

Research and application of online monitoring technology for mine dust prevention and control equipment

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Abstract

In order to effectively monitor the dust prevention equipment in coal mines and promote the intelligent construction of coal mines, the Caojiatan mine dust online monitoring system and intelligent control of dust prevention and control equipment have been conducted. An online dust monitoring system for Caojiatan mine is built, which realizes real-time monitoring of dust concentration, water supply network flow rate, pressure and other parameters in major underground locations such as coal mining face, excavation face, and main roadway. It can also achieve limit exceeding warning. The developed intelligent control system of anti dust equipment has achieved the function of remote control of the operation status, opening and closing of the shearer body spray, the shearer dust edge tracking spray system, the wet dedusting fan, the automatic sprinkler dust suppression device, and has realized the intelligent operation and control of the anti dust device.

Keywords

Mine safety, dust, anti dust equipment, online monitoring, intelligent construction.

1. Introduction

With the increasing intensity of coal mining, a large amount of coal mine dust will be generated in production processes such as mining, excavation, transportation, and transfer [1,2]. On the one hand, the harm of its dust causes illness to the human body, and on the other hand, when the dust reaches a certain concentration, there is a risk of explosion. In addition to the direct harm to the human body caused by the generated high-temperature gas and huge impact force, damaged equipment and mine collapses can also cause mechanical damage to miners. At the same time, dust falling on equipment or instruments can hinder heat dissipation, accelerate wear, and cause equipment or instruments to malfunction [3-5]. Therefore, doing a good job in dust monitoring and prevention is of great significance for improving the underground working environment, preventing dust explosions, and ensuring coal mine safety production.

The dust online monitoring system is a system designed for the dust hazard in the coal mine, which has the functions of real-time online monitoring of dust, temperature, humidity, noise and other occupational hazard factors, and remote monitoring of the main anti dust equipment (spray pump station, dedusting fan) [6,7]. It is based on advanced automatic spray dust reduction technology, network technology, computer information technology, automatic control technology, modern communication technology, and consists of system software, ring network switch, network switch, mining sensors, dedusting fan, spray pump station, automatic spray device, etc. It is compatible and cooperative with other mine subsystems, such as safety monitoring subsystem, centralized control subsystem, to achieve intelligent monitoring of dust in the whole mine.

2. Research on the architecture of mine dust monitoring system

2.1. Analysis of working conditions

The 2-2 (2-2 lower) coal seam currently being mined in Caojiatan Mine is a thick coal seam with significant thickness variation but obvious regularity. The coal seam structure is simple and the entire area is minable, belonging to a stable type of coal seam. At present, there are two fully mechanized caving working faces and two rapid excavation working faces arranged in the entire mine, and the continuous mining working face is mainly used for cutting holes. According to preliminary research, the main sources of dust in the entire mine are the fully mechanized mining face and the fast excavation face. In addition, a small amount of dust is also generated in the transportation roadway and main inclined shaft. Therefore, this research on dust prevention and control equipment monitoring technology mainly selects the fully mechanized caving face, fast excavation face, main transportation roadway, and main inclined shaft as the monitoring objects, to achieve online monitoring and control of dust from multiple locations and long-distance underground.

Through detailed research on the dust production laws, prevention and control measures, and on-site conditions of the fully mechanized mining face, fast excavation face, main transportation roadway, and main inclined shaft of Caojiatan Mine, it is analyzed that the respiratory dust management limit of the high mechanized mining face is set at $15\text{mg}/\text{m}^3$, the respiratory dust management limit of the fast excavation face is set at $25\text{mg}/\text{m}^3$, and the dust management limit of the main inclined shaft and main transportation roadway is set at $8\text{mg}/\text{m}^3$.

2.2. Functional requirement analysis

(1) The system should have the function of real-time monitoring of underground dust concentration, noise, temperature, humidity, water supply network flow rate, pressure and other parameters. The monitoring range should include coal mining working face, excavation working face, main roadway and other underground dust production workplaces. Among them, the monitoring range of total dust concentration is at least $0.1\text{mg}/\text{m}^3$ to $1000\text{mg}/\text{m}^3$.

(2) The system shall have the function of real-time monitoring the operation status and operating parameters of the underground dust control equipment. The monitoring content shall include the start and stop status of the spray dust control equipment, spray flow, water pressure and other operating parameters.

(3) The system should have the function of setting the operating parameters of anti dust equipment at the ground center station and remotely controlling the anti dust equipment.

