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The Recent Technological Development of Intelligent Mining in China

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ABSTRACT

In the last five years, China has seen the technological development of intelligent mining and the application of the longwall automation technology developed by the Longwall Automation Steering Committee. This paper summarizes this great achievement, which occurred during the 12th Five-Year Plan (2011–2015), and which included the development of a set of intelligent equipment for hydraulic-powered supports, information transfers, dynamic decision-making, performance coordination, and the achievement of a high level of reliability despite difficult conditions. Within China, the intelligent system of a set of hydraulic-powered supports was completed, with our own intellectual property rights. An intelligent mining model was developed that permitted unmanned operation and single-person inspection on the work face. With these technologies, the number of miners on the work face can now be significantly reduced. Miners are only required to monitor mining machines on the roadway or at the surface control center, since intelligent mining can be applied to extract middle-thick or thick coal seams. As a result, miners' safety has been improved. Finally, this paper discusses the prospects and challenges of intelligent mining over the next ten years.

1. Introduction

Intelligent mining, which is based on mechanized and automatic mining methods and which combines informatization with industrialization, has brought about a revolution in the coal industry [1]. This new technology can carry out mining automatically by intelligently perceiving the circumstances around the work face, intelligently controlling each mining machine, and automatically navigating mining equipment. Intelligent mining has three main characteristics: ① Mining machines have the intelligent ability to work by themselves; ② real-time data can be captured and updated promptly, including geological information, the changeable boundary line between the coal and rock, the positions of machines and of the mining process, and so on; and ③ machinery can be automatically controlled according to the conditions of the work face. When decision-making and machine operation can be conducted automatically, the work face is called an "intelligent mining work face" [2].

During the period of the 12th Five-Year Plan (2011–2015), several key technologies were achieved through active research. These technologies and achievements included: a set of intelligent equipment for mechanized mining; information transfers; dynamic decision-making; performance coordination; and the achievement of a high level of reliability despite the complicated mechanized procedures, large equipment system, and bad working conditions in China.

An intelligent system comprising a set of mechanized mining equipment was completed, with Chinese intellectual property rights. An intelligent mining model was built that permitted unmanned operation and single-person inspection on the work face. Using this model, the mining process can be monitored from the roadway or from the surface control center. In this way, our domestic technology has reached the international level; it can meet our coal production needs and provide direction for the future technological development of the Chinese coal industry. Fig. 1 shows the stages of intelligent mining technology development in China.

2. International intelligent mining

China's coal mining technology is still advancing toward the level

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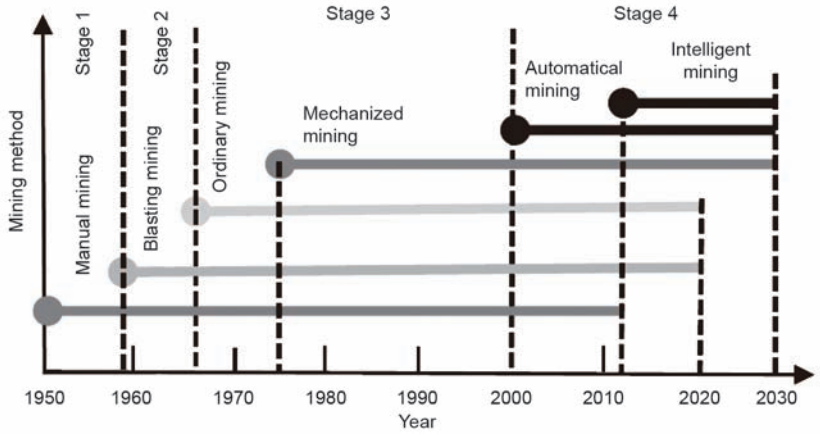

Fig. 1. Stages of intelligent mining technology development in China.

of the mining technology in Australia, Germany, and the United States. Therefore, we pay considerable attention to the Longwall Automation Steering Committee (LASC) longwall automation technology, which was developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO), and to the Intelligent Mining Service Center (IMSC), which was developed by Joy Global Inc. (now Komatsu Mining Corp.) in the United States. These applications are briefly discussed below.

