
The Design and Analysis of a Split Type Full Hydraulic Tunnel Drill Rig

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Abstract

The segmented all-hydraulic tunnel drilling rig is a kind of equipment designed for narrow roadway, which is mainly used for drilling such as gas extraction, exploratory drainage and grouting of roof and floor in middle and deep holes. This paper mainly introduces the design idea of the rig, including the overall scheme, key structure, hydraulic system and appearance design, and describes the key structural parts and hydraulic system in detail. This drill adopts the whole hydraulic fractal structure, which can drill with low speed, large torque and large bore, and realize the non-pole speed of the actuator. At the same time the drill has a simple structure, convenient operation, the characteristics of strong adaptability of roadway, through the optimization of structural design, improved the rig fuselage adjustable Angle range and to process, improved the technology of drilling adaptability.

Keywords

Tunnel drill; Track; Full hydraulic pressure; Split type; Coal mine roadway.

1. Introduction

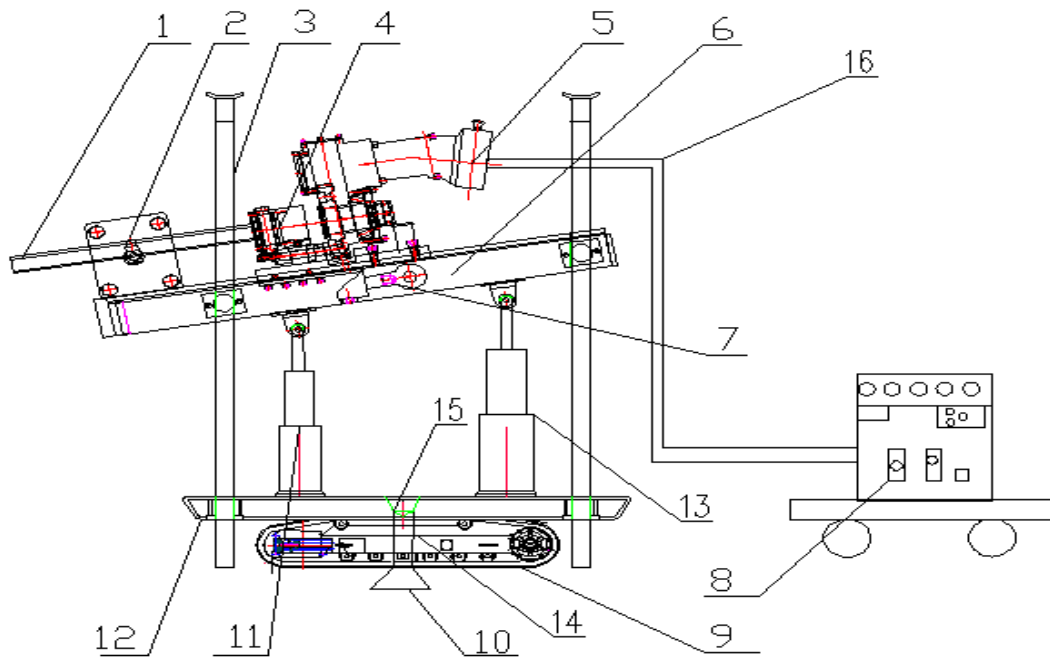
Directional drilling technology in coal mine is a key technology for controlling coal gas and ensuring efficient production. As coal mine tunnel development of drilling technology and equipment level, crawler self-propelled rig structure recognised by the user's wide, especially good coal mine roadway conditions during the construction of the coal seam gas drainage borehole, the application of crawler drilling rig drilling construction efficiency is improved effectively. Due to the influence of small Angle adjustment range of the fuselage and poor adaptability of roadway and technology, the integrated tracked directional drilling machine cannot meet the general requirements of most coal mines. For this reason, it is an inevitable trend to design a tracked full hydraulic directional drilling rig for narrow roadway [1].

This paper designed a new type of hydraulic directional drilling machine can be used to narrow roadway, through the structure optimization design improves the rig fuselage adjustable Angle range and to process, improved the technology of drilling adaptability. The drilling rig has the characteristics of simple structure, convenient operation and strong adaptability of roadway.

