Coal Mine Ventilator Remote Monitoring System Based on the Fuzzy Control

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Abstract. For the reason of more complex ventilation system and more ventilation parameters needed in the coal mine, the standard mathematical model of ventilation system is hard to be set up. At the same time, the common practice cannot obtain the satisfactory effect. This paper put forward a remote monitoring system of coal mine ventilation based on a fuzzy control to realize the real-time monitoring of mine ventilation systems. The remote automatic control program of ventilator will be realized by Siemens modules and configuration softwares. The results show that the fuzzy automatic control system is useful, with the characteristic of safe, reliable and easy-operating. It provides a reliable guarantee for safe production of coal mines and the efficient operations of the fan.

Keywords: Ventilator, Fuzzy control, Remote monitoring.

1 Introduction

The ventilation plays a very important role in the process of coal mining. Mine ventilator undertakes the task of safeguarding the whole underground coal mine safe production. Because of the relatively poor working conditions, more level and depth, complex roadway distribution and high rate of fans accident, these are giving a great threat to the safety of underground workers. Therefore, the safety, reliability and economic operation of ventilator remote monitoring are of vital significance in mine production. To make the ventilator operate safely and efficiently, we must adopt remote automatic control system. The system structure goes through the transformation from the industrial control computer as the core of the centralized control model to the PLC as the core of a distributed control model. The conventional control method for automatic adjustment of the ventilator is difficult to achieve the expected effect. The remote monitoring system of coal mine ventilation system can overcome the various drawbacks in theory. The fuzzy control method has features of rapid response, simple control, without modeling, so the ventilation system based on fuzzy control has been got practical application.

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2 System Working Principle

The basic idea of fuzzy control is to use computer to replace human experience control, and these experience with the fuzzy control rules is mostly expressed by language. Considering the nonlinear and multi-interference of this system, the fuzzy control method is able to avoid the difficult problem of modeling, and has better control performance, so adopting the program that fuzzy control technique adjusts remote automatically of Ventilator. This system collects all ventilator operation parameters to industrial PC, and then through the software for the fuzzy algorithm controls the start-stop of the ventilator, thus achieving unattended and intelligent target. The results show that the fuzzy control automatic adjustment system control has good effect. This proves that making full use the advantage of classical control method and fuzzy control method to control the air volume of fans is practical and feasible. And along with the manufacturers have introduced the fuzzy reasoning module, which makes the system more mature and stable[2].

3 Fuzzy Control Theory

3.1 Fuzzy Control Overview

Fuzzy Logic Control was short for Fuzzy Control. It is a computer numerical control technology based on fuzzy set theory, the fuzzy language variables and fuzzy logic reasoning. Fuzzy Control is essentially a kind of nonlinear control, belonging to the category of intelligent control. A major feature of fuzzy Control not only has systematic theories, but also has a large number of the application background[5].

3.2 Fuzzy Control System Element and Basic Principles

The fuzzy control system structure is similar with regular feedback control systems, including fuzzy controller, the input and output interfaces, executive body, controlled object and measuring devices. The difference is that fuzzy control system is based on fuzzy mathematics, fuzzy linguistic form of knowledge representation and fuzzy logic rules reasoning, using computer control technology to form a channel digital control system with feedback channel closed-loop structure. The structure of fuzzy control system, as show in Fig.1.

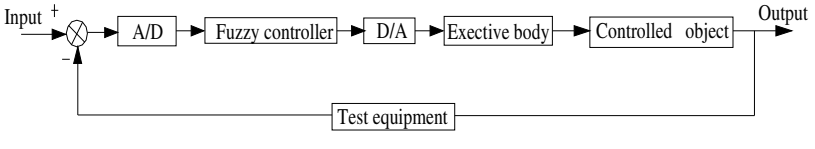

Fig. 1. The structure of fuzzy control system

Fuzzy control system can be divided into the following four parts[3]:

(1) Fuzzy controller: Actually, it is a micro-computer, the fuzzy controller is the core of the fuzzy control system, and it is mainly achieved by software on the computer in practice.
(2) Input /output interface device: Fuzzy controller through an input/output interface gets digital signal quantity from controlled objects, makes output digital signal of fuzzy controller decision through D/A transformation, then converts it into analog signals, and gives actuators to control the controlled object.
(3) Controlled objects and the implementing agencies: Controlled objects can be linear or nonlinear, constant or time-varying, also it can be single or more variables, delay or without delay and have a variety of strong interference. Controlled objects lack of accurate mathematical model suitable to select fuzzy control.
(4) Sensor: Sensor is a device which converts controlled objects or controlled variables of various processes to electrical signals. Controlled variables are often non-power, and sensors play a very important position in the control system, whose precision directly affects the precision of the whole control system.

Fuzzy control is a computer intelligent control based on fuzzy set theory, the fuzzy linguistic variables and fuzzy logic reasoning, and its core part is the fuzzy controller. Its basic principle, as show in Fig.2.

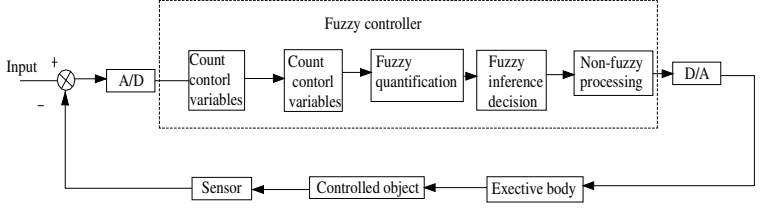

Fig. 2. Fuzzy control basic principle

4 Design Ventilator Fuzzy Controller

There are many kind of fuzzy controller structures, we use two-dimensional fuzzy controller according to the actual situation of the controlled object in this system[4].

