

# The Development and Prospect of Intelligent Technology in China's Coal Mines

Sizhuo Wang<sup>1,\*</sup>

<sup>1</sup> School of Energy Science and Engineering, Henan Polytechnic University, Jiaozuo China

\* Corresponding author: Sizhuo WANG

**Abstract:** With the development of science and technology, the coal industry has also ushered in a new look. In order to ensure the production capacity and employee safety of coal mines and conform to the high-quality development path in the 14th Five-Year Plan, coal mines are now moving towards intelligence. Intelligent technology in coal mines not only greatly improves work efficiency, but also ensures the safety of coal miners' lives, which is strongly supported by the state and is accelerating development under the impact of 5G technology. This paper summarizes the development status of intelligent coal mine technology in China in recent years from three aspects: intelligent mining, monitoring and management technology, and looks forward to the development trend of intelligent coal mine technology in the future, so as to point out the direction for the construction of intelligent coal mines in the future and escort high-quality development.

**Keywords:** China coal mines; Intelligent; Unmanned; Coal mine safety; Coal mining technology.

## 1. Introduction

During the 13th Five-Year Plan period, the industrial structure of coal mines in China was continuously optimized, and a large number of small and medium-sized mines with high energy consumption and high pollution were eliminated. At the same time, in order to meet the requirements of high-quality development, intelligent technologies such as ' smart mine ' and ' unmanned mining ' are also further developed. The " 14th Five-Year Plan for Mine Safety Production " pointed out that coal will remain the main energy source in China for a long time in the future. To ensure the safe and high-quality development of coal mines, improving intelligent technology is the key, and a high-efficiency, high-yield and green digital mine construction route will be explored. In fact, for traditional mining, intelligent mines have the characteristics of safety, stability and low pollution. The workers are transferred to a relatively safe environment, which reduces the number of accidents and deaths and strengthens the safety guarantee. Science and technology is the first productive force, so that all mines go to the road of ' equipment + intelligence ', add a force to the national energy industry, and strive to achieve the goal of the second hundred years.

## 2. Mine Intelligent Mining Technology

### 2.1. Present situation of intelligent mining technology

Intelligent mining technology includes intelligent coal mining technology and intelligent mining technology. Among them, intelligent coal mining technology is practical in coal production. Intelligent mining technology can effectively reduce labor, realize unattended coal mining, and make it possible for monitoring center and ground control center to operate remotely<sup>[1]</sup>. Intelligent mining technology can not only improve the rate of coal mining, but also effectively protect the safety of workers. Compared with traditional mining technology, its main advantage lies in its stable working ability and fault prediction. However, its

shortcomings are also very obvious. In actual coal mining, the fuselage of intelligent mining machinery is often relatively large and complex, and it is difficult to work accurately in the narrow working space mined, which is obviously a behavior that reduces mining efficiency. Then, in the process of intelligent mining, environmental pollution may occur.

In foreign countries, intelligent mining technology has been developed very mature. Coal enterprises in the United States, Germany and Australia have developed early, and have invested more in intelligent mining. They have developed memory cutting technology, electro-hydraulic control technology and frequency conversion technology of shearer. Now they can basically realize three-person automatic mining in medium-thick coal seams with good geological conditions, and further on the road of unmanned mining. As for the domestic intelligent mining technology compared to foreign countries, the domestic late start, slow development, harsh geological conditions. The popularity of intelligent mining is far less than that of foreign countries, the degree of informatization and digitization is slightly lower, and there are few core technologies developed independently. However, with the efforts of many industry workers, I believe that China 's intelligent mining will be more mature in the near future.

From 2016 to 2021, the Chinese government has gradually strengthened its emphasis on intelligent mines, and given corresponding guidance and suggestions. The types of intelligent mines have also gradually extended from coal mines to non-coal mines. Intelligent mining technology has made many breakthroughs. However, due to the limitations of technology, capital and geological structure, the application of automatic mining technology is not enough, and it is still in the primary stage of exploration. For example, thick coal seam has not really realized the automation of mining, and intelligent mining has not been accepted by all geological structures.