2. Overall Scheme Design

When making drill overall technical solution, fully research at home and abroad of all kinds of coal mine roadway conditions, combined with the construction of drained gas of nearly horizontal directional drilling needs, determine the overall structure of the new type of directional drilling [2].

The drilling rig adopts the drilling rig and pump truck two-body structure and the crawler self-way. Both bodies have independent walking function, which is convenient for quick on-site relocation and flexible to be pushed around. The pump truck is used to supply power to the drilling vehicle and pump high pressure water to drive the motor rotary at the bottom of the hole for directional drilling. The overall layout of the drill is shown in figure 1.



1-drill rod, 2-gripper, 3-support positioning rod, 4-chuck, 5-hydraulic rotary motor, 6-guide rail, 7-feeding hydraulic cylinder, 8-power control system, 9-caterpillar, 10-expanding disk, 11-front hydraulic cylinder, 12-swing unit platform, 13-rear hydraulic cylinder, 14-rotary unit hydraulic cylinder, 15-rotary bearing, 16-towing mechanism.

Figure 1. The structure of drilling rig

The drilling rig adopts full hydraulic drive mode, featuring compact structure and flexible layout. The key parts are connected by hydraulic hose, which has good disintegrating property, and the control mechanism can realize remote operation. Rig overall scheme design, emphasizing on drill matching problem of main function and the directional drilling construction technology, mainly to solve the machine structure, hydraulic system and the design of the drilling rig function key technology. According to the technical requirements of directional drilling in narrow roadway construction, the main performance parameters of the crawler full hydraulic directional drilling machine of this model are determined as shown in table 1.

Table 1. Design requirements for performance of drilling rig

Performance Parameters	Value
rated torque / N·m	850-3200
rated speed / (r/min)	70-240
braking torque of spindle / N·m	850
inclination angle of spindle / (°)	-30-30
maximum feed or pull force / kN	70/102

3. Basic Structural Principle of Split Type Full Hydraulic Tunnel Drill

The split type full hydraulic tunnel drilling machine is mainly composed of rotary device, feed device, frame and clamping device.

3.1 Gyrator

The rotary device consists of three parts: variable motor, gear reducer and glue drum hydraulic chuck. The hydraulic oil drives the variable motor, drives the gear reducer, decelerates through two stages, then drives the spindle and the hydraulic chuck, and finally realizes the rotary motion of the drill. Variable motor displacement can control the rotary speed of the rotator. The spindle adopts a through-hole structure, and the rotary device is installed on the towing plate of the feed body. With

the help of feed shantou red, it moves back and forth along the guide rail of the fuselage, so as to realize the feeding or lifting of drilling.

3.2 Holder

Rig adopts the disc spring clamp, hydraulic loosening often closed gripper, was fixed in the fuselage feed device, clamping hole drill pipe, used with gyrator, to realize automatic mechanical catalpa discharge pipe, reducing labor intensity. The slip on the clamp is placed on the slip seat, and the axial position of the slip is restricted by two pins. The circular direction is fixed by a pair of flat bonds on the slips. When two pin rods are pulled out, the slip can be taken out along the direction of the flat key.

3.3 Console

Control board is a control device of drilling rig, is composed of control valve, pressure gauge and pipe fittings, by manipulating the stage valve combination operation enables rotary drill rig, feed, pulling and chuck, gripper linkage function.

3.4 The Pump Station

Pump station is the hydraulic power source of drilling rig. By the deputy pump, cooler, explosion-proof motor, oil filter, fuel tank, base parts, such as motor work through coupling drive the main oil and corn, pass through inhalation of low pressure oil tank and oil pump discharge and high pressure oil, and then by the control board to control the oil pipeline flow 'to, thus the normal work of the drill rig of the actuator.