4.1 Fuzzy

Ts is sample period of this system, obtaining its input response r and y in every sampling time, and getting error e and deviation rate train Δe, e and Δe as fuzzy controller input.

$$e(n) = r(n) - y(n)$$

$$\Delta e(n) = \frac{e(n) - e(n-1)}{T_s} \tag{1}$$

$$Y = \frac{12}{b-a}\left(x - \frac{a+b}{2}\right) \tag{2}$$

The actual deviation and deviation changes between a and b. Using the 2nd formula change them between -6 and +6. The exact amount will be converted into a blur. Interval discretization of the domain will be divided into n files, and each file corresponds to a fuzzy set, such as NL, NM, NS,O, PS, PM, PL.

4.2 Rule Base

Controlled objects are deeply understood, and the corresponding control rules are given:

if E= NL and ΔE= PL then U = PL
if E= NM and ΔE= PL then U = PM

if E= PM and ΔE= NL then U = NM
if E= PL and ΔE= NL then U = NL

4.3 The Fuzzy Relationship Matrix and Fuzzy Decisions

All the control rules will be tabulated, which constitute the rule base in Table 1.

Table 1. Control rule base

ΔE \ E	NL	NM	NS	O	PS	PM	PL
PL	PL	PM	NL	NL	NL	NL	NL
PM	PL	PM	PL	NS	NS	NS	NS
PS	PL	PM	NS	NS	NS	NS	NL
ZE	PL	PM	PS	O	NS	NS	NL
NS	PL	PM	PS	PS	PS	PM	NL
NM	PL	PL	PL	PM	PM	NM	NL
NL	PL	PL	PL	PL	PM	PM	NL

4.4 Fuzzy Decision

This system uses the gravity center method for fuzzy decision-making. Fuzzy reasoning process is based on fuzzy control rules to get fuzzy relationship matrix R, then according to the synthesis of fuzzy reasoning rules to control the amount of output fuzzy sets Uij.

$$R_{ij} = (E_i \times EC_j) \times U_{ij} \tag{3}$$

In the formulas: Rij is the fuzzy relation between various rules. Ei is the fuzzy vector of error e. Ecj is the fuzzy vector of ec. Uij is output vector of fuzzy controller.

5 System Design

System software mainly consists of sensor intelligent identification, data collection and processing, algorithm, mechanical status, fault analysis and diagnosis, alarm and print

out to complete their corresponding function. Software system adopts configuration compilation. At the same time, signals are analyzed in time domain and frequency domain.It analyzes and judges the final data processing, outputting in the form of digital or graph etc.

The system uses high-performance sensors, selects the Siemens S7-300PLC, adopts Advantech industrial computer, and takes on-line UPS, to ensure that the system can operate regularly when the system power is switched. And through the switches, pass the system to office automation network and group company nets in the mine. System structure diagram, as show in Fig.3.

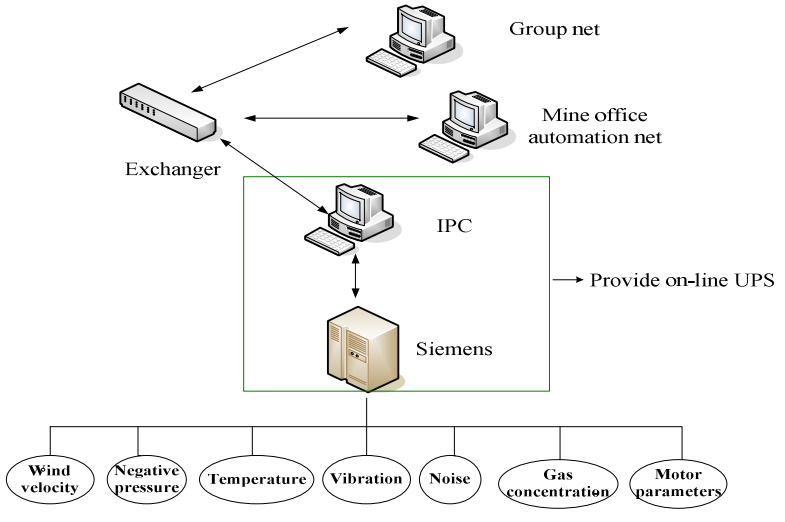

Fig. 3. System structure diagram

The system has mainly functions: 1. real-time monitoring ventilator system operation parameters, and touring display. 2. Analyzing the acceleration time domain and frequency domain. 3. Fuzzy control. Software controls real-time data parameters and the set reference. 4. The intelligent diagnosis. Use the intelligent fuzzy system inside of industrial PC, and then position accurately the common mechanical breakdowns in the ventilator. 5. Alarm print.

6 Summaries

Using fuzzy control method can well realize remote automatic monitoring of the whole mine ventilator, with unattended. Choosing appropriate pace can accelerate the operation speed. Real-time monitoring system organically combines ventilator information monitoring and office automation network together, which has provided protection for every relevant units in mine and grasping the information timely and accurately. It can guarantee the ventilator's data acquisition and fault alarm in the harsh environment, still can find position and type of the failure timely and accurately, which

has laid a good foundation for the next step to eliminate the failure, and has provided reliable guarantee for the safety production and high effective production. This situation has played an active role in improving the security situation in coal mining. But fuzzy control system theory has some important theoretical issues to be unresolved.

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