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Research on Intelligent Mining Technology and Its Application and Safety Strategy

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ABSTRACT

This paper discusses the development, application and challenges of intelligent mining technology. Firstly, the basis of intelligent mining technology is introduced, including intelligent perception, intelligent decision-making and control, and the application of big data and cloud computing in this field. Subsequently, the paper expounds the practical application of intelligent mining, such as the intelligent mining system of underground and open-pit mines, as well as the intelligentization of the beneficiation process, and analyzes its effect through typical cases. The paper also discusses the impact of intelligent mining on safety and environment. At the same time, this paper points out the challenges and problems faced by the development of intelligent mining technology, and looks forward to its future development trend and direction. Finally, the importance and significance of intelligent mining are summarized, and some suggestions are put forward to promote the innovation and development of intelligent mining technology, so as to improve the level of intelligent mining in China and realize the sustainable development of mining industry.

KEYWORDS

Intelligent mining; Security and economy; Sustainable development.

1. INTRODUCTION

As an important traditional energy industry in China, the coal industry is an important part of China 's national economy. Its intelligent construction is directly related to the process of China 's national economy and social intelligence. Intelligent coal mine is the core technical support for the high-quality development of the coal industry. It deeply integrates artificial intelligence, industrial Internet of Things, cloud computing, big data, robots, intelligent equipment and modern coal development and utilization to form an intelligent system of comprehensive perception, real-time interconnection, analysis and decision-making, autonomous learning, dynamic prediction and collaborative control. It realizes the intelligent operation of coal mine development, mining (stripping), transportation, ventilation, washing, safety guarantee, operation and management, which is of great significance for improving the level of coal mine safety production and ensuring the stable supply of coal. By 2025, large-scale coal mines and coal mines with serious disasters will basically realize intelligence, form a technical specification and standard system for intelligent construction of coal mines, and realize intelligent decision-making and automatic coordinated operation of systems such as development design, geological guarantee, mining (stripping), transportation, ventilation, washing and logistics. Robot operation in key positions underground, open-pit coal mine to achieve intelligent continuous operation and unmanned transportation. By 2035, all kinds of coal mines will basically realize intelligence, build a coal mine intelligent system with multi-industry chain and multi-system integration, and build a coal mine intelligent system with intelligent perception, intelligent decision-making and automatic execution.

With the advancement of intelligent construction, each link of coal mine production will gradually realize remote control, and the control of each system equipment will be transferred from the underground to the ground. The daily production of coal mine will mainly rely on the cooperation of intelligent control center, intelligent technical support center and intelligent operation and maintenance team, so as to realize the transformation of coal mine from ' high-risk production ' to ' intrinsic safety ', from ' scale production ' to ' quality benefit ', from ' labor intensive ' to ' technological innovation ', from ' traditional mining ' to ' intelligent mining '. In order to achieve high-quality development of the coal industry. Coal mine intelligence is conducive to improving production efficiency and achieving accurate exploration. It can also extend the industrial chain of coal enterprises and create new industries such as coal mine intelligent equipment and coal mine robot research and development. Carrying out the intelligent construction of coal mines is an important measure to implement the new strategy of " four revolutions and one cooperation " energy security. Intelligent coal mine is a complex system engineering involving multi-disciplinary, multi-disciplinary and multi-field highly integrated and constantly updated iteration. At present, the intelligent construction of coal mine is in the initial stage, and it is also in the acceleration stage. The National Energy Group will carry out the intelligent construction of coal mine in a scientific and orderly manner according to the stage objectives, and promote the intelligent transformation and upgrading and high-quality development of the coal industry.

With the continuous progress of information technology, the application of intelligent mine technology has been deepening, covering many aspects such as mine production, safety and management. For example, intelligent mining technology improves mining efficiency and reduces manual intervention ; the intelligent safety monitoring system realizes real-time monitoring and early warning of mine safety. The intelligent management system optimizes the mine production management process and improves the management efficiency. In recent years, China 's intelligent mine construction has achieved certain results, and some large mining enterprises have achieved intelligent production. These enterprises have adopted advanced technology and equipment, established an intelligent production management system, realized real-time monitoring and optimization of the whole process of mine production, and improved production efficiency and economic benefits. Although China 's intelligent mining industry has made great progress, it still faces some challenges. For example, some small mining enterprises lack of financial and technical support, it is difficult to carry out intelligent transformation ; at the same time, the technical standards and norms of intelligent mines are not yet perfect, and further research and development are needed.

