Discussion on Application of IOT Technology in Coal Mine Safety Supervision

Zhang Yinghua\textsuperscript{a}, Fu Guanghua\textsuperscript{a}, Zhao Zhigang\textsuperscript{b}, Huang Zhian\textsuperscript{a,*}, Li Hongchen\textsuperscript{b}, Yang Jixing\textsuperscript{b}

\textsuperscript{a} State Key Laboratory of High-Efficient Mining and Safety of Metal Mines (University of Science and Technology Beijing), Ministry of Education Beijing 100083, China.

\textsuperscript{b} Planning & Technology Department Communication & Information Center of State Administration of Work Safety, CICSAWS Beijing, China

Abstract

According to condition that safety situation of national coal mine production remains serious, and serious accidents have not been effectively curbed, current status of safety supervision informationization is analyzed. Through introducing concept of Internet of Things (IOT), view of using IOT to help safety supervising authorities of coal mine strengthen supervision on enterprises implementing principal responsibility for safety was put forward, and specific application of IOT in safety supervision of coal mine was analyzed thoroughly. Program of networked remote inspecting technology on basis of IOT was proposed, which provides a new way for innovating supervising way, thereby working effectiveness of supervision against coal mine can be enhanced, and serious situation of safe production in coal mines can be improved, finally safe and stable development of coal industry can be further promoted.

Keywords: Coal mine, Safe production, Supervision, Informationization, IOT

1. Introduction

In recent years, situation of safe production in coal mines of China is significantly improved, but it is still serious. From 2005 to 2009, 57,106 accidents occurred totally, among which 11,308 are accidents in coal mine, accounting for more than 20%. Number of serious accident of coal mine reaches to 176, as 4101 people died. Although national policies and measures for strengthening safety of coal mine are introduced from time to time, serious accidents still occur frequently. One important reason is that all levels of supervising authorities of coal mine lack effective tools to supervise enterprises’ implementation of guidelines and policies of safety, as well as lacking supporting means of late tracking supervising and supervision against rectification and governance of hidden dangers of coal mine, especially lacking informationalized supporting means [1].

As fact proves, scientific, accurate and effective information is the key of ensuring safety supervision of coal mine. Although some basic informational measures have been built through carrying out of projects such as first stage of the golden safety project, they are only preliminary business managing informational system, con not deal with serious situation of safe production and need to be further expanded and improved. Appearance of Internet of Things (IOT) provides an effective way for strengthening safety supervision of coal mine. Through adopting IOT technology, remote dynamic...
supervision against coal mine can be strengthened, intelligent supervision against coal mine can be realized, capacity of early warning, emergency response and investigation can be improved, and supervising and decision-making level of coal mine supervising authorities can be enhanced, thereby accidents can be avoided and loss can be reduced maximally, finally grim situation of safe production of coal mine can get improved effectively.

2. Problems of coal mine safety supervision information

Currently, coal supervising administrations can’t effectively supervise underground unsafe behaviours of people, unsafe condition of matters, unsafe condition of environment and defects of management, especially can’t carry out daily supervision and inspection against monitored information, making serious accidents still occur frequently as results of unsafe behaviours such as personnel moving illegally and damaging detecting probes. Levels of process management of businesses such as one ventilation and three prevention supervision, identification of major hazards, gas level classification, standardization of safety and quality, producing capacity checking and others need to be enhanced through adopting informational technology, and dynamic safety supervising capacity of coal mining enterprises need to be further developed.

First stage of the golden safety project build preliminary safety supervising informational system for coal mine safety supervising institutions at all levels, but they are only fundamental and partial, not comprehensive coverage of safety supervising businesses, as only overview of safe production of coal mine can be known. Basic informational database against high-gas mine and outburst mine has not been built, moreover, networked supervising intensity against “one ventilation and three preventions” and controlling of significant hidden dangers is inadequate.

In supervising process against illegal and violating acts, safety supervising agencies of coal mine can only understand unsafe behaviours of coal mining enterprises through on-site inspection or accident investigation, and they lack informational means to systematically inspect distribution, number, action and training situation of underground workers [2].

3. Application of IOT technology

IOT is such a kind of network that in accordance with agreed protocol goods are connected to Internet through radio frequency identification (RFID), infrared sensor, global positioning system (GPS), laser scanner and other information sensing devices for informational exchange and communication, achieving intelligent identification, location, tracking, supervising and management. In this network, goods can communicate with each other without human intervening. Its essence is to realize automatic identification of goods and informational interconnection and sharing through adopting RFID technology and Internet. RFID tags store specific and interoperable information which is collected automatically to a central informational system through wireless data communicating network, achieving identification and informational exchange of goods through open computing network, finally achieving transparent management of goods.

The so-called “intelligent safety supervision of coal mine” refers that coal supervising institutions at all levels adopt IOT technology to communicate with mining enterprises and establish effective tracking systems and database systems, achieving dynamic supervision and early warning against illegal production through remote inspection, and using data collected by sensors to aid emergency rescue, accident investigation and so forth. Specific applications of IOT technology in safety supervision of coal mine are as follows [3-6].

3.1. Tracking supervision of underground personnel

(1) Accurate location, automatic identification and training supervision of underground personnel. Existing systems can’t meet needs of emergency rescue and management of underground workers. Through adopting IOT technology, informational systems used for accurate location of underground personnel, recognition of iris and face, safety training and management of working licences can be developed.