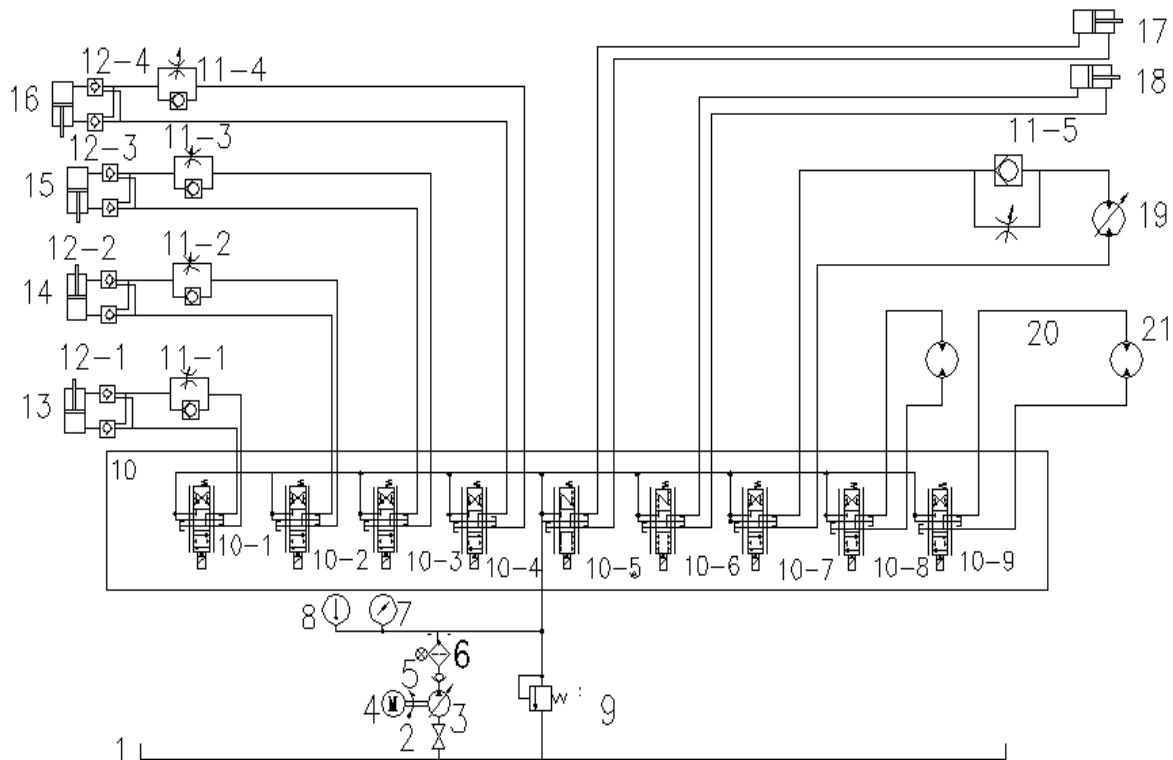
4. Hydraulic System Circuit Design

According to different functions, the hydraulic system of drilling rig is mainly divided into 5 parts: rotary system, drilling system, auxiliary stable Angle adjustment system, crawler walking system and mud pump control system. The system adopts double-pump open circuit design, in which the main and auxiliary pumps adopt load sensitive control mode and constant pressure variable control mode respectively to realize the purpose of system energy saving. The main pump is used to provide pressure oil for the quick operation of the rotary system and drilling system as well as the crawler walking system. The auxiliary pump is used to provide pressure oil for the slow speed operation and various auxiliary functions of the drilling system. The rotary system mainly provides rotary power for the rotary device, and the drilling system can realize the construction of different working conditions. Drilling system is mainly to provide feed device into operation when the feed force and pulling force, by the movements of the drilling system can realize to feed pressure regulating and speed regulation, and according to the site construction requirements, realize the compression and decompression [3-5]. Design of the control system of slurry pump is totally independent of every other function system, by the concrete pump truck control and operation, thus completely unaffected by drill each function system, the scene is more stable and reliable operation.

