used in small and medium-sized mines [1].

The integral crawler drilling machine integrates the main engine, pump station, control console and other parts on the crawler platform, which is characterized by strong downhole mobility and high construction efficiency [2-4]. Due to the large volume of the integral crawler drilling machine, it is mainly used in large and medium-sized mines. When the integral crawler drilling machine is drilling, the equipment and personnel must directly face the borehole orifice that may have gas outburst, which has certain safety hidden danger. The integral crawler drilling machine is mostly used in the construction of near horizontal drilling with small Angle adjustment range, so it cannot carry out the construction of large Angle and multi-horizontal drilling efficiently.

2. Design of split type crawler drill

2.1 Overall design idea

ZDY4300LF type (A) is the overall design train of thought of drill rig main execution unit and power operation unit respectively on two tracks body [5], designed with single size is small, strong maneuverability, underground drill more degrees of freedom of the host, wider range of adjustment, stable and reliable, suitable for different complex construction conditions of new type of coal mine with...
split type crawler drill rig.

ZDY4300LF(A) drilling machine is composed of two parts: pump truck and drilling truck. The power/control units, such as motor pump group, fuel tank and main control console, are integrated in the pump truck, while the main execution units, such as main engine and frame, are integrated in the drilling truck. When working, the pump truck and the drilling truck are connected by high-pressure hose, and their relative positions can be flexibly arranged according to the drilling field conditions.

The basic parameters of ZDY4300LF(A) drilling rig, such as rated torque, maximum feed/draw force, and rated power, are shown in Table 1.

| Name                  | Parameters        |
|-----------------------|-------------------|
| Rated Torque /Nm      | 4 300~1 050       |
| Rated speed /(r/min)  | 60~200            |
| Maximum feed/pull-out force /kN | 90/120 |
| Pitching Angle /(°)   | ‒90~90            |
| Azimuth Angle /(°)    | ‒90~90            |
| Height of horizontal opening /m | 1.25~2.25 |
| Rated power /kW       | 55                |
| Rig Size /m           | 2.3×0.85×2.1      |

2.2 Design of multi-luffing combined frame

ZDY4300LF drill more luffing modular rack type (A) (figure 2) only 0.85 m, width from outside on top device, the main pillar, lifting oil cylinder, host, horizontal sliding cylinder and adjustable Angle slewing bearing parts, such as through the frame combination of action, realize the host level opening height, the distance between the host and the orifice, host Yang Angle over A wide range of adjustment, as well as the host of solid implementation work.

Among them, the external lifting cylinder and the internal lifting cylinder built in the main column can achieve the elongation and shortening of the three-layer main column, and drive the host machine to realize the adjustment of the horizontal opening height within the range of 1.25m ~ 2.25m, and can construct nearly horizontal multi-row drilling. The horizontal sliding cylinder of the main engine can adjust the distance between the main engine and the orifice within 0.4m, which is convenient to install or remove the orifice pipe between the gripper and the orifice. The Angle adjusting slewing bearing drives the main engine to adjust the elevation Angle of 0~±90° relative to the main column, so as to realize the drilling construction of various elevation angles in the whole section of roadway. The built-in upper jacking stabilizes the oil cylinder in the main column, and the oil cylinder extends upward through the upper jacking device, which makes the drill jacking the top/bottom of the tunnel, reduces the vibration caused by the reverse torque during construction, and improves the safety of the drill.
2.3 Design of key components

ZDY4300LF drill jumbo type (A) part of the width of only 0.85 m, and the feeding device, gyrator, key components such as drill gripper, centralizer devices between the two frame main pillar and the width dimension of the key components must be less than 0.55 m, so in the design of the key components to optimize design, size and function to meet the demands.

The rig gripper is used to clamp the drilling tool in the hole when starting and drilling down, and it can be combined with hydraulic chuck to realize mechanical twisting and unloading of the drill pipe\(^6\text{-}\text{8}\). In order to adapt to the compact layout of drilling machine, the clamping device is optimized. The width of the new cylindrical compound force clamp (FIG2) is only 0.32 m, while the width of the traditional horizontal clamp is 0.675 m. The new type of gripper adopts the principle of slant increase force for drill pipe clamping, the Angle of slant increase force is 9\(^\circ\), the clamping force of the slips is appropriate, and the clamping/loosening speed is fast; The clamping device adopts disc spring clamping and oil pressure auxiliary clamping to prevent the lack of clamping force of disc spring and the occurrence of accidents such as running drill during the construction of large Angle drilling. The new type of cylindrical compound force clamping apparatus is characterized by compact structure and large clamping force, which is especially suitable for compact drilling RIGS.

2.4 Hydraulic system design

ZDY4300LF(A) drilling rig hydraulic system is composed of two parts: drilling truck system and pumping truck system, which are connected by high pressure tubing. The power/control systems, such as the motor pump set, fuel tank and main control console, are integrated in the pump truck, while the drill truck only integrates the complete rig execution system. When walking, only 3 rubber pipes need to be connected between the two cars, and 12 rubber pipes need to be connected when working. The connection and disassembly of the rubber pipes are completed by quick changing joint, which is convenient and quick, and the sealing reliability is high.

In the hydraulic system of drilling machine, it has rich linkage functions such as clamping and turning,
shackle, etc. Only one command is needed, 3–4 parts of drilling machine can work together, which makes the operation easier and workers' labor intensity lower. The necessary safety protection circuit is set up in the system. For example, when drilling through the layer at a large Angle, the anti-drop protection circuit can prevent drill pipe from sliding down and injuring people. In the case of stuck drill during the drilling of soft protruding coal seam, the anti-stuck drill protection loop that can be automatically pulled back by the feeding cylinder is provided to improve the safety of the system [10-13].

3. Industrial tests
The pitch Angle adjustment range of ZDY4300LF(A) drilling rig can reach 0–±90°. There are 5 drilling holes through the floor of Huangling No. 2 well, the maximum Angle is 87°, and the corresponding hole depth is 117 m. Through the test verification, the drilling machine has the ability to carry on the tunnel full section drilling construction. The drilling Angle and corresponding depth through the layer are shown in Table 2.

| Bore number | Azimuth Angle /(°) | Borehole dip /(°) | Depth of bore/m |
|-------------|--------------------|-------------------|-----------------|
| Number One  | -10                | 45                | 87              |
| Number Two  | -7                 | 52                | 126             |
| Number Three| -6                 | 60                | 153             |
| Number Four | -4                 | 73                | 150             |
| Number Five | -3                 | 87                | 117             |

4. conclusion
The design and application of ZDY4300LF(A) drilling rig fill the blank of compact full-section crawler drilling rig in underground coal mine. The experimental application of drilling RIGS in different working conditions, such as boreholes, cross-boreholes and soft coal boreholes, shows that.

The overall layout of the drill is compact and narrow, which is suitable for tunnel construction under poor underground transportation conditions and frequent roadways for the drill.

The drilling machine has many degrees of freedom and flexible adjustment, which is suitable for the construction of different azimuths, elevation angles and horizontal multi-row drilling holes, such as near-horizontal drilling hole, tunnel full-section cross-layer drilling hole.

With large capacity and reliable performance, the drilling machine can meet the construction requirements of deep boreholes in coal mines. In particular, in the case of hole collapse in soft coal formation, the drilling machine has a good ability to deal with accidents inside the hole.

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