Research on Drilling Depth Measurement Technology based on Drilling Rig Parameter Monitoring

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Abstract. In view of the problem that the drilling depth is measured by manually counting drill pipes in the process of underground drilling construction in coal mine, combined with the multi-channel sensor parameters loaded on the parameter monitoring device of mining tunnel drilling rig, a new drilling depth measurement method is proposed. This method mainly relies on multiple pressure sensors assembled on the drilling rig to reflect different drilling rig operation states, and the drilling depth is obtained by increasing or decreasing the displacement parameters of the power head. It is suitable for tunnel drilling rig equipped with drilling rig parameter monitoring device. It not only saves hardware cost, but also adds a monitoring function of the device. At the same time, it provides a new technical path for accurate and reliable drilling depth measurement.

1. Introduction

In order to ensure the safe production of coal mines, a large number of boreholes are often needed for gas drainage, water exploration and drainage, roof and floor grouting, etc. At present, the underground coal mine mainly relies on the traditional way of counting the drill pipe after lifting the drill, or by setting up a video monitoring device in the drilling yard, a specially assigned person can monitor and count the number of drill pipes in real time to determine the hole depth, which is time-consuming and laborious, and has a great impact on human factors, which has caused a lot of inconvenience to the production management and construction inspection of coal mining enterprises [1-2].

With the continuous development of drilling supporting technology and instruments, in order to improve the condition monitoring of drilling rig in the construction process, various types of drilling rig parameter monitoring devices have been developed in China in recent years [3-5]. However, as one of the most important monitoring parameters in the construction process, "drilling depth", there has been no accurate monitoring method, based on the multi-channel sensors installed on the drilling rig to monitor the operating parameters of the drilling rig, this paper calculates the real-time drilling depth during the drilling rig construction. This method avoids the risk of hole collapse after lifting and cannot be verified. At the same time, it has nothing to do with the construction process and the used drill pipe, and has strong universality.

2. Parameter Monitoring Device for Mining Rigs

Considering the special requirements of the actual working conditions under the coal mine for the drilling rig parameter monitoring system, the drilling rig parameter monitoring system needs to be designed as a whole, as shown in figure 1, which is composed of external sensor group, data collector, explosion-proof computer and system software. The working process of the system is as follows: the external sensor group is installed at the key mechanism of the directional drilling rig with quick
connector or non-contact connection. During the drilling process, the working parameters of the directional drilling rig are transformed into analog signals or digital signals in real time and transmitted to the data collector; the data collector collects and processes the parameters and sends them to the explosion-proof computer in the form of CAN bus; the system software in the explosion-proof computer is used for real-time data display, graphic drawing and database storage. The directional drilling construction personnel optimize the drilling parameters and control the drilling process according to the drilling parameters displayed in the explosion-proof computer. The explosion-proof computer reserves the connection interface with mine ethernet and MWD system, which can meet the needs of remote data transmission of drilling parameters and monitoring while drilling trajectory at the same time.

Figure 1 Composition block diagram of mining drilling rig parameter monitoring system

The system software is mainly used for monitoring parameter display, processing and data storage. The key of its design is the overall architecture design, parameter data and graphic display design, drilling condition identification and alarm system design. In terms of overall architecture, the system software takes windows operating system as the basic platform, customizes the system operation interface through configuration software, and carries out program development based on VC++ design language. In order to facilitate inter system call and improve system universality, the software adopts modular design, including modules such as data storage, data display, data communication, function configuration and system help. The composition of system function modules is shown in figure 2. In order to ensure the accuracy and security of data, set exclusive permissions for different personnel. Designers can configure system parameters, alarm parameters, user management, communication frequency, can channel and other information. Drillers can only query relevant information through the system.

Figure 2 Functional composition of mining drilling rig parameter monitoring system
3. Method of Borehole Depth Measurement

By monitoring the control hydraulic pressure and power head displacement during drilling rig construction, judging the current drilling rig situation and calculating the drilling depth is a new technology that can monitor the drilling construction depth in real time, and can monitor the drilling depth in real time during the operation of the drilling rig.

