

Discussion on the Development of Intelligent Drilling Technology and Equipment for Gas Drainage

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Abstract: This paper deals about the application and development of gas drainage intelligent drilling technology and equipment from remote automatic drilling, ground controlled drilling, ground long distance automatic control drilling, downhole remote control drilling, sub-source, and sub-area independent unit management. The main direction of our research is to achieve full automatic drilling, intelligent drilling and drilling robots that can realize gas drainage, and also to promote innovation and development of gas drainage intelligent drilling technology.

Keywords: *gas drainage; intelligent drilling; development*

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1 Introduction

China mines large amount of coal for energy production, the rate of accidents at its coal mines has increased dramatically in recent years. Gas accidents are very hazardous, and in the event of a gas explosion it may lead to adverse effects such as enormous casualties and property damage. Proper gas drainage is an important means to prevent gas accidents. However China's traditional gas extraction drilling technology and equipment performance is low, mainly based on manual operation, have only limited intelligence level while the phenomenon of modern intelligent gas extraction concepts and technologies have much advancements.

Therefore it is of great significance to promote the development of intelligent drilling technology and equipment for gas extraction, in order to improve the safety production capacity of coal enterprises.

2 Downhole remote control drilling technology and equipment

Since the rigs used in the past are manually operated and the positions of the orifices are relatively close, safety accidents often occur. In order to reduce the risk of this operation, China Coal Technology and Engineering Group has proposed to control the distance between the operator and the orifice, and extend the distance between the hydraulic rig console and the main machine to improve the safety of the construction personnel^[1]. However, this kind of operational knowledge only increases the distance of operation, and the rig operator and assistant still need to labor, and the level of intelligence is limited, and has not been promoted and applied. Further, by 2007 China Coal Technology and Engineering Group developed a remote control system and remote video control system, which can be used to operate the rig 150 meters away from the drilling place, also they have developed a loading and unloading system for the drill pipe, which can replace the artificial drill rod. At the same time, temperature and pressure sensors were developed to monitor the working state of the rig. The development and application of the above technologies effectively compensate for the lack of intelligence in gas extraction drilling in China^[2].

In 2009, China Coal Technology and Engineering Group once again studied the long-distance drilling technology and equipment for protruding coal seams,

and realized the lossless connection of drill pipe threads. For the first time, the automatic screwing of the drill pipe thread was realized, which solved the problem of joint wear caused by the mechanical loading and unloading of the drill pipe during the past. Also in addition to that the problem of handling small capacity of the drill pipe system in the past leads to the development large-capacity drill large-capacity drill pipe handling system in order to improve the working efficiency of the upper and lower drill pipes.

At the same time, the development of hybrid hydraulic and electric control system is carried out to promote the rotation of the drilling rig and promote the linkage of the clamp double gripper, thereby improving the safety of the construction. After the development of remote control drilling technology and equipment, it can solve the difficulties in traditional drilling through the form of remote operation in the underground and the monitoring of drilling rigs. These developments leads to improve the drawbacks of the previous mechanized drilling, improve the automation level of gas extraction drilling technology and improve the efficiency of labor at the construction site.

3 Ground control drilling technology and equipment

Downhole remote control drilling technology and equipment play an important role in improving the safety of gas drainage, but it is still not capable to reduce the work force working underground. Therefore, research on ground control drilling technology and equipment is to solve the problem of gas drainage safety. One of the important ways. In 2010, China Coal Technology and Engineering Group developed a ground-controlled downhole gas extraction machine, which realized the first research and development of technology and equipment at home and abroad. For the first time, the coal mine drilling rig was controlled on the ground, and the ground control of the drilling was controlled with the integrated control system of the coal mine to control the ground drilling^[3]. At the same time, in the development process of ground control drilling technology and equipment, it is also the first time to develop a drill pipe loading and unloading technology based on the adaptive control principle, which controls the wear of the thread during the loading and unloading process. And developed a remote audio-

visual interactive system, which can monitor the audio and video of the construction site on the ground, and realize the voice intercom between the ground and the underground, so that the ground and underground can achieve interaction^[4]. In addition, for the development of the rig control system failure warning technology, the status of the electro-hydraulic control system can be monitored by various sensors, and the ground control station can read the monitoring data in real time, and warn the faulty equipment on the construction site, and provide instructions for repairs.