2. INTELLIGENT MINING TECHNOLOGY FOUNDATION

(1) Intelligent sensing technology

Coal production is a process of interaction between human intelligence, mining machinery and coal rock. Fully mechanized mining face is a complex system. Intelligent mining must have the independent ability of process planning, coal rock change identification, cutting state regulation, operation effect optimization and safety guarantee, so as to provide intelligent sensing information for intelligent decision-making and intelligent execution[1]. In addition to the main production systems such as mining and transportation, auxiliary systems such as power supply, liquid supply, communication and lighting should also enter the collaborative operation of equipment groups in intelligent mining. Through the centralized control operation platform, the data acquisition, information interaction and collaborative control of each subsystem are realized, and the three-dimensional model of spatial precise positioning and real-time scene based on multi-sensor data information fusion is constructed, which provides the algorithm model basis for the perception application of underground environment and equipment target objects in three-dimensional space, and forms the intelligent sensing technology system of fully mechanized mining.

(2) Intelligent decision-making and control technology

Intelligent mining gets rid of the direct participation of people on the basis of traditional coal mining methods, and realizes the intelligent operation of coal mining according to independent decision-making. Based on the basic theory and mathematical model of intelligent mining, the multi-source information fusion architecture of intelligent mining complex giant system in three-dimensional real scene is established. The prediction mechanism with big data analysis and reasoning of mining behavior as the core and the dynamic decision-making model driven by prior knowledge of fully mechanized mining are constructed. The model following adaptive control method of mining equipment group under the influence of time-varying multi-factors is given, and the health status evaluation method and maintenance decision-making mechanism of mining equipment system based on combination weighting method are formed. The theoretical system of safe and stable operation guarantee technology for the coupling of surrounding rock environment and production system is established. The fully mechanized mining production process is a collection of parallel operations in multiple links of coal mining, transportation, power and safety. Each link requires parallel control of multiple equipment to coordinate operation. Based on the intelligent perception system, the intelligent control system uses industrial Internet technology, big data technology, automation technology and fully mechanized mining expert knowledge base technology to build an intelligent mining control technology system with parallel evolution, closed-loop feedback and collaborative optimization through intelligent comprehensive application[2].

(3) Application of big data and cloud computing in intelligent mining

Big data technology can process and analyze massive mine production data, extract valuable information and knowledge, and provide data support for mine management and decision-making. Through data mining and analysis, we can find the hidden rules and trends, and provide data support for mine management and decision-making. At the same time, through the analysis of mine production data, we can understand the problems and bottlenecks in the production process, and provide data support for improving the production process and improving efficiency.Secondly, cloud computing technology can provide comprehensive information services for intelligent mining. Through cloud computing technology, massive amounts of data can be stored in the cloud to achieve centralized management and maintenance of data, as well as backup and recovery of data. In addition, cloud computing technology can also provide a variety of application services, including data processing, visual display, safety monitoring, etc., to provide comprehensive information services for mine management and operation[3].

3. APPLICATION OF INTELLIGENT MINING

Underground intelligent mining system is an intelligent mining system that integrates a variety of advanced technologies. It is composed of intelligent mining equipment, sensors and computer networks. It can automatically control the opening and stopping of mining equipment, automatically optimize mining schemes, and improve production efficiency and safety.

The design of underground intelligent mining system needs to consider many aspects, including the geographical environment of the mine, mining technology and equipment, safety production requirements and so on. Generally speaking, the underground intelligent mining system needs to realize automatic control of mining equipment, automatic optimization of mining scheme, real-time monitoring and early warning, information management, intelligent decision-making and so on.

Open-pit mine intelligent mining technology is an intelligent mining system that integrates a variety of advanced technologies. It can improve the mining efficiency of open-pit mines, reduce costs, improve safety, and reduce the impact on the environment. The intelligent mining technology of open-pit mine mainly includes

Intelligent sensing technology: Through sensors, radars, cameras and other equipment, the mining environment of open-pit mines is sensed and monitored in real time, and the geographical

environment, rock distribution, ore body morphology and other information of the mine are obtained, which provides data support for subsequent mining decisions.

Intelligent planning technology: based on the data obtained by intelligent perception technology, through computer technology and artificial intelligence algorithm, the mining scheme of open-pit mine is optimized, including mining sequence, mining path, mining method, etc., to improve mining efficiency and resource utilization.

Intelligent control technology: Through the automation equipment and control system, the remote monitoring and automatic control of open-pit mining equipment are realized to ensure the stable operation and safe production of the equipment. At the same time, through the real-time monitoring and adjustment of the mining process, the fine control of the mining process is realized, and the mining quality and efficiency are improved.