5. Hydraulic System Simulation of Rig Lifting Mechanism

5.1 Establishment of Simulation Model

The lifting mechanism is an important actuating mechanism of the drilling rig, which plays an important control role in the flexible control of the high level drilling height of medium-thick coal seam, and greatly affects the safety of drilling construction. Therefore, through the simulation analysis of the safety of the hydraulic system of the lifting mechanism, the overall design of the rig and the reliability of the power unit can be verified. The AMESim modeling and simulation process is divided into four steps:



1-oil tank, 2-check valve, 3-variable pump, 4-motor, 5-one-way valve, 6-filter, 7-pressure gauge, 8-thermometer, 9-relief valve, 10-3 position 4 port hydraulic valve, 11-one-way throttle valve, 12-hydraulic two-way lock, 13-front hydraulic cylinder, 14-rear hydraulic cylinder, 15-swivel unit hydraulic cylinder, 16-feed hydraulic cylinder, 17-gripper cylinder, 18-chuck cylinder, 19-punch unit rotary motor, 20-walking unit left rotary motor, 21-walking unit right rotary motor.

Figure 2. Hydraulic system of the drilling rig

Sketch mode: set up the system simulation model;

Submodel mode: select the Submodel of the element;

Parameter mode: set the parameters of the model;

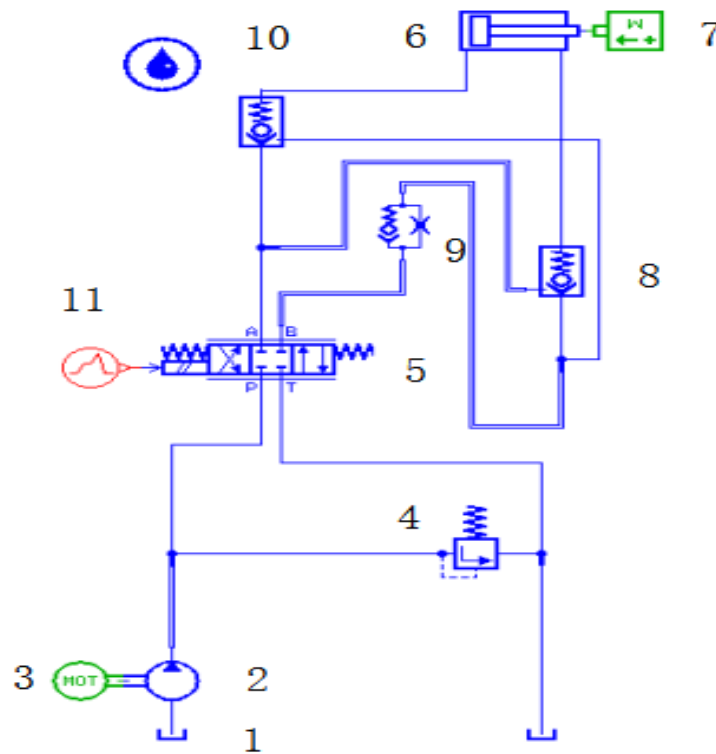
Simulation mode: Simulation calculation and analysis.

In the process of model, some hydraulic components need to be equivalent treatment: no manual valve in the AMESim software system, so in the process of modeling, the step signal input, to simulate the manual process. In addition in order to simplify the problem, and don't make the problem of distortion, in establishing the model of the hydraulic system, make the assumption that the oil density, viscosity, elastic modulus and damping coefficient of pore characteristics of will not change with the change of pressure and flow rate. After the above treatment and simplification, the model is finally established as shown in figure 4.

Analysis on simulation results

5.2 Displacement of Piston Rod of Hydraulic Cylinder

The displacement curve of the piston rod of the hydraulic cylinder is shown in figure 7. The piston rod begins to extend at 0s. The piston rod movement speed gradually increases then decreases from 0s to 30s, and piston rod displacement remains unchanged from 30s to 35s. From 35s to 45s, the piston rod is still not moving, and the lifting mechanism at this stage is in the state of support and lock. The piston rod retracts at a relatively smooth speed from 50s to 90s, and the motion of the piston rod is relatively gentle and the simulation meets the requirements of the drilling rig design.



1-oil tank, 2-variable pump, 3-motor, 4-relief valve,5-3 position 4 port hydraulic valve,6-hydraulic cylinder, 7-mass, 8-hydraulic two- way lock,9-one-way throttle valve,10-index of hydraulic fluid, 11-signal source.