Because there are many models and hydraulic control methods of underground drilling rigs in coal mines, it is difficult to summarize the method of calculating drilling depth by monitoring drilling rig parameters, so we take ZDY3500L drilling rig of Xi’an Research Institute Co., Ltd. of China Coal Science and industry group as an example. The gripper / chuck of ZDY3500L drilling rig is independently controlled, the gripper is normally closed, the chuck is normally open, and is equipped with mud pump punching and slag removal. The drilling rig parameter monitoring device installed on the drilling rig is mainly composed of various parts in figure 3. The detection host is responsible for the collection, processing, calculation and display of the information of each sensor, which is the core of the device. The displacement sensor monitors the displacement of the power head, It can be realized through the built-in stroke sensor of the oil cylinder, or through the external laser displacement sensor or Hall sensor. The other pressure sensors respectively detect the pressure at each position as shown in the figure, including the inlet and outlet oil pressure P1 of the gripper, the oil pressure P2 of the chuck, the forward and reverse rotation pressure P3 and P3’ of the rotary motor, the feed and pull-out pressure P4 and P4’, the mud pump pressure P5 and the displacements of the power head.

![Detection Host](image)

**Figure. 3 Hole Depth Monitoring Device**

Hole depth calculation method: when the gripper is opened (P1>a) and the chuck is clamped (P2>b), the displacement change of the superimposed power head Sn=(s2-s1)+(s3-s2)+...+(sn-sn-1); a, b represents the critical oil pressure value when the gripper and chuck act, sn represents the distance from the drilling rig to send the drill pipe into the drilling hole at the nth time, the maximum value of sn is the drilling depth, time t = 1,2,3... n. In addition, the parameter monitoring of P3, P3’, P4, P4’ and P5 shows the action state of the drilling rig and verifies whether the displacement change of the power head is normal. Table 1 lists the drilling rig parameters under several typical drilling rig construction states.

| Serial Number | Pressure Parameters | Rig Status                  | Displacement Change |
|---------------|---------------------|------------------------------|---------------------|
| 1             | P1>P1’ , P2>P2’ , P4>P4’ , P5=0 | Rotary feed water           | increase            |
| 2             | P1>P1’ , P2<P2’ , P4=0       | Rotary lifting belt water    | reduce              |
| 3             | P1>P1’ , P2>P2’ , P4=0       | Rotary feed without water    | increase            |
| 4             | P1>P1’ , P2<P2’ , P4=0       | Rotary lifting without water | reduce              |
| 5             | P1>P1’ , P2=P2’ , P4=0       | Rotary punching              | unchanged           |
| 6             | P1=P1’ , P2<P2’ , P4=0       | Non rotary lifting without water | reduce  |
In some cases, the drilling rig parameter monitoring device can also be simplified, such as omitting the verification process of P3, P3', P4, P4' and P5, and not detecting the rotation, feed in and pull-out and mud pump pressure; or when the drilling rig has the linkage function of gripper P1 and chuck P2, only one of gripper P1 and chuck P2 is detected; or the gripper and chuck operating valve are directly controlled by the solenoid valve. Through electrical connection, just confirm the switching state of the solenoid valve, etc. In short, according to different drilling rig types, hydraulic control methods and working conditions, the monitoring methods of drilling rig parameters may be slightly different, but the core detection principle remains the same, which is to calculate the distance from the drilling rig to send the drill pipe into the drilling hole by monitoring the working parameters of the drilling rig in real time.

4. Conclusion
There is still much room for improvement in the reliability and accuracy of the measurement of drilling depth by means of the parameter monitoring device of the mining drilling rig, in the field application, it is necessary to accumulate all kinds of data and experience to perfect the technical details, for example, it is affected by the elastic deformation of the drill pipe, the setting of various parameters of the drilling rig and the misoperation, etc. will affect the accuracy of the final measurement. The method of measuring the depth of drilling hole by the parameter monitoring system of drilling machine, and real-time monitoring the variation of drilling machine parameters and recording the depth of drilling hole in the course of drilling construction, can not only be applied to the quality inspection of drilling hole construction, it can also be used in the construction of intelligent drilling system, such as drilling machine fault monitoring and drilling construction state monitoring.

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