

COAL MINE EXPERT SYSTEM FOR PREWARMING OF COAL ACCIDENTS

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Abstract - China is a coal accident-prone country. In all coal accidents, the most serious incident is roof accident. Roof accidents are account for over 45% of the total mortality in coal enterprises. Roof accident is threatening the lives and safety of miners, and seriously affects the output of enterprises and economic benefits. Industrial Ethernet has been developed based on the roof abscission layer computer monitoring system. The displacement sensor can monitor the location of roof abscission layer. Through the speed displacement changes we can master the roof movement dynamic process .With the help of expert system of the roof forecasting, the workers may get early warning. A great number of facts have proved that the monitoring system has achieved the targets of the design requirements. Its successful application in coal enterprises can promote production safely and efficiently, and have brought remarkable economic and social benefits.

Key Words: The roof abscission layer, on-line monitoring, displacement, Ethernet, expert.

INTRODUCTION

China is a coal accident-prone country. In 2006, national roof accidents accounted for 45% of the total deaths, ranking first in the country. In 2007, the number of roof accidents and total deaths still remained first in the country. As everyone knows, the mine roof strata are generally typical layered structure: the separation between the roof strata of ten precedes the start of roof damage and instability. Roof control is a never-ending task that is because roof, even the best one, slowly deteriorates, so it must be frequently examined with corrective support applied when needed. Domestic and foreign scholars attach great importance to the roof separation of work. Some foreign countries, which are more advanced in mining technology, such as the United States, the former

Soviet Union, Poland and other countries, have been using many methods to monitor roof movement. These methods include micro-seismic monitoring methods, acoustic detection and air drilling. These methods have been also applied in our country. However, the shortcomings of these methods are: monitoring processes and operations are more complex, only when the probe are installed in the elastic area can we receive a reliable signal. What is more serious is that each destroys of the overlying strata information is likely to be absorbed by the monitoring equipment. It is therefore difficult to determine the correct location of the source and exact location of the damage. Back in the 1980s, from Poland, France, Germany, the United Kingdom and the United States, China imported a lot of monitoring equipment's, such as DAN6400, TF200, MINOS and Senturion-200. But these security-monitoring systems were more expensive, and had not enough supporting equipment or good application. The roof abscission layer is the biggest hidden danger in bolting support tunnel. The automatic monitoring system can measure displacement and can avoid potential roof cave-ins; provide roof support parameters for supporting roadway layout design. The monitoring system can provide a reliable safety monitoring data, so as to effectively prevent the roof landslide incidents, ensuring coalmine safe production. Separation damage and fracture rock movement reflect the different process; separation is a dynamic mechanical behaviour, generally after initiation, expansion, reaching the maximum in the thickness direction after the fracture. The roof abscission layer often happens in the working face or the location of the roadway, the separation of data can be collected online; the data adapter connects with computer. The computer can process and analyze the data and display the result in time. For mining or excavation roadway, the roof dynamic monitoring separation

detection method is generally used to monitor roadway rock and loose separation of the roof, the roof separation sensor measures relative displacement between two different basis points installing inner the roof. The establishment of dynamic monitoring system based on Ethernet in coal mine can realize real time dynamic monitoring of all the separate testing pots. The roof accidents will get early warning.

2. THE PRINCIPLE OF ROOF ABSCISSION

LAYER SENSOR

Roof *abscission layer* sensor can measure deformation of the roof. The system uses indirect methods to achieve accurate measurement of displacement, it will be transformed a corresponding linear displacement into the angular displacement, through the accurate measurement of angular displacement can be calculated the accordingly exact line value of displacement. Potentiometers-angular displacement sensor is a cheap measuring angular displacement sensor, and the external circuit is simple conversion. When sensor on the shaft rotates at variable resistor, the sliding resistance in the body will change. The measurement bridge circuit (make up of four resistances) will be unbalanced, and will output a synchronous changing voltage signal. Potentiometers angular displacement and output voltage signal is a linear relationship. Figure.1 is the installation method of the sensor in the roadway roof. There are two points: A and B. A is deep basis point and B is on basis point. When *the roof abscission layer inner rocks happen*, the distance between point A and point B will change. Using this method, we can know the movement of roof in time and take corresponding measures.