(4) The system should have a list display function. The display content includes location, name, monitoring values, work status, etc.

(5) The system has the function of displaying real-time and historical analog curves.

(6) The system has the function of displaying equipment layout diagrams. The display content includes device name, relative position, and operating status.

(7) The system should have functions such as over limit alarm, fault alarm, alarm parameter setting, alarm information query, and historical data query.

2.3. Technical principles and overall system architecture

The system mainly consists of dust concentration sensors, flow sensors, pressure sensors, dust prevention equipment, dust monitoring substations, switches, computer hosts, system software, display screens, etc. Dust concentration sensors are installed in the main operating areas of the mine, such as the fully mechanized mining face, excavation face, transportation roadway, and inclined shaft, to monitor the dust concentration of the entire mine in real-time online. The flow sensor and pressure sensor are arranged at the water supply point of the main operation area to monitor the flow and pressure of the dust spray water supply in real time.

The main operating parameters of dust prevention equipment come from their respective boxes. The information of various sensors and dust prevention equipment control boxes is transmitted to the ground through dust monitoring substations and switches, and is displayed in real-time through system software and display screens. At the same time, based on the preset control strategy, the system software can also carry out early warning through the analysis of the dust concentration data of the whole mine, and intelligently control the opening and closing of spray at different locations in the associated area, finally realizing the intelligent control of dust control in Caojiatan Coal Mine.

The system is mainly used to collect and transmit information on dust concentration, temperature and humidity, pressure, flow rate, monitoring node positions, and major dust prevention equipment in the monitoring area of the mine. The data information of monitoring nodes is transmitted through switches and then connected to the ground user operating system through the ground ring network. Then summarize, analyze, and process. The user interface manages and controls the information and behavior of monitoring nodes by sending instructions. The overall framework diagram below is shown in Figure 1.

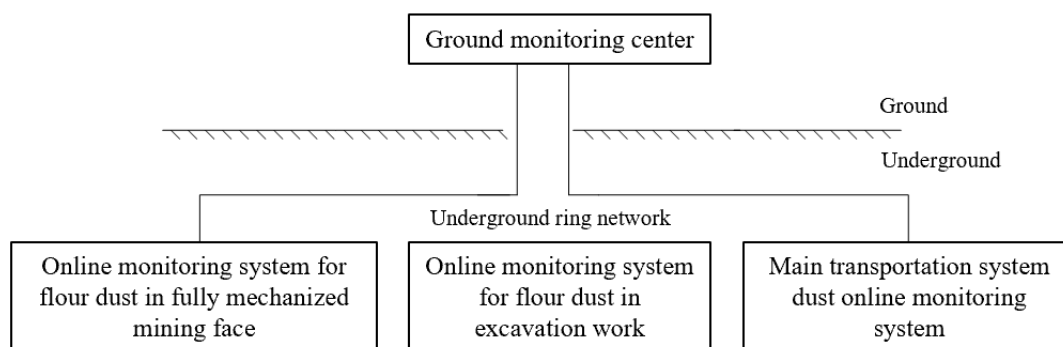


Figure 1 Overall framework diagram of monitoring system

3. Development of mine dust monitoring system platform

Based on the on-site investigation of Caojiatan Coal Mine and the opinions of the mining party, the key content of this monitoring system software development is as follows: ① Based on the actual on-site situation and new functional requirements, carry out corresponding secondary development and optimization of the existing "Dust Prevention Equipment Remote Online Monitoring System" in Caojiatan Coal Mine. ② Appearance optimization: The system needs to be integrated into the on-site system cluster of the mining party in terms of appearance, and the sensory aspect needs to be a whole, not independent. ③ Operation optimization: The system is optimized targeted based on the usage of business personnel in various departments of the mining site, in accordance with the operating habits of business personnel, reducing the time to learn and accelerating the efficiency of use. ④ New mobile service: to meet the needs of mobile informatization. We have added the development of a mobile system that is linked with the computer system, enabling real-time synchronization of accounts, permissions, and data.

3.1. Research on optimization of dust monitoring system platform

(1) Research on system interface optimization

Based on the sensor types and customer concerns of Caojiatan Coal Mine's access equipment, secondary development will be carried out on the rationality of display content, layout style, etc. The interface style and color requirements will match the existing control room's large screen display in Caojiatan Coal Mine. The system login interface is required to include: the system name, the words and logo of middling coal Science and Engineering Group Chongqing

Research Institute Co., Ltd., the interface background is Caojiatan Coal Mine, and the color and style are consistent with the style of the on-site management system. Classify and layout the functional entrances of the backend management system and modularize them, reducing the time for operators to search for functional entrances and accelerating work efficiency.