Figure 3. Simulation model of lifting hydraulic system

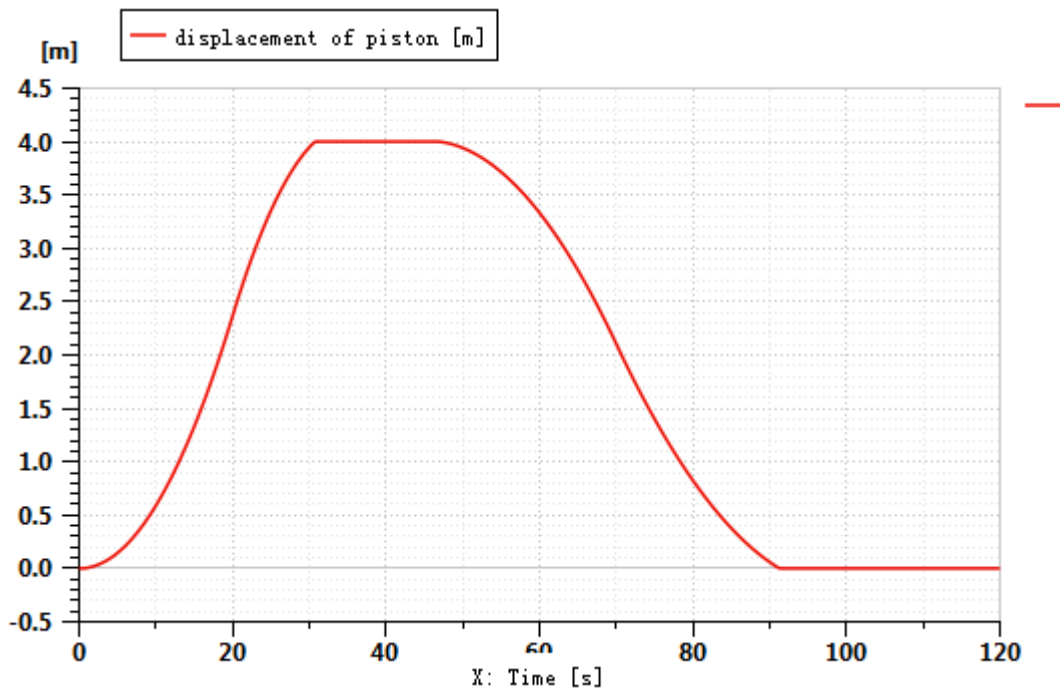


Figure 4. Displacement curve of hydraulic cylinder piston

6. Conclusion

Based on the existing structure and working principle of coal mine drilling rig, this paper carries out the design and lifting speed simulation research of the split all-hydraulic tunnel drilling rig.

Developed by drill has big power, small volume, convenient to move, high safety, drilling and accident treatment ability and so on significant advantages, in thick coal seam in the deep extraction ability of drilling construction, can be in the thick coal seam mine gas disaster management for equipment security. AMESim simulation software was used to simulate and analyze the lifting characteristics of drilling rig. In combination with the hydraulic schematic diagram, AMESim software was used to model the lifting hydraulic system of drilling rig. At the same time, the accuracy of the model is verified by comparing the simulated velocity curve with the displacement. The real results show that the drill can meet the complex working conditions of the drill.

References

- [1] Keya, Rue Zhang, Bashan Sun. Development of high power two-piece crawler rig with soft coal seam zdy5000RF [J]. Metal Mines, 2017, 491 (5): 131-134.
- [2] Yeung Yao, Heian Wang, Dong Fan, et al. Development of ZDY1200L crawler hydraulic tunnel boring machine [J]. Geology and Exploration of Coal Geology, 2008, 36(3): 75 -78.
- [3] Peng Fang. Design of ZDY4000LD (A) crawler hydraulic steering drill [J]. Geology and Exploration of Coalfields, 2014, 42 (4): 74 -77.
- [4] Xin sheng Yin, Hong Liang Tina, Key Yao, et al. Application of Load Sensing Technology in Full Hydraulic Power Head Tunnel Rig [J]. Coal Science and Technology, 2008, 36 (1): 75 -77.
- [5] Peng Fang, Hong Liang Tina, Di Wu, et al. ZDY6000LD (A) crawler hydraulic steering drilling rig and its application [J]. Coal Geology and Exploration, 2011, 39 (2): 34 -37.