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COMMENTS

Anlin SHAO

Can industrial intelligence promote industrial transformation? —Case of mining enterprises

The development mode of human society has undergone profound changes in the past two decades due to the rapid development of information technology and is experiencing a new landmark intelligence revolution. Intelligence is a global development strategy for the revitalization of the manufacturing industry proposed after the industrial electrification, automation, and informatization revolution. As intelligence progresses, individuals, enterprises, organizations, cities, countries, natural systems and social systems benefited from the interconnection and interworking that become increasingly thorough and comprehensive. For the first time in human history, almost anything can be made digital and interconnected. Intelligent technology may be embedded in everything in the future. It could provide highly intelligent services and may bring new and smart development ideas for economy and society.

The current economic development trends of China and the world indicate that the manufacturing industry will have to face greater competition pressure in the future. To promote green manufacturing and ensure its sustainable development, Germany proposed the concept of Industry 4.0 in 2013. In 2015, The Chinese government put forward the grand plan of "Made in China 2025" in the "Government Work Report," and proposed the development ideas of manufacturing in the future. The core ideas of "Industry 4.0" and "Made in China 2025" are to use industrial big data and analytical techniques to enhance the efficiency and intelligence of the production process, that is, to integrate machines, resources, products and people by maximizing the use of information, communication, and optimization techniques based on the analytics of industrial big data to achieve intelligent manufacturing (Preuveneers and Ilie-Zudor, 2017; Zillner et al., 2016).

Mineral resource is the foundation of industry. Transformation and development of mining enterprises play a vital role in industrial development in China. Therefore, this work examines whether industrial intelligence can promote industrial transformation, from the aspect of smart mines.

Construction of smart mines is a trend with far-reaching significance

The concept of intelligent mining driven by foreign mines appeared in the beginning of this century. Finland, the United States, Canada and other developed countries have been striding along the intelligent direction in the mining industry, and have achieved high-efficiency, high-level security (Uronen and Matikainen, 1995; Pukkila and Sarkka, 2000; Sarkka et al., 2000). Domestic mines have also kept in pace with Internet development; they aim for deep integration of information and industrialization and gradually transform from mechanized mines to automated and digital ones. Most of them have achieved timely acquisition, network transmission, standardized integration, visual display, and automated operation, and have reduced costs and improved efficiency. However, a large gap remains between domestic and advanced levels. During the design and implementation of "Made in China 2025" and intelligent manufacturing, domestic mining enterprises should seize the opportunity to accelerate the construction of smart mines, and occupy the high ground in this new round of industrial competition.

Different stakeholders in smart mines have different views. Smart mining is an advanced stage of information technology. It is a comprehensive integration of strategies, management and technology, and adapts to strategic needs of diversified, large-scale, green development. It is closely

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Anlin SHAO (✉)
AnSteel Group, Anshan 114021, China
E-mail: alshao@163.com

integrated with advanced technology, management philosophy, and advanced information technology, and established based on a collaborative management network of large data, cloud computing, mobile Internet, and Internet of Things. Smart mines also involve an advanced mining development mode that possesses the distinctive characteristics of excellent corporate culture, rigorous business processes, efficient coordination of information, dynamic adjustment control, rapid response to implementation, and independent optimization and improvement. Compared with traditional mechanized, automated, and digital mines, smart mines involve long-term strategic considerations, more systematic management thinking, more efficient response capability, more comprehensive interoperability, and deeper intelligence. These mines are expected to bring a revolutionary upgrade for mining enterprises in the aspects of resource utilization, safe production, comprehensive control, change and innovation, and green development. Smart mines have a far-reaching significance for scientific mine development.

Construction of smart mines is implausible but feasible

Industrial intelligence was proposed to promote industrial development, but the related technology is not sufficiently mature, several issues exist in the application process given the specific industrial background (Drath and Horch, 2014). Accordingly, the construction of smart mines also encounters the following difficulties:

1) Mine production has the typical characteristics of a process industry. It is a complex system composed of multiple processes, such as exploration, mining, ore dressing, mineral processing and smelting. Its complexity is not only reflected in the complexity of system composition and structure but also in input and output of fossil, energy, information, and capital flow. Moreover, the exploited objects and operating environment are unknown and possess uncertainty, and managing multi-level equipment including production, workshops and factories composed by traditional stand-alone equipment is a complex system. Tracking control and dynamic adjustment in the production process are extremely difficult.

2) The development levels of mining enterprises are asymmetric. Thus, establishing a standardized industrial intelligence system is difficult: Several large-scale enterprises with advanced technology and equipment may have already realized intelligent production, but many small and medium-sized enterprises still suffer from a large gap between their automation/information technology and the realization of the basic level of industrial intelligence. This issue cannot be resolved by national support only. Industrial intelligence is a systematic project. The various subjects and supporting facilities in an intelligent system have to keep up with the development pace, and awareness of using intelligent digital production is also required. This requirement results in difficulties in the establishment of a standardized industrial intelligence system.

3) Industrial intelligence subverts the traditional management mode. In the industrial intelligence mode, product customization is achieved, and enterprises can determine customer needs from the Internet and utilize dynamic data mining and analysis to help customers participate in product design and manufacturing. By constructing the process model through the full use of big data in the production process and optimization techniques, integrated optimization for the whole process, scheduling, planning, inventory, logistics, and supply chain in intelligent manufacturing can be achieved (Ivanov et al., 2016; Marques et al., 2017). The business mode changes from order-based manufacturing to service-based manufacturing. This scenario results in a change in the traditional industrial enterprise management mode, how to change the management mode to realize final intelligence while ensuring the normal development of existing circumstances thus becomes a challenge (Gorecky et al., 2014).