Intelligent decision support system: Based on big data and artificial intelligence technology, the mining data of open-pit mines are deeply analyzed and mined to provide managers with scientific decision-making basis and improve the accuracy and timeliness of decision-making. At the same time, through the analysis and prediction of historical data, it can provide reference for future mining decisions.

4. SECURITY AND ENVIRONMENTAL ISSUES OF INTELLIGENT MINING

(1)New security and environmental challenges in the context of intelligent mining and their engineering responses

The comprehensive advancement of intelligent mining technology has profoundly reshaped the operation mode of traditional mining engineering. The ' less human / unmanned ' mining with 5G, Internet of Things and artificial intelligence as the core has greatly reduced the casualty rate caused by traditional geological disasters such as roof fall and permeable at the physical isolation level, but it also makes the safety and environmental problems of mines present new characteristics of interdisciplinary and high complexity. In the practice of mining engineering, we must be highly vigilant against the secondary risks brought by technological evolution.

(2)In the safety dimension, the core hidden dangers of intelligent mines are changing from traditional geomechanical disasters to system reliability failure and human-machine conflict. First of all, the underground has harsh engineering geological environment such as high humidity, high dust, strong vibration and electromagnetic interference, which can easily lead to physical degradation and failure of high-precision sensors, cameras and communication base stations. Once the underlying data is ' perceptually distorted ', AI-based intelligent ventilation, gas warning or roof monitoring systems may make fatal wrong decisions. Secondly, in the stage of transition to full unmanned, there is a serious risk of ' man-machine space-time coupling ' in the narrow underground roadway. It is often difficult for on-site inspection personnel to accurately predict the running track of fully automatic fully mechanized mining equipment or unmanned mine card, which can easily lead to human-machine collision accidents. In addition, if the highly integrated digital control system encounters the underlying computing power interruption or network security threat, it will lead to the instantaneous paralysis of the entire mine's production and safety defense line.

(3)In the environmental dimension, intelligent mining shows a significant ecological ' double-edged sword ' effect. The advantage is that relying on three-dimensional geological modeling and intelligent cutting technology, accurate mining and in-situ filling of gangue underground are realized, which effectively reduces surface subsidence and solid waste discharge. However, the new environmental load can not be ignored. The continuous high-load operation of underground massive IoT nodes, edge computing data centers and 5G base stations has greatly increased the overall power consumption and carbon footprint of the mining area, forming an environmental protection paradox of " high energy consumption for high intelligence. " At the same time, harsh working conditions lead to

extremely high scrap rate of mining electronic intelligent terminals. If waste batteries, circuit boards and other heavy metal electronic waste (E-waste) are not properly recovered, it will pose a new type of hidden pollution source to fragile groundwater systems and mining soil[4].

To sum up, the future-oriented intelligent mining can not only stay in the simple stacking of information technology, but should be deeply rooted in the actual working conditions of mining engineering. It is urgent to develop high-reliability mining sensing equipment that adapts to extreme geological conditions, improve the safe operation boundary of human-machine collaboration, and vigorously introduce low-power green IoT technology, so as to build the bottom line of mine safety and ecology while pursuing the ultimate mining efficiency.

5. CONCLUSION AND PROSPECT

(1) Conclusion

Intelligent mining is an important innovation in the field of mining. It improves production efficiency, reduces cost, improves safety and reduces environmental impact by introducing advanced automation and intelligent technology. In the future, with the continuous development of science and technology, intelligent mining will continue to progress and improve, bringing greater changes and development to the mining industry.

(2) Prospect

In the future, intelligent mining will make greater breakthroughs in the following aspects:

More advanced automation and intelligence: With the continuous development of artificial intelligence, machine learning and other technologies, intelligent mining will achieve more advanced automation and intelligence, and further improve production efficiency and safety.

More accurate data analysis and optimization: Through more accurate analysis and optimization of the data generated in the mine production process, more accurate control and optimization of the production process are realized, and resource utilization and production efficiency are improved.

More environmentally friendly production methods: With the continuous improvement of environmental awareness, intelligent mining will adopt more environmentally friendly production methods to reduce the impact on the environment and achieve green mining.

Interdisciplinary integration development: intelligent mining involves many disciplines, such as computer science, mechanical engineering, geology and so on. In the future, these disciplines will be further integrated and developed to provide stronger technical support for intelligent mining.

Intelligent mining is an important development direction in the mining field, and greater breakthroughs and progress will be made in the future. At the same time, with the continuous progress and application of science and technology, intelligent mining will bring greater changes and development to the mining industry.

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