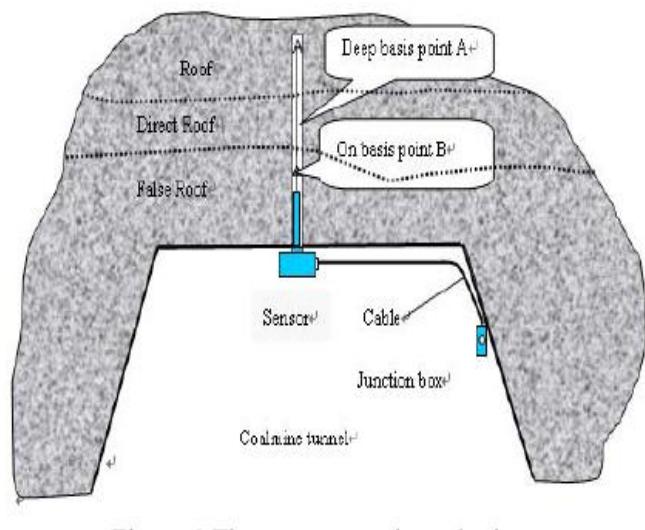


Figure 2.1: The sensors work methods

Roof separation sensor performance parameters are present as follows:

- (1) Installation depth 1-20 meters.
- (2) Measurement range 0-150mm.
- (3) Measurement accuracy: 1%.
- (4) 7-18 V power supply.
- (5) Output: industrial Ethernet.
- (6) Ex forms: Explosion-proof and safe.

3. THE COMPUTER MONITORING SYSTEM

The monitoring system is integrated with computer technology, data communications technology and sensor technology. It can apply in the complex conditions of fully mechanized coalface and roadway roof accomplish automatic monitoring and analysis.

- (1) Real time controls the movement of the roof, Forecasting and early warning the occurrence of risk.
- (2) Can monitoring location, separation speed change and identify significant deformation within the region, and determine the scope of damage inside the roadway roof, identify and evaluate current working conditions.
- (3) Through monitoring data and analyzing result the system can give the reasonably supporting control parameters of the roadway.

- (4) When more than setting parameters, with the functions of alarming.
- (5) Having the hardware fault diagnosis and display function.
- (6) Data query, curve printouts.

4. HARDWARE

4.1. UNDERGROUND SYSTEM SCHEMATICS

On the underground system, the master control chip is AT89C52. The microcomputer unit is ATMEL Company's low-power, high-performance 8-bit CMOS microprocessors. The CD4051 is a single 8-Channel multiplexer having three binary control inputs, A, B, and C, and an inhibit input. The three binary signals select 1 of 8 channels to be turned on, and connect one of the 8 inputs to the output. A / D converters use TLC1549, the device is 10, switched capacitor, successive approximation, has two digital input terminal and a 3-state output (Chip Select / CS, input - output clock I / O CLOCK and data output DATA OUT), the maximum I / O CLOCK input frequency of 110 MHz. The data memory selects DALLAS DS1225Y, the device has capacity of 8 K, single +5 V power supply, storage cycle is 150 nanosecond, and the number of reading and writing for 1010, write without time delay, high reliability, particularly applicable to a fast reading and writing application system. The 74LS138 of Circuit is used to be decoder; it can select one channel of whole eight sensors signal. MDLS16468 is used as LCD (liquid crystal display), the specific use of methods please refer to the literature [4]. RTL8019AS is network controller, network controller connects with isolation filter 20F01, and the role of interface RJ45 is to improve the anti-jamming capability of system. Network interface modules and industrial Ethernet connections will ensure the monitoring data send to ground host computer in time. Figure 2 shows the working principle of hardware on the underground.

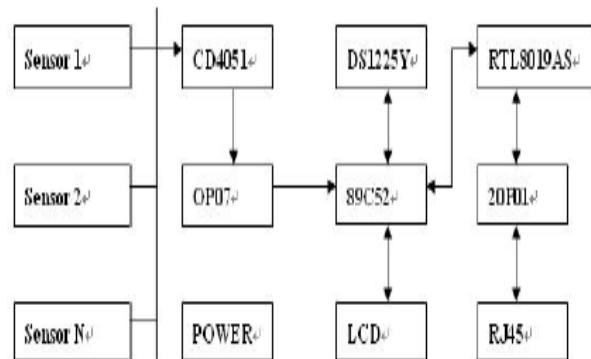


Figure 4.1.1: The working principle of hardware

4.2 COMPOSITION OF NETWORK

MONITORING SYSTEM

The function of the ground network system includes:

- (1) Data receiver module, monitoring server.
- (2) The mine office LAN (local network) and client.
- (3) GPRS data transceiver modules and short message service (SMS) sending to mobile phone subscribers.

The monitoring network monitor method is that it through the main station of underground access to Industrial Ethernet. The network ring network switches or telephone cables and transmit data to ground. When using of industrial Ethernet ring network and transmitting to data, the selection of the RJ45 interface and station master station must system communication mode. Monitoring system through industrial grade server PC transmits the RDS (Remote Data Services) data to the communications unit. Industrial PC configures Ethernet interface (RJ45) and LAN switches. Ethernet access server monitoring underground NPORT ring network interface, monitoring data must ensure the same physical ring network link. Figure 3 shows the industrial Ethernet topology of monitoring system.