### 2.2. Development of intelligent mining technology

The development process of coal mine intelligence can be

divided into four stages. From the single machine automation stage to the integrated automation stage, the programmable control, remote centralized control operation, alarm and locking are realized. The primary data processing, primary system linkage and information comprehensive release are realized. At present, it is in the local intelligent stage of the research process to the transparent working face. In the future, it will reach the level stage of realizing the coordination of transparent mine and whole mine control. Intelligent mining technology is further promoting the research and development of underground high-speed wireless communication technology, coal mine identification technology and automatic straightening technology, adjusting equipment performance to accelerate the integration of 5G technology to improve the speed of information transmission, and ensure the smooth communication data and the dynamic capture of equipment information. Intelligent control of sewage discharge, create more coordinated and efficient mining conditions, and ultimately achieve unmanned mining operations.

As one of the emerging coal mining technologies, the intelligent mining technology of gob-side entry retaining with roof cutting is a comprehensive upgrading of the existing fully mechanized mining technology in China. Practice shows that through the reasonable application of this technology, the effective implementation of non-pillar mining can be effectively realized. Based on this technology, relevant staff can effectively realize the rational recovery and utilization of resources in the process of coal mining, so as to further promote the effective improvement and optimization of coal mining level. Practice shows that in the mining process, this technology can promote the further development and optimization of the control level of coal seam mining machinery by the staff, which is of great value to the safety of coal mining.

Green mining technology of coal mine. In order to respond to the national '14th Five-Year' development plan, green mining of coal resources is very necessary. Green mining technology can comprehensively plan and scientifically analyze the use of mining technology, and effectively reduce the generation and disposal of pollutants in coal production. The theoretical basis of this technology lies in the law of joint fissures and separation formed by the movement of key strata in the rock strata after mining and the seepage law of gas and groundwater in the broken rock strata. The main contents include water-retaining mining, coal mining under buildings and separation grouting to reduce subsidence, strip and filling mining, coal and gas co-mining, coal roadway support and underground treatment of some stones, coal underground gasification and so on. The application of green mining technology can reduce the difficulty of coal mining and improve the safety of coal mining workers at work.

Adaptive height adjustment has a deep influence on the development of intelligent mining. Adaptive height adjustment is mainly composed of intelligent control technology and coal-rock interface automatic identification perception technology. The two technologies have different functions. The main function of the former is to adjust the height of the shearer drum. In practical application, the technology is mainly based on the coal-rock interface recognition curve. Its advantage is that the equipment can be controlled in real time and the control delay of the technology is relatively small. This technology has shown superior performance in the process of coal mining, which has been

highly recognized by the majority of coal industry practitioners. The researchers pointed out that the key and difficult point of this technology in the application process is how to effectively identify and perceive the coal-rock interface.

Automatic scheduling control technology, which can be seen as 'free adjustment of product needs' technology. In the process of coal mining, through the reasonable application of this technology, the coal demand can be taken as the goal, and the propulsion speed, coal mining progress and work intensity of the shearer can be automatically planned. In this process, the relevant parameters designed include the inclination angle of the working face, the thickness of the coal seam, the hydrological conditions, the gas factor, the carrying capacity of the transportation system and the demand for coal. A comprehensive analysis can effectively plan the progress of the shearer reasonably, so as to reasonably realize the regulation and control of the relevant equipment, so as to realize the further improvement of the intelligent level of production work.

The development of intelligent mining technology has developed rapidly in recent years. Although the degree of development is a little worse than that of foreign countries, with the assistance of high-tech technologies such as big data, 5G communication and intelligent robots, intelligent mining will usher in a new chapter.

### **3. Intelligent Monitoring Technology of Coal Mine**

#### **3.1. Present situation of coal mine safety monitoring**

Coal mine safety production is the basis for ensuring the economic benefits of coal enterprises, and it is also the main content and primary link of its production and operation. In the past 10 years, China's raw coal production has experienced a rise, fall and rebound before and after the supply-side reform. However, the level of coal mine safety is constantly improving, and the mortality rate per million tons is generally declining year by year. This is due to the promotion of mechanization and intelligence of coal mines to the promotion of less people and unmanned, and the policy level attaches great importance to safe production. At present, many mining areas in China are equipped with safety monitoring system. As a monitoring system for production safety, coal mine safety monitoring system plays an important role in preventing and reducing coal mine safety accidents. Through monitoring, early warning and other functions, it ensures the safety of coal mine production. For example, the coal mine gas extraction monitoring system is used to monitor the methane concentration, pressure, flow rate, temperature and other parameters in the coal mine gas extraction pipeline, monitor the state of the pump and valve, and realize the functions of methane overrun sound and light alarm, pump and valve control. Because the gas in the extraction pipeline contains a large amount of dust and water, the gas composition is complex, and the negative pressure in the pipeline changes greatly. The closer to the front end of the extraction, the lower the gas flow rate in the pipeline. The coal mine gas extraction monitoring system has high requirements for sensor performance<sup>[7]</sup>. Nowadays, with the rapid development of intelligence, in order to improve the accuracy and sensitivity of the coal mine safety monitoring system, optimize its functions, and improve the reliability and

