Design of Wireless Communication System in Mine

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Abstract. In order to improve the control efficiency of large equipment such as scraper, transporter and crusher, and reduction in personnel, increased security factor, based on PLC automatic control and wireless interconnection technology, a mine wireless communication system including wireless control host, wireless handheld and wireless relay substation is developed. The system carried out industrial experiments on the mining face in coal mine. The test results show that the system is easy to install and maintain, the equipment is stable, the wireless signal covers no blind areas, the call is clear, the data transmission is reliable, and the wireless remote control of the large equipment is achieved.

Keywords: Mine; Wireless communication; PLC.

1. Introduction

Coal mining face space is narrow, geological situation is complex, scraper and crusher, and other large equipment are wired control mode. However, at present, the wired communication control mode in the working face is difficult to install, the cable wiring is not convenient, the failure rate is many and so on, all kinds of start and stop control of large equipment is fixed position set fixed personnel, the relevant personnel cannot stop the device and voice communication in case of emergency. At present, underground wireless communication mainly adopts Wi-Fi, Li-Fi, LTE, Zigbee, and Bluetooth, there is a problem of low communication efficiency. For example, short communication distance and large delay. The existence of these problems, resulting in many security risks, more personnel settings, coupled with a wide variety of equipment types, resulting in a large labour intensity, difficult maintenance, poor security conditions [1-4]. With the deep research of the informatization and automation of coal mining, the communication demand of multi-type data in working face is more and more, and it is becoming very important, which makes the shortcoming of wired communication mode more and more prominent, so more attention is paid to the use of wireless communication mode in coal mine. [5][6]

In order to improve the production safety factor of coal mining face, reduce the difficulty of downhole maintenance, improve work efficiency, and promote the process of fully mechanized mining automation and unmanned procession, the author combined with Datong Coal Mine Group, according to the geological conditions and working conditions of coal seam, based on the design idea of intrinsic safety circuit, comprehensive use of low power technology, wireless communication technology and automatic control technology, based on wireless relay mode for flexible networking, a set of wireless communication set control system is constructed to realize fully mechanized mining face scraper
machine, crusher, pumping station and other large equipment wireless remote control, and to achieve any location in the mining area of wireless voice communication and wireless data transmission, it opens up a new way to improve the technical level and safety factor of the working face.

2. System Composition and Realization

2.1. System Architecture

The wireless communication collection and control system is mainly composed of 3 parts: terminal device, transmission equipment and centralized control equipment. System equipment contains mining explosion-type wireless collector host, mining of this type of wireless relay substation and mining of this type of wireless handheld machine, developed and produced by Dalian Kinsenyi Electronic Technology Co., LTD. And the system structure is shown in Figure 1.

Figure 1. Structure of wireless communication collection and control system.

All devices are interconnected via wireless relay links, and multiple wireless relay stations form a high reliability wireless link, and when one of the relay stations fails, the system can be re-interconnected and automatically set up. Wireless collector host can realize the output of wireless data access and control instructions, and then control the working face scraper machine, reprint crusher, pumping station and other large equipment. Wireless relay substation realizes wireless signal access and long-distance relay transmission, wireless handheld machine realizes wireless remote start and stop control of voice communication and working face three machines.

2.2. System Function

(1) Machine wireless boot and stop: Through the collector host to control the crusher, reprint machine, the closure of the power supply part of the transporter to achieve the switching of its working state, and in the collector host to add a wireless module, to achieve the use of wireless handheld machine remote control signal transmission and reception, and then control the working state of the three machines. Through changing the traditional mode of the need for workers at the same time wired way to control, greatly improved the timeliness and accuracy of control, to avoid the workers in the case of panic cannot stop the equipment in a timely manner and the consequences of disoperation.

(2) Wireless voice full coverage: Wireless handheld machine not only has the control of the three-machine boot and stop, but also can carry on the full speech coverage to the coal mining area, through the handheld intercom function, which realizes the long-distance communication between the workers, and can still provide the clear voice and the high decibel output in the downhole noisy environment. It also reduces the walking time which workers waste in order to communicate.