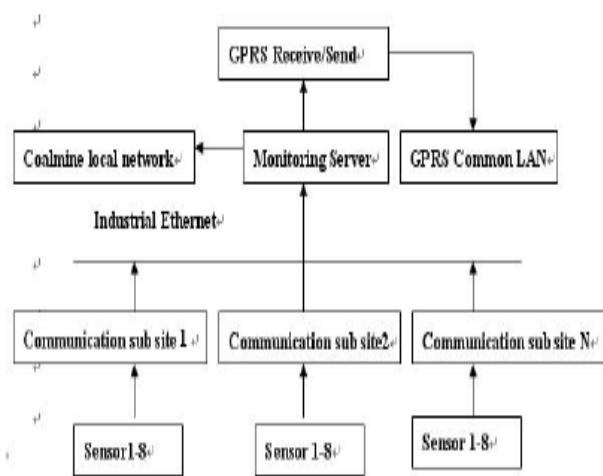


Figure 4.2.1: Industrial Ethernet topology

5. SOFTWARE DESIGN

5.1. SYSTEM ORGANIZATION

The system monitoring and analysis software runs on Windows 2003 server platform, SQL server database used on the C / S and B / S structure, support mine LAN client mode and web access patterns. Monitoring and analysis software supports GPRS / CDMA public data transmission network by Short message information and alarm functions. Monitoring server connectivity GPRS (general packet radio service) / CDMA (code division multiple access) data to the unit, according to software configuration information, authorized users can receive different information and alarm data services. There are two alarming method information: early warning information and emergency alarm information. The alarming information is from expert system, it based on the monitoring data for decision-making. Block diagram of the system software organizations is shows as follows:

5.2. EXPERT SYSTEM DESIGN

An expert system is a computer program that simulates the judgment and behavior of a human or an organization that has expert knowledge and experience in a particular field. Also an expert system is an interactive

computer-based decision tool that uses both facts and heuristics to solve difficult decision making problems, based on knowledge acquired from an expert. An expert system is a model and associated procedure that exhibits, within a specific domain, a degree of expertise in problem solving that is comparable to that of a human expert.

An expert system compared with traditional computer:

$$\text{Inference Engine} + \text{Knowledge} = \text{Expert System.}$$

$$(\text{Algorithm} + \text{Data Structure} = \text{Program in traditional computer}).$$

Compared with conventional applications, expert systems have a stronger analysis of the reasoning and judgment; it's a simulation of thinking to solve problems in specific areas. Expert system block diagram of the structure shows in Figure 5.

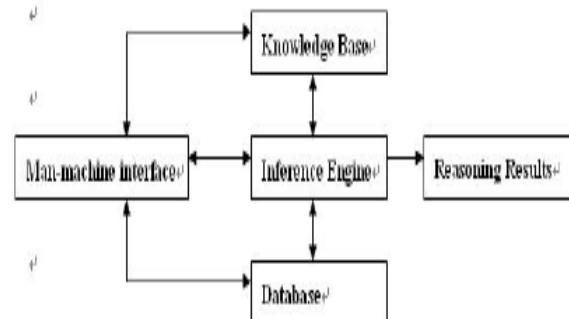


Figure 5.2.1: The expert system principle

The task of designing knowledge base is the core of the establishment of expert system that can be divided into two parts: knowledge acquisition and knowledge exchange. Access to the knowledge of the system comes mainly from the national coalmine production safety standard, professional knowledge, experts and the experience of the frontline staff. Knowledge acquisition can be identified and dealt with in the form of analysis. Knowledge exchanging usually adopts a rule, the basic rule of the form is IF <premise conclusions> THEN <conclusion>. Inference Engine part is responsible for the use of knowledge in the knowledge base of data analysis,

being used for decision-making forecasts. Database includes basic parameters, testing some of the findings of the data analysis, forecasting the course of intermediate results, as well as the forecasting process of all the information. It can create and print a report when it is necessary.

6. CONCLUSION

Powerful and efficient communication networks with a wide range have been installed via Industrial Ethernet. The roof separation monitoring system proposed have been successfully used in fifty-coal mine enterprise. The system has many profits: such as real-time processing, cooperation, reliability, recoverability, redundancy and maintainability, security, etc. Sensors usually install in the following position: coalmine working surface, head entry, tail entry, excavation, and roadway and so on. The operators can master roof dynamic movement through the different basis points relative displacement. They can also understand the current environmental changes in the rock movement. The roof accidents may be avoided to a large degree. The system, which is used to protect the coalmine safe production, has been made contributions to the enterprise and society.

7. REFERENCES

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