stability of the coal mine safety monitoring system, the state has clearly put forward the requirements to improve the coal mine safety monitoring system, and has made clear requirements for its technical indicators and functions, aiming to promote the intelligent development of the coal mine safety monitoring system<sup>[2]</sup>.

The coal mine safety monitoring system is mainly tested in two aspects of sensor layer technology and transmission layer technology. The problem that needs to be paid attention to in the sensor layer is the improvement of the protection level, and the environmental factors have a great influence on the sensor<sup>[3]</sup>. The transmission layer technology currently upgrades the acquisition function of the bus-type substation from analog acquisition to multi-channel bus acquisition, which effectively increases the transmission speed. After the upgrade, there are other functions such as data analysis and rapid control. Now the bus substation of coal mine safety monitoring system has 7 bus functions, of which 4 are responsible for collecting sensor data. The main component of the wireless signal converter, which can be directly connected to the mine bus sensor cable, through the combination of underground wired and wireless transmission network technology, to achieve flexible configuration of the line ; the regional cooperative controller takes the embedded processing system as the carrier, through the centralized collection of wired and wireless, it can make safety prediction according to the underground environment, equipment operation, personnel, etc., and can also deal with sudden accidents to achieve the purpose of pre-control.

### **3.2. The development of intelligent monitoring system**

After more than 10 years of comprehensive promotion and application of coal mine safety monitoring system, the deficiencies in technical standards, installation, use and maintenance management are gradually exposed, such as : low system stability, poor reliability, poor compatibility, inconvenient management and maintenance<sup>[4]</sup>. In the face of these problems and shortcomings, the upgrading and transformation of coal mine safety monitoring system is imperative. For example, in view of the shortcomings of low stability, through the anti-electromagnetic interference test of the system, through the digital information sensor, the protection level of the system is improved, and the storage data is encrypted<sup>[5]</sup>. The main network of the system adopts industrial Ethernet, which simulates the wired transmission mode between the sensor and the substation. There are two ways to integrate the bus and the branch line to ensure the efficiency of signal transmission. As the country requires intelligent development, the development of monitoring systems is also getting faster and faster.

Distributed laser methane monitoring technology. The number of gas monitoring points in coal mines is limited, and the data collected by traditional gas monitoring technology is not accurate enough. Using distributed laser methane monitoring technology, through its adjustable laser absorption technology, combined with optical path space division multiplexing technology, through the introduction of laser automatic correction system, can complete the accurate monitoring of gas in mines, solve the problem that traditional sensors cannot work for a long time, and reduce. Distributed laser methane monitoring technology can realize synchronous monitoring of 8 gas chambers<sup>[6]</sup>. According to the monitoring requirements, the monitoring surface can be expanded to

twice, the monitoring range is greatly improved, and the response time is also greatly shortened, which can realize synchronous monitoring of gas. It can improve the safety early warning ability.

Ultrasonic time difference method section wind speed monitoring technology. The ventilation of underground roadway in coal mine is not uniform. The wind speed error of measuring the wind speed of a point in space instead of a plane will be relatively large, and there is a blind area of lower limit measurement, which is difficult to meet the needs of intelligent ventilation system construction. The cross-section wind speed monitoring technology based on ultrasonic time difference method can realize the full-section wind speed measurement of the roadway. The multi-line measurement and the fitting integral of the roadway surface are used to accurately calculate the ventilation volume and provide stable and accurate monitoring data for intelligent air conditioning.

High resolution laser trace monitoring technology. This technology can solve the problem of inaccurate measurement of natural fire beam tube in goaf. Through the on-line monitoring sensor of carbon monoxide, the local measurement and treatment of ignition characteristic gas can be realized, and the early warning and prevention ability of fire can be improved.