(2) Optimization of backend management platform function operation

According to the operational habits of the on-site business personnel of the mining company, customize and optimize the system's functional layout, making common functions more prominent and designed with multiple entrances. In line with the operational procedures of business personnel, the logic for jumping between system functional sub modules is more reasonable.

①Real time monitoring module in the background: Unlike the large screen display style, system operators hope that the monitoring interface is simple, does not use fancy effects, has comprehensive monitoring information, is not easy to have too many monitoring modes, and can become familiar with and accustomed to the system interface in a short period of time.

②Historical monitoring data tracing: On the real-time monitoring page, it is possible to quickly query historical data reports, such as equipment operating parameters or detection data curve trends. The data display is intuitive, and the operation needs to be simple and fast. The interface level generally does not exceed two levels.

(3) Real time alarm and data statistics report optimization

On the real-time monitoring page, alarm information can be intuitively reflected, and alarm details can be redirected to view alarm history quickly. The interface operation is simple and fast, and the interface hierarchy jump logic is clear and intuitive. According to the research on the demand intention of on-site staff at Caojiatan Coal Mine, the following report content can be added and developed: ①A statistical report on the operation of equipment and sensors, which includes information such as total running time, running time in the current startup state, number of failures, hourly failure rate, and start stop times. ②Sensor data collection report, which includes multi time dimension statistics, data fluctuation curves, and other information. ③Alarm information statistics report, which can be classified into level alarms, category alarms, calculate alarm duration, and post alarm problem handling time. ④Develop data information reports that require special attention. The data reports support multi-dimensional and multi condition filtering, and the data report interface is displayed in a comprehensive form of lists and graphics. It supports linkage between list and graphic operations, and supports data download and export as well as report graphic downloading.

3.2. Research on intelligent control application of dust prevention and control equipment

Carry out the application research of the whole mine dust monitoring and intelligent control system of dust prevention equipment, study the system management limit, the layout position of information acquisition devices (sensors and sensing devices), the information upload category, the remote monitoring of main dust prevention and reduction equipment [dust removal fan, spray pump station (start switch is RS485 communication)], and the customization of the upper computer monitoring platform.

Automatic control of spray of shearer body

It has the functions of automatically starting and stopping the high-pressure external spray system of the shearer according to the operation state of the shearer (the external spray system of the shearer is supplied by a separate spray pump station and pipeline), online monitoring and remote control of the status of the external spray of the shearer, and can realize online monitoring of the pressure and flow of the external spray system.

Dust source tracking spray dust suppression system of mining shearer

It has the function of identifying the operation status, operation position, operation direction and operation speed of the shearer, realizing the function of adjusting the number and form of support spray in a variety of ways, such as remote online and manual, and realizing the opening or stopping of support spray following the movement of the shearer drum.

Intelligent control of wet dust removal fan

Capable of automatically (manually) starting and stopping the dust removal fan based on the operating status of the excavation equipment, monitoring the operating parameters (current, voltage, power) of the wet dust removal fan online, monitoring the processing air volume of the dust removal fan, and making predictions and warnings.

Intelligent control of automatic sprinkler and dust reduction device

It is equipped with intelligent control of automatic sprinkler in main production links underground, including touch control, timed light control, dust concentration overrun and other control methods, and has the functions of dust suppression device opening status, spray pressure, flow online monitoring, dust suppression device remote monitoring, device operation parameter setting and so on.

Online monitoring of dust concentration

Implement dust monitoring (manual and automatic collection), data analysis, early warning, and alarm for all workplaces with dust hazards underground.

4. Conclusion

(1) An online dust monitoring system for Caojiatan mine is constructed, which enables real-time monitoring of dust concentration, water supply network flow rate, pressure, and other parameters in major underground locations such as coal mining face, excavation face, and main roadway, and can also achieve limit exceeding warning.

(2) The developed intelligent control system of dust control equipment can control the operation status, opening and closing, etc. of the shearer body spray, the shearer dust edge tracking spray system, the wet dust removal fan, the automatic sprinkler dust control device, and realize the intelligent control of the dust control device.

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