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Design and application of the control system of mine damper and window

Jinliang Gao, Chengwei Liu, Weihong Li

National Energy Group Inner Mongolia Dayan Mining Group Co., Ltd., Hulunbuir, Inner Mongolia, 02112, China

Abstract: *It is impossible to realize automatic control or remote control of the damper window between the +267m yard and the channel connection lane of the working face in the North second mining area of Yannan Coal Mine. There are some problems such as inconvenient pedestrian traffic, untimely ventilation network for disaster control, small width of air regulation and high intensity of air regulation, which greatly affect the reliability of the ventilation system and threaten the safe and efficient production of the underground. In view of this problem, the relevant theories and applications of the damper window control system are studied, and the traditional plug-in window is changed into the louver window which adjusts the air area by rotating motion. In addition, the flow of personnel or vehicles passing through the damper and the control system of the damper window are designed by using micro-control technology combined with the actual situation. Through practical use, under the operation of this system, the use function of the damper and window meet the requirements of underground safety production, remote control is reliable, stable operation, and can realize the adjustment of large width of the air volume, which greatly reduces the input of human resources and improves the intelligent level of Yannan Coal mine.*

Keywords: *Yannan Coal Mine; Damper window; Control system; Ventilation system; Microcontrol technology*

1. Introduction

Mine ventilation system is one of the core systems in the mine production system, which is mainly used for the normal breathing of underground workers and the removal of dirty air. As important ventilation facilities in the ventilation system, air doors and air Windows are generally installed in the important communication alleys under the mine. They are mainly used for the passage of personnel and goods, and also have the function of ventilation network regulation[1-4], so as to achieve on-demand air supply and regional air supply. In particular, when a fire occurs, the fire source can be extinguished without oxygen by regulating the short circuit and reverse wind of the air flow, etc., and the smoke exhaust channel can be shortened to avoid the expansion of the disaster scope[5].

At present, the contact lane between the +267m truck yard and the trough under the working face in the North second mining area of Yannan Coal Mine needs to provide convenient access services for personnel and materials, and has the role of wind regulation. When necessary, the air flow of the working face is cut off and guided. At present, there is no auxiliary control system for the damper installed in the liaison lane, and the windshield adopts a traditional baffle plate, which requires manpower to open the damper, causing inconvenience to pedestrians. At the same time, the windshield is composed of a simple baffle plate, which increases the risk of high air conditioning and cannot realize remote air regulation.

In view of these problems, the control system of damper and wind window is designed from three aspects of intelligence, information and networking, so as to effectively solve the shortcomings of inconvenient pedestrian traffic, artificial risk control wind is not timely, and work intensity is high.

2. Design of control system

In order to facilitate the adjustment of the air volume and reduce the use of underground electricity, the wind window adopts the louver type that can rotate up and down[6], the damper adopts a four-link mechanism, and the power source selects 0.4~0.8MPa compressed gas. Under the movement of the cylinder and the air motor, the control of two air doors and wind Windows is realized.

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2.1 Hardware design

In order to realize the automatic opening and closing of the damper and the Angle adjustment of the wind window shutters, this design uses the STM32G303VCT6 chip as the main controller, and its circuit is mainly composed of the power supply circuit, data acquisition circuit, solenoid valve drive circuit, Ethernet circuit, voice alarm circuit, etc.

Each damper is equipped with infrared sensors on both sides to detect passing targets. When something is detected in the wind door, a signal will be transmitted to the MCU, and after signal analysis and processing, the corresponding on-off signal will be sent to the solenoid valve, and finally under the expansion and expansion of the compression cylinder, the air door will be switched on and off.

The adjustment of the wind window area is mainly manifested in the change of the opening Angle of the shutter. Under the drive of the solenoid valve, adjust the positive and negative rotation of the air motor, and then through the swing of the connecting rod, the Angle of the shutter can be changed between 0 and 90°. In order to read the rotation Angle of the shutter, an Angle encoder is installed on the rotation axis of the air motor, and the signal is read by a single chip computer, and the current Angle of the shutter is obtained through analysis and processing.

Any mechanical movement of the damper has the hidden danger of clamping the car. Although there is an anti-pinch function in the control program, in order to use the damper more safely and avoid personnel injury caused by the damper clamp, the connection form of the telescopic cylinder and the damper is improved, that is, the extension of the cylinder and the gravity of the counterweight block are used to achieve the closure of the damper, and the indent of the cylinder is used to achieve the opening of the damper. This way, not only can prevent the damper pinch accident that occurs when the pedestrian does not pass the damper in time, but also when the control box is powered off, it does not affect the opening and closing of the damper, and the installation is more simple and convenient.