Construction of smart mines is difficult in such an extremely complex environment.

For this reason, many people believe that the construction of smart mines is impossible. In fact, although China's construction of smart mines is still in its infancy, many problems remain to be solved, and no existing mode can be used for reference, we cannot deny the achievements that have been attained in the aspect of "Internet + mine." Building green, intelligent, safe, efficient, smart mines is the current trend. Rome was not built in a day. As complex systematic projects, smart mines cannot be built overnight. Time is required for a new concept to be adopted, explored and tried. The process may consume much time, may require modification, and may encounter setbacks and failures. However, as long as we pursue in this direction, persevere to maintain it, and continue to enrich and develop it, we can achieve our goal.

In 2013, as the largest iron ore enterprise in China, ANSTEEL Mining Corporate, put forward the development strategy of "smart mine" according to the national strategy after fully completing the construction of a digital mine. "Coordination of five stages" mining and metallurgical system engineering theory is used to pursue a dynamic balance among safe production, green initiative, resource utilization, and business efficiency. Relying on intelligent perception, Internet of Things, big data, cloud computing, mobile applications and other information technology means, the practice can be explored from three dimensions of smart production, intelligent management and Intelligent service, which initially form the solutions of strategy+management+technology, and we can take a substantive step toward the construction of smart mines. ANSTEEL Mining Corporate was among the first batch of state-level intelligent manufacturing pilot demonstration

units. The author believes that in the future, more mining enterprises will join the ranks, and smart mine construction prospects can be expected. We might even be able to control the operation of an entire mine via a mobile phone. To ensure the positive role of industrial intelligence, corresponding methods should be considered during the promotion.

Construction of smart mines requires superior top-level design

Traditional digital mine planning often involves a bottom-up approach and gradually adjusts to meet management needs via digital production process. The accumulation of construction information for many years, especially the idea of intelligent manufacturing, requires that smart mine planning should involve a top-level design, starting from business development strategy needs (from top to bottom) to systematic promotion. First, we must establish a system concept and an overall view. The uncontrollable characteristics of resource geological conditions require that the construction process of smart mines start from "big mining" as a whole. All aspects of the production must be taken as an organic whole and optimized according to the processing methods of the large system so as to maximize the overall value. Second, we must build a supporting platform. Based on the ubiquitous network environment, a platform for standardized facilities must be built to achieve the standardization of information operation and maintenance. An integrated digital mining platform must be constructed to achieve transparency in production management. A humanized safety management platform is also required to pursue production safety. An integrated business control platform must be built to achieve standardized and efficient collaborative management, and an automatic control technology platform must be constructed to achieve process linkage and intelligent control of production. Third, we should pay attention to collaborative innovation. The technical advantages of production, learning, research, and application must be integrated in the field of mining, information technology, and other industries to carry out comprehensive key technology research and application promotion of smart mines. We should also strive to form a dynamic, coordinated, optimized smart mine overall environment.

Key research directions for the construction of smart mines

The domestic mine information function should be changed from the original support business and operations to the leading industry development and innovation to achieve the goals of "building an integrated platform to create a mining ecology, transforming businesses with information technology, highlighting the characteristics of the industry to form a mining model, and implementing intelligent manufacturing to reflect the role of demonstration." Focus should be put on the promotion of three dimensions of intelligent production, intelligent management and intelligent service.

First, new models of intelligent production can be implemented to achieve a revolution in production methods. With the implementation of production as the core, the technologies of Internet of Things, acquisition and positioning can be used to achieve iron flow, energy flow, information flow, and capital flow as a whole linkage. We can also utilize intelligent command, automated scheduling, punctual organization, and lean production to achieve effective allocation of resources. Focus should be put on the development of the whole process of intelligent control research, and the traditional mode of separate process management must be changed to achieve intelligent control from mining to the finished product. We should carry out "unmanned" mining operations as the overall solution, and utilize automatic control technology to achieve the change from remote supervision to unmanned control, which is not only a requirement to achieve essential security, but also an inevitable choice to improve labor productivity and reduce cost. A "virtual mining" feasibility study must also be conducted as the construction of a large underground concentrating mill is a global frontier issue. Virtual simulation technology can be used to establish underground mining and mineral processing layout control models, create underground integrated management and control mode, and achieve virtual mining, which in turn will achieve a revolutionary upgrade on non–waste, non–disturbance green and efficient development.

Second, we could implement new models of intelligent management to achieve efficient business collaboration. We could rely on information technology to reshape the management process, make digital processing, achieve structured organization, and perform an intelligent analysis of the management process, management standards, statistical analysis and other needs to achieve a dynamic process and efficient coordination of business management. By focusing on research on the common technology of data service, we can build a smart mine data storage and management service platform, study data collection models for stable external data sources, analyze the manner of information management, establish data analysis and decision support models, use data warehouse, and data mining technologies, and aggregate enterprise management wisdom, to ensure the realization of strategic objectives.

Third, new models of intelligent service may be implemented to create resource value. Application service model standards can be applied to ensure the effective implementation of information service model. Transformation from a business e-commerce platform to an industry public platform must be implemented to enhance the industry-wide supply chain service management level. A

feasibility study of information cloud service should also be conducted to build an industry information service platform, provide services for special information needs of the same industry, and create data bases for the country to establish a data center for mines and to achieve the maximum value of information resources.

In summary, construction of smart mines has become the only means for the transformation and development of the mining industry. Although such construction is difficult, it can be done if we have sufficient confidence, determination and patience. Industrial enterprises, including mining enterprises should conform to the trend, promote the integration of information and industrialization deeply, and drive the transformation and upgrade of the mining industry based on the "Internet Plus" concept so as to promote the overall competitiveness of the industry and ensure sustainable development.

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