Gas extraction ground control drilling technology can transmit control signals and video signals in real time with high accuracy and stability. After the development of adaptive loading and unloading drill pipe and control system failure warning technology, the automation level of gas extraction drilling has been further improved. However, the actual situation of the manual drilling operation has not been changed which is a crucial part. The loading and unloading of the drill pipe is still stagnant at the level of mechanized operation and complete automation cannot be realized.

4 The ground long distance automatic control drilling technology and equipment

In 2013, China Coal Technology and Engineering Group developed a ground long-distance automatic control drilling machine, which solved the difficulty of conveying the drill pipe with large inclination angle, and developed a multi-joint drill pipe manipulator, which was carried out for the first time. A wholesome automatic upper and lower drill pipe along with tilt angle handling. In this technology, the development of automatic drilling control strategies and procedures were realized. Drilling parameters, automatic adjustment technology and intelligent adjustment anti-click drilling technology were developed. The first automatic drilling of coal drilling was realized^[5]. At the same time, improvement in electro-hydraulic proportional precision control system helps us to collect and transmit the signals from various sensors such as the PTZ camera and the pressure sensor, thereby realizing the operation of drilling downhole on the ground and ensuring the transfer of the rig, accuracy of the drilling posture adjustment.

After the development and application of this technology, the automation level has been greatly improved. On the basis of the ground control, the drilling process and the loading and unloading of the

drill pipe are simultaneously automated, and the drilling has been initially carried out. The parameters of the automatic adjustment, intelligent anti-drilling and other functions, and the realization of the rig transfer, drilling posture adjustment has greatly improved the safety of the construction site^[6]. During the specific drilling operation, the intelligent control of the drilling process is ensured to be automatically executed according to the specified drilling process, so as to achieve optimal control of the drilling process.

However, since many technologies were the one which was developed much earlier, the equipment size is large, the tilting range of the loading and unloading lever is large, the efficiency of the automatic loading and unloading lever is low, which directly affects the service life of the sensor and cannot promote the development of drilling industrialization.

5 Remote control automatic drilling technology and equipment

In the period of 2014-2016, on the basis of the above research, the China Coal Technology and Engineering Group conducted a key research on the long-distance automatic drilling technology and equipment on the ground. Mainly to realize the automation of the drilling function and improve the drilling performance, the stability of the site, the effectiveness of on-site construction, and the development of remote automatic drilling products. For the very first time, the long-distance control of the dual-mode coal mine drilling rig was developed, so that the drilling rig construction can be controlled on the ground, and the drilling can be operated within 50 meters through the portable wireless strict control system^[7]. At the same time, a composite manipulator and an open drill pipe storage tank have been developed, which can greatly improve the stability and work efficiency of the automatic drill pipe, thereby expanding the range of the tilt angle. In the application process of this technology, a self-learning control algorithm is adopted, which can optimize the intelligent anti-drilling technology, and establish a mathematical model of the drilling coefficient and an intelligent drilling database, so that the control parameters can be controlled. In order to improve the efficiency and stability of drilling. In the development of this technology, the development of hydraulic system module technology was carried out, which simplified the hydraulic pipeline problem and reduced the difficulty of on-site safety and maintenance. At the

same time, by optimizing the circuit and buffering the collision avoidance, the performance of the sensor can be improved and the service life of the sensor can be extended. The remote automatic rig technology not only improves the automation level of the drill pipe and drilling construction, but also can turn a number of key technical achievements to the technical reality, so that the effectiveness of the construction, the stability of the structure, and the service life of the sensor can be improved^[8].