2.2 Software Design

Based on the analysis of the traffic condition of the damper of +267m parking lot and the distance between the damper, the pedestrian or traffic flow is designed. The specific flow is as follows:

Step 1: Pedestrians or vehicles first trigger the infrared sensor on the outside of the damper;

Step 2: Wait 3 seconds, the cylinder extends the driving rod, open the damper;

Step 3: After the damper is opened in place, wait for pedestrians or vehicles to pass;

Step 4: If the pedestrian or vehicle triggers the inside infrared, and completely passes the infrared detection area, the cylinder retracts to pull back the connecting rod, close the damper, and continue to perform the next step; Otherwise, after 15 seconds, execute the throttle closing procedure. At the same time, if any infrared is triggered during the throttle closing, stop closing the door immediately and return to the second step;

Step 5: Pedestrians or vehicles trigger the infrared sensor on the inside side of another damper;

Step 6: Wait 3 seconds, the cylinder extends the driving rod, open another damper;

Step 7: After the damper is opened in place, wait for pedestrians or vehicles to pass;

Step 8: If the pedestrian or vehicle triggers the outside infrared, and completely passes the infrared detection area, the cylinder retracts to pull back the connecting rod, close the damper, and mark the completion of passage; Otherwise, after 15 seconds, perform the damper closing procedure. Similarly, if any infrared is triggered during the damper closing, immediately stop closing the door and return to the sixth step.

If the two air doors are opened at the same time, it will lead to abnormal air flow in the connecting lane. Therefore, under the original mechanical lock device, an electrical lock is added, accompanied by sound and light alarm prompts, to prevent workers from misoperating, to avoid the occurrence of airflow disorder, resulting in the failure of the ventilation system.

Compared with the damper, the control of the wind window is relatively simple, and only the opening Angle of the shutter can be adjusted to achieve the adjustment of the air volume of the contact lane. When the air motor is turning, the opening Angle of the shutter is increased, and the opening Angle of the shutter is reduced when it is reversed.

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The software part uses Keil MDK-ARM as the programming platform, and the programming language is C language. In the whole process of software program design, the idea of modular programming is adopted, which is mainly composed of system initialization program, data acquisition program, timer initialization, serial communication program, TCP network communication program, solenoid valve and sound and light alarm driver.

3. Application effect analysis

In the actual test and use, when A pedestrian or vehicle is near the damper A, the infrared sensor outside the damper detects the traffic signal and sends it to the controller. At the same time, the electromagnetic valve corresponding to the command is issued, and the damper automatically opens, as shown in Figure 3. In the process of opening the damper, the audible and visual alarm sends out the "Damper is opening, please pay attention to safety" prompt, and the indicator is blinking red. If the damper is fully opened, change to the "Damper is open, please pass safely" prompt, and the indicator is green. At the same time, close the damper B, and the sound and light alarm of the damper will issue a prompt "the opposite damper is open, please wait", and the indicator is blinking red. When pedestrians or vehicles safely pass through the damper and trigger the infrared sensor on the inside side of the damper, the damper automatically closes, as shown in Figure 4. When the damper is closed, the sound and light alarm sends a warning "the damper is closing, please pay attention to safety", and the indicator is blinking red. If the damper is completely closed, the sound and light alarm will restore to the initial state.

At the same time, if it is necessary to pass through the damper B, the infrared sensors on both sides of the damper B are triggered, the damper automatically opens, and the audible and visual alarm is issued to prompt safe passage, and the damper A is closed. After the passage is completed, the damper B is closed and the initial state is restored.

Through the test, when the electric control box of the downhole damper is in the state of power failure or the pressure of the downhole pressure duct is insufficient, the damper can be opened directly by pushing the door, which is not affected by the telescopic cylinder choking.

When adjusting the air area of the air window, the opening Angle of the air window can be adjusted by controlling the corresponding button, and the wind Angle can be adjusted in a wide range of 0~90°, increasing the air volume control range.

The control system of the damper window is connected to the underground ring network system, and the function of remote control and status monitoring of the damper window is realized by using network communication

4. Summary

In order to improve the convenience and controllability of the ventilation system of Yannan Coal Mine, the control system of the damper and window is designed by using micro-control technology. The hardware is composed of electric control box, gas control box, infrared sensor, sound and light alarm, telescopic cylinder, air motor and other devices. In terms of software, according to the traffic conditions and the distance between the damper of Yannan Coal Mine +267m car yard, the pedestrian or traffic flow is designed, and the program is written. In actual use, the application effect is ideal, pedestrians or vehicles can smoothly pass through the damper, and the safety is also high.

By adjusting the Angle of the louver, the function of connecting the roadway with large air volume and width can be realized. At the same time, driven by the solenoid valve, the opening Angle of the louver can be adjusted directly through the button, and remote adjustment can be realized through the underground ring network. The problem that the air adjustment of the key location is not timely and the wind control is unstable is solved.

After the improvement of the connection form between the telescopic cylinder and the damper, the indent of the cylinder is used to drive the door frame through the wire rope to realize the opening of the damper, the indent of the cylinder is extended, and the gravity of the counterweight block is used to realize the closing of the damper. The steel wire rope is connected between the cylinder and the door frame to avoid the hidden danger of clamping or clamping under the strong action of the cylinder, and the opening of the damper is not affected by the power failure or insufficient air pressure of the electric control box, which enhances the practicality.

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Through the design and application of the air door and window control system in Yannan Coal mine, it provides convenience for the mine workers, saves a lot of labor, improves the practicability and stability of the auxiliary system of the mine, and improves the safety of the production system to a great extent. It is preliminarily estimated that after the installation of the damper and window control system designed in this scheme in the main connecting lane of the mine, the labor cost can be saved by more than 1 million yuan a year, and it has better economic benefits.

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