## **4. Intelligent Management Technology of Coal Mine**

### **4.1. Intelligent monitoring and communication**

The intelligent management technology of coal mine leads the monitoring system and mining system. The management system monitors the mine information at all times. Using the monitoring equipment, the management department can obtain the running state of the underground equipment in real time, ensure the normal operation of the relevant facilities and equipment, and reduce the probability of accidents. The actual position, health status and emotional state of the staff can also be transmitted to the management department through the monitoring system to effectively ensure the safety of the workers. The management system also grasps the mining progress and expected output at all times, and collects the roadway parameters in the mining work. In terms of communication, it is necessary to ensure that the information is not interrupted and the sound is clear. It is necessary to prepare for normal communication and special communication<sup>[7]</sup>. The normal communication system is mainly used in general working conditions to ensure the smooth progress of mining work. The communication system is used to transmit mine information to ensure the smooth communication between the workplace and the ground console. The special communication system is mainly to deal with special situations. Once a disaster occurs in the mine, a special communication system should be adopted immediately to ensure that the information is transmitted inside and outside the mine in time.

### **4.2. Intelligent Decision Making and Execution**

The intelligent decision-making system of the intelligent management system makes the optimal decision by analyzing and processing the information collected by the on-line monitoring system on the spot<sup>[8]</sup>. With the rapid development of information technology, all walks of life can realize management work through cloud computing, realize information and intelligent management in coal mines,

digitize all kinds of work information, and use information system to obtain the overall information of coal mines. Due to the huge scale of information in coal mines, cloud computing technology must be used to complete storage and processing work to ensure that coal mines effectively use the information data collected at present. Through cloud computing technology, it can not only save the cost of manual calculation, but also effectively improve the data processing level of enterprises and ensure the smooth development of the construction of safety production information system. After receiving the decision, the system executes the action immediately, such as increasing the ventilation volume, suspending the underground equipment, making reasonable decisions on the complex situation of the underground, using the system to convey the decision-making instructions, and improving the overall work efficiency.

## 5. Conclusion

With the continuous promotion of national policies and the effective support of new generation of information technologies such as 5G, the intelligent and intelligent construction of coal mines in China continues to accelerate. In the ' 14th Five-Year Plan ', intelligent mines will be added to high-quality development as a mainstream construction plan. A number of high-tech enterprises such as Longruan Technology and North Road Intelligent Control have also emerged in China, which have been put into the tide of intelligent informationization of coal mines. With the deepening of technology construction such as industrial Internet of Things basic platform, intelligent equipment and robots, and coal mine big data, the industry will form leading enterprises with development advantages, the development

pattern of coal mine intelligent industry will be more obvious, and the market concentration will continue to increase. Connect the coal mine with intelligence, promote the cloud deployment of traditional information business, and finally realize the unmanned production of the whole process of the mine.

## References

- [1] Zhao Changxin,LIU Haiqing. Research status and prospect of intelligent mining technology in coal mine[J]. Automation for Industry and Mining, 2022, 48(S2): 27-29.
- [2] Li Ming. Research on the status quo and intelligent development of coal mine safety monitoring system[J]. China New Communications, 2022, 24(02): 121-122.
- [3] Fan Rong, Xv Jin. Current situation and development trend of intelligent management and control technology for coal mine safety[J]. Intelligent Mines, 2021, 2(01): 55-58.
- [4] Liu Cheng, Sun Dongling, Deng Fei ,LI Jiangong, Long Qingming. Intelligent prevention and control and intelligent monitoring technology of multiple disasters in coal mine[J]. Smart Mines, 2022, 3(07): 105-114.
- [5] Zheng Huahua. Analysis and application of intelligent technology of coal mine comprehensive mining face[J]. Mining Equipment, 2022(06): 55-57.
- [6] Wu Yang. Analysis of intelligent ventilation system in coal mine[J]. Energy and Energy Conservation, 2022(11): 146-147.
- [7] Zhang Qiang. Application of intelligent information management system in coal mine[J]. Mining Equipment, 2022(04): 278-279.
- [8] Qiao Weiming. Application of intelligent mining technology for comprehensive mining face of coal mine[J]. Mining Equipment, 2022(06): 14-15.