(2) Closed loop controlling of Personnel, equipment and environment. Closed loop controlling such as gas air-power being locked to prevent gas explosions, electrical and mechanical being locked to prevent working with electricity and so on is important guarantee for safe production of coal mine. Through adopting IOT technology, closed loop controlling of all types of workers, operated equipments and working environment can be achieved.
3.2. Monitoring and warning of environment

(1) Informational aid of investigation and handling of accidents. Through adopting IOT technology, environmental parameters in mine can be detected and stored, and used as important basis of accident identification and accountability confirmation after accidents occur, providing important reference for investigation and handling of accidents.

(2) Warning of serious disaster. Warning of serious disaster is an important measure to ensure safe production of coal mine. Existing safety supervising system has low accuracy and can't meet actual need. Through adopting IOT technology, accuracy of warning can be improved.

3.3. Monitoring and warning of device

(1) Whole process monitoring of safe explosives used in mine. Through adopting IOT technology, tracking management of safe explosives’ production, transportation, storage, using and other stages of whole process can be achieved, and accidents caused by private production and improper behaviours in transportation, storage and using of explosives can be avoided.

(2) Whole process monitoring of significant and critical equipments used in mine. Normal operation of significant and critical equipments such as boring machine, conveyor, elevator, fans and so forth is important guarantee for safety of coal mine. Through adopting IOT technology, whole process tracking management and healthy diagnosis of significant and critical equipments can be achieved, providing high-efficient material guarantee for coal mine.

3.4. Supervision of management

(1) Management and supervision of emergency plan, rescuing equipment and rescuing team. Through adopting IOT technology, effect of emergency plans, training situation of rescuing team, maintaining situation of rescuing equipment can be inspected and mastered. After accident occurs, the best combination of emergency plan, rescuing equipment and rescuing team can be built up in the shortest time, providing timely and effective support for emergency rescue of coal mine.

(2) Management and supervision of implementation of operating procedures. Through adopting IOT technology, executing and implementing situation of operating procedures and “three measures” can be tracked, then relevant personnel can be handled and educated. Through analyzing effect, rules and regulations can be further improved, and executing intensity can be strengthened.

4. Networked remote inspection technology program

Theory of safety management, theory of accident causes and IOT technology are combined together to focus on prevention in advance, emphasize early warning, guide emergency rescue and assists accident investigation. Through this, “comprehensive, all-weather, all-factor, whole process” real-time monitoring and intelligent disposition of producing process, workplace and security elements can be achieved, and “interconnection of goods, intelligent perception, interaction of goods, intelligent disposition” in safety supervision can be realized too.

Through adopting a large number of sensors, dynamic information of various aspects of mine (including deformation, smell, pressure and so forth) can be obtained, perceived, transmitted, analyzed and processed, and warning and processing against possible information of disaster can be carried out timely. Combining actual situation of mine, abnormal data can be analyzed so that key areas to monitor can be defined and their situation can be displayed dynamically and real-timely. Moreover, location of hidden danger can be marked, then thematic maps can be generated, and then warning can be issued.

Characteristics of networked remote inspecting technology are as follows: firstly, it aids safety supervision of mine and its acting unit issues warning timely and automatically after hidden dangers are discovered; secondly, the information stored in database can be used as auxiliary and reference for emergency rescue and accident investigation; thirdly, relevant data of mine can be obtained in advance, providing information and guide for subsequent on-site supervising, thus supervising performance can be improved effectively. Fig 1 shows block diagram of the networked remote inspecting technology.
Networked remote inspecting system includes safety supervising system, positioning system and dynamic data supervising system. They combine organically and achieve informationalized safety supervision of coal mine together [7-9]. Details are as follows:

4.1. Safety supervising system

Traditional video surveillance can’t supply specific data parameters and accurate information, so can’t ensure mine’s safety fully.

Through adopting IOT technology, different types of nanoscale sensors can be installed at key locations of mine so that sound, frequency, image and other information can be monitored. Sensors scan matters around them, and then send data to data processing unit. If there is an unusual circumstance, acting unit would issue a warning and notify relevant personnel automatically. Fig 2 shows simplified block diagram of safety supervising system.

4.2. Positioning system

Due to influence of power supply, underground signal and other factors, effect of traditional positioning system is not notable, and its maintaining cost is too high.
Through adopting IOT technology, a mine can be divided into several areas, and ID scanning sensors can be installed in each area to scan IDs of corresponding staffs. Information obtained can be transmitted to storing unit through data transmitting unit. Fig 3 shows simplified block diagram of positioning system.

![Fig. 3. Simplified block diagram: positioning system](image)

4.3. Dynamic data supervising system

Existing data supervising system has only single function and narrow transmitting range, and can’t respond to emergency automatically.

Through installing sensors, data such as gas concentration, exhausting volume of each mine can be monitored, and through data transmitting unit, data can be real-timely transmitted to data processing unit for processing and preservation. When some data is too high, the system will automatically adopt effective measures and inform related workers to prevent accidents from happening. Fig 4 shows simplified block diagram of dynamic data supervising system.

![Fig. 4. Simplified block diagram: dynamic data supervising system](image)

5. Conclusion

The concept of “IOT” breaks traditional thinking and introduces new idea, technology and method for safety supervision and management, corresponds to the scientific and security development concept, and reflects essential connotation of “Safety and prevention first, comprehensive treatment”. Through adopting IOT technology for remote dynamic supervision, coal mine supervising pattern can be innovated, tracking inspection on illegal action can be achieved, capabilities of emergency response and accident investigation can be increased, situation of safe production can be further improved, and safe and stable development of coal industry can be promoted.

References