(3) Wireless relay flexible Self-networking: For downhole conditions, signal attenuation is often relatively larger, so the handheld machine wireless signal transceiver, distance is limited, handheld machine if the use of high-power module, will greatly reduce the battery power supply time. So, we introduced wireless relay devices that make up a high-reliability wireless link through multiple wireless relay stations, and for wireless relays that do not move frequently, using a high-capacity battery power, while increasing the size and weight, is still acceptable. Flexible self-networking
function realizes that when a relay in a wireless link fails, the relay system can re-network the rest of the normal working relay equipment to ensure the normal operation of the whole control system.

3. Application of Mine Face

3.1. Wireless Communication Control System in Mine Face
The length of the fully mechanized mining face in the coal mine is 150m, and a total of 120 brackets are installed. The equipment originally used in the fully mechanized mining face was wired control mode, and the workers needed to start and shut down the equipment at the same time, in order to avoid the risk caused by the emergency, it was necessary to place 1-2 staff and equipment to maintain a certain distance to achieve timely control. But staff are unable to be at work at all times, and a short departure can also pose risks. Therefore, the control part of fully mechanized mining equipment is reformed, the wired control is upgraded to wireless control and the control port is increased, and the special staff is no longer fully required for real-time monitoring. Through multi-person, long-distance wireless control, to achieve a one-click start and stop of all equipment and control of the reliability and timeliness, can reduce the risks brought about in production.

The use of this type of explosion-proof collector to control the existing equipment, through the use of plug-in wiring box to connect the collector host with the equipment, reducing the equipment complex wiring mode, but also convenient troubleshooting and maintenance. Through the display interface of the collector host, you can see the current working time and the start and stop operation of each device. The collector host has added the Wireless Transceiver module, which can not only control the working state of the fully mechanized mining equipment through the button of the collector host, but also control the fully mechanized mining equipment through the wireless interconnection with the collector host of the remote wireless handheld machine. The remote wireless handheld also provides an additional half-duplex voice intercom function.

3.2. Industrial Testing
Industrial testing has been in the mine face of Datong Coal Mine Group since June 2018, and the system equipment layout is shown in Figure 2, practical application is shown in Figure 3. The collector host is placed in the cascade equipment serial vehicle collection room, each wireless relay substation in the working face does not need to consider the installation order, according to the interval of 30 bracket distance installed on the hydraulic support, in the groove according to 100 meters interval arrangement. Miners carry wireless handheld machines, make wireless calls anywhere in the mining area, and wireless remote control of the three-machine and pumping stations in the working face. During the test period, the end of the working face bracket to the Groove Set control host has achieved good wireless coverage, handheld machine call effect is clear, the working face can realize the wireless remote control of the equipment, wireless data transmission is reliable, all equipment to reach the IP66 protection grade, waterproof and dustproof performance, communication equipment stable operation. Through the application of this system, the miner can realize the voice call in any position, can complete the remote control of the equipment in the mobile, thus improving the efficiency of the equipment control of the working face, reducing the staffing, reducing the labor intensity of the miners, and the equipment installation is simple and easy to maintain, thus improving the safety factor and reducing the maintenance cost.
4. Conclusions
Aiming at the special working conditions of coal mining face, starting from improving work efficiency and production safety factor, based on the design idea of intrinsic safety circuit, using the technology of low power consumption technology, wireless communication technology and automatic control, this paper constructs a set of wireless communication collection and control system, and realizes the scraper machine of fully mechanized mining face, reproduces crusher, wireless remote control, wireless voice communication and wireless data transmission for large equipment such as pumping stations. The equipment used in this system is wireless interconnection, easy to install, maintain and use, improve the safety factor and work efficiency at the same time, but also save maintenance costs, and achieved good social and economic benefits.

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