2.1. The introduction of LASC

In Australia, LASC is engaged in automatic and intelligent mining technology for coal mines [3]. Three main achievements were obtained by applying a precision optical fiber gyroscope and a method of navigation and orientation. The first achievement is the fixing of the three-dimensional (3D) position of the shearer (deviation less than ±10 cm); the second is a system of straight adjustment (deviation less than ±50 cm); and the third is a horizontal level control system for the work face. In this way, the initial automatic controlling system was completed. The mining process can be monitored from a distant position, such as the roadway. These achievements were rapidly applied in the coal industry. By combining drill geological information with excavation information, the situation of a coal seam can be described; the 3D position of the shearer is then fixed on the seam via gyroscope. Thus, automatic mining is implemented and the difficult problem of how to distinguish the boundary line between coal and rock is solved.

The key technology of LASC longwall automation includes fixing the 3D position of the shearer, keeping the conveyor and supports straight and level, raising the shearer drum automatically, and providing 3D remote monitoring video feeds [4].

Fig. 2 shows the stages of development of LASC longwall automation technology. At present, the Tiandi Science and Technology Co., Ltd. is cooperating with the CSIRO. We have improved greatly as a result of our work with LASC, and our intelligent mining technology has been greatly enhanced.

2.2. The introduction of IMSC

The IMSC is a remote monitoring system that is applied to the longwall coal work face, which was developed by the American company Joy Global Inc. (recently taken over by the Japanese company Komatsu Mining Corp.). This system captures the real-time information and data of all mining machines at any time. It allows mining engineers to adjust coal production procedures according to information reported by the system regarding alarms or breakdowns (Fig. 3).

The IMSC provides a machine working analysis report of the coal

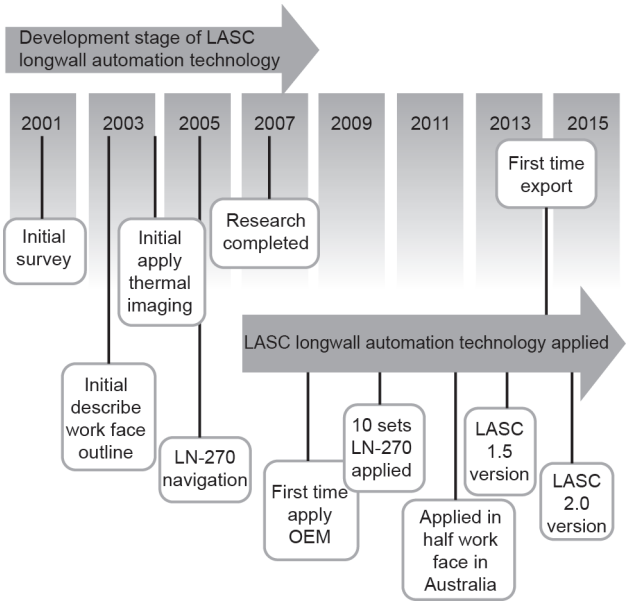

Fig. 2. The development of intelligent mining with LASC longwall automation technology. OEM: original equipment manufacturer.

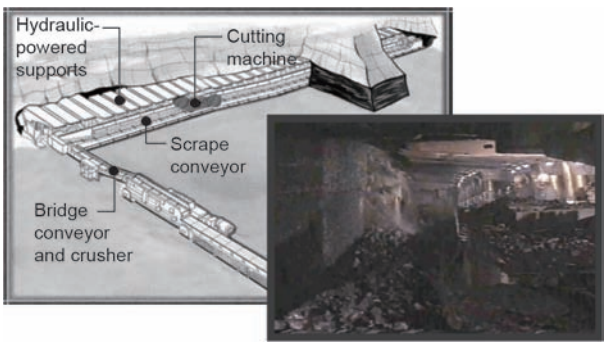

Fig. 3. Devices at the work face monitored by the IMSC.

mine by day, week, month, and season in order to guide the reasonable arrangement of a production procedure and machine-repair time. All the coal mines are monitored in real time at the general headquarters of the Anglo American company located in Brisbane, Australia. According to the equipment working parameters and monitoring data, engineers can adjust the production procedure at any time. Usage of this system led to an increase in production capacity of 15%, with greatly beneficial results [5].