In addition, the construction of a dynamic and wide-ranging intelligent feedback adjustable intelligent pumping station can adjust the transmission of the pumping according to the change of the gas deposition volume of different coal seams at different times, so that it is truly intelligent.

6 Adopting the method of sub-source and sub-regional independent unit management

At present most coal mines have set up gas drainage stations on the ground to conduct centralized pumping of gas. However, it is difficult to separate gas pumping and sub-regional management. China has now begun to test the pumping parameters for each hole to improve the fineness of management. However, due to the complexity of the system construction and cost issues, it is difficult to implement. Though the underground area is different, the overall extraction conditions are the same. If the drilling and gas parameters are basically consistent on one extraction surface, it can provide a feasible basis for the management of separate units of sub-sources and sub-regions and realize the scientific nature of gas drainage on the basis of cost savings. The parameters set by the ground centralized pumping are for the entire mine and cannot meet the parameter requirements of all areas of the well^[9]. Therefore, the unit management of gas parameter monitoring and automatic feedback in the source and sub-regions can realize the intelligent management of the partitions such as negative pressure and flow, thus realizing the monitoring, monitoring and management of the pipeline.

7 Directional drilling technology

China's gas explosion is very much in mine accidents. During the drilling construction of gas drainage accidents of nozzle holes, card holes or step holes are very common to take place. Which leads to an increase in the depth of hole formation and a decrease in the hole formation rate,

which affects the effect of gas drainage. Therefore through the combination of the hole bottom screw and the rig power head, the trajectory of the sliding directional drilling can be determined, and the advantages of the composite drilling can be effectively utilized, thereby increasing the hole formation ratio of the medium hardness coal seam and ensuring the hole depth. Within a reasonable

range^[10]. At present, China has promoted directional drilling technology within dozens of mining areas, and the application records are constantly refreshed in the specific application process as shown in Table 1. Dongbaode Coal Mine has created a record of 2,570 meters of directional borehole depth in the coal seam of the world's coal mines, as shown in Figure 1.

Table 1. Directional drilling depth statistics

Year of construction	Construction location	Drilling depth / meter
2008	Tingnan Coal Mine	1046
2010	Sihe Coal Mine	1059
2011	Baode Coal Mine	1112
2012	Dafosi Coal Mine	1212
2014	Sihe Coal Mine	1881
2017	Baode Coal Mine	2311
2019	Baode Coal Mine	2570

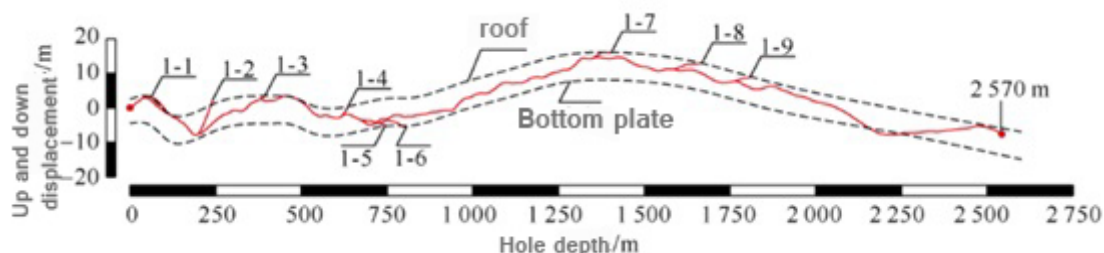


Figure 1. 2570m super long directional drilling track profile

8 Conclusion

In summary with the continuous development of China's coal mining industry, improvement in the intelligent development of coal gas drainage, strengthens the fine management of gas extraction which ensures safe production of coal, promoting healthy development of coal enterprises is of great significance. At present, China has implemented advanced monitoring and control, automatic control, and intelligent equipment in the intelligent development of gas drainage, which has laid an important foundation for the development of coal gas drainage and the safe production of coal enterprises.

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