Research on Air Conditioning System of Subway Station Based on Fuzzy PID Control

Pesquisa

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***Abstract*—Because the subway station has the characteristics of large area, wide space, complicated regional function and large passenger mobility between regions, the controlled objects in the subway station environment are characterized by time-varying, randomness, non-linearity and large lag.As the PID control parameters are fixed throughout the control, for the highly complex subway station environment, the PID control becomes helpless, it is difficult to achieve the best.Therefore, a fuzzy PID control method is proposed.This method combines the fuzzy control and the PID control technology to establish the fuzzy PID controller, which can effectively realize the reasonable control of the ambient temperature of the subway station.**

ampla
Assim
É uma boa aplicar PID, mas é complexo calibrar as variáveis

Keywords-the subway; Controlled object; PID control; fuzzy PID control

I. Introduction

With the rapid development of China's economy, the subway has become a symbol of modern city.The subway has the advantages of safety, punctuality, fastness, comfort, environmental protection and large passenger capacity. Subway station is a special underground building and a place where people gather. With the continuous improvement of living standards, people for the subway station environmental comfort requirements are also improving, air conditioning has become an indispensable equipment in the subway station.

Ambiental
Subterrâneo

PID control is difficult to change the PID parameters online, and it is difficult to control the nonlinear, time-varying and complex control objects.Subway environment has the characteristics of time-varying, random, non-linear and large lag. Therefore, the fuzzy PID control and control system of subway station air conditioning is proposed. The combination of fuzzy control and PID control has the characteristics of flexibility of fuzzy control[1] and the advantages of high precision PID controller.In this paper, fuzzy PID control technology is used in the subway station temperature control,in order to provide passengers with a comfortable and safe ride environment.

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II. DESIGN OF FUZZY CONTROLLER FOR AIR CONDITIONING SYSTEM OF SUBWAY STATION

At present, the main control of the subway station ambient temperature is através through the station temperature and the default temperature value to compare to determine the air conditioning and other equipment conditions.In the control process, the air conditioning and other equipment are full load operation, the ventilation and cooling capacity are relatively constant. They can not according to the actual needs of the station for intelligent adjustment.In this paper, the fuzzy PID control model is based on real-time data collected from the station to calculate, and then to ativar achieve the control of the subway air conditioning control gear, and then determine the air conditioning and other equipment conditions, to achieve a constant station temperature.Fuzzy PID control system is a ring control system[2]. The basic schematic is shown in Fig.1.

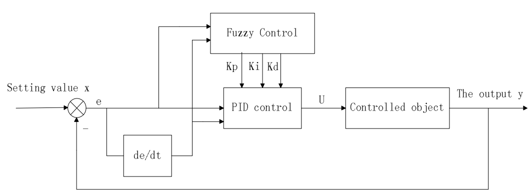

Figure 1. Fuzzy PID control schematic

III. DETERMINATION OF FUZZY VARIABLES AND THEIR MEMBERSHIP FUNCTIONS

A. *Determination of fuzzy subset and domain*

According to the work of the station air conditioning system, fuzzy PID controller uses two input three output[3] form,I set the temperature difference between the temperature of the subway station and the set temperature (e) and the temperature change rate (ec) as the input variable, the three gains of the PID controller(K_p,K_i,K_d) as the output variables.As shown in Fig.2.

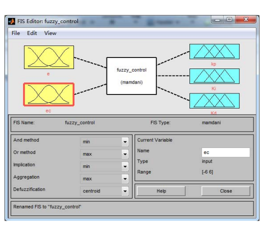

Figure 2. Mamdani type fuzzy system

Assuming the input variables e and ec, the fuzzy sets[4] of output variables K_p, K_i and K_d are {NB, NM, NS, ZO, PS, PM, PB}.The elements in the subset represent Negative Big, Negative Medium,Negative Small,Zero,Positive Small, Positive Medium,Positive Big.The quantization domain of the input and output variables is [-6 6].

B. *Determination of membership function*

Combined with the characteristics of the subway environmental air conditioning system, the fuzzy set membership function of the fuzzy variable is chosen as the normal distribution[5], as shown in Fig.3.

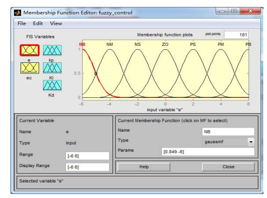

Figure 3. Normal distribution

C. *The establishment of fuzzy rules*

The choice of fuzzy rules is the core of designing fuzzy controllers[6].

In the PID controller, the choice of K_p value depends on the response speed of the system.Increasing the K_p can increase the response speed and reduce the steady-state error; however, the K_p value produces a large overshoot, and even makes the system unstable.Reducing K_p to reduce overshoot and improve stability, but if K_p is too small, then the response speed will slow down, the adjustment time will be longer.Therefore,the initial adjustment should be appropriate to take a larger K_p, and in the middle of the adjustment, K_p is a smaller value; and in the latter part of the adjustment process and then transferred to the larger K_p value to reduce the static error, improve control accuracy.According to the above analysis, the fuzzy control rules of K_p are listed in Table□.

TABLE I. THE FUZZY CONTROL RULES OF KP

K_p e_c e	NB	NM	NS	ZO	PS	PM	PB
NB	PB	PB	PM	PM	PS	ZO	ZO
NM	PB	PB	PM	PS	PS	ZO	NS
NS	PB	PM	PM	PS	ZO	NS	NS
ZO	PM	PM	PS	ZO	NS	NM	NM
PS	PS	PS	ZO	NS	NS	NM	NB
PM	PS	ZO	NS	NM	NM	NM	NB
PB	ZO	ZO	NM	NM	NM	NB	NB

In the system control, integral control is mainly used to eliminate the system's steady-state error.For some reason (such as saturation nonlinearity), the integration process may produce integral saturation at the beginning of the adjustment process, causing a large overshoot of the adjustment process.Therefore, in the early adjustment process, in order to prevent integral saturation, its integral effect should be weaker, or even zero;In the middle of the regulation, in order to avoid the impact of stability, its integral role should be more moderate; Finally in the latter part of the process, it should enhance the integral effect to reduce the adjustment of static.Based on the above analysis, the fuzzy control rules of K_i are listed in Table □.

TABLE II. THE FUZZY CONTROL RULES OF KI

K_i e_c e	NB	NM	NS	ZO	PS	PM	PB
NB	NB	NB	NM	NM	NS	ZO	ZO
NM	NB	NB	NM	NS	NS	ZO	ZO
NS	NB	NM	NS	NS	ZO	PS	PS
ZO	NM	NM	NS	ZO	PS	PM	PM
PS	NS	NS	ZO	PS	PS	PM	PB
PM	ZO	ZO	PS	PS	PM	PB	PB
PB	ZO	ZO	PS	PM	PM	PB	PB

The adjustment of the differential link is mainly for the introduction of large inertia process, the role of differential coefficient is to change the dynamic characteristics of the system.The differential coefficient of the system can reflect the trend of signal change and can introduce an effective early correction signal in the system before the deviation signal changes too much, thus speeding up the response speed, reducing the adjustment time and suppressing the oscillation.And ultimately change the dynamic performance of the system.Therefore, the selection of K_d has a great influence on the regulation of dynamic characteristics.K_d is too large, the adjustment process will lead, resulting in adjustment time is too long; K_d is too small, the adjustment process will be backward, resulting in increased overshoot. According to the actual process experience, in the early adjustment, should increase the differential effect, which can be smaller or even avoid overshoot; and in the medium term, because the adjustment characteristics of K_d value changes are more sensitive,Therefore, the K_d value should be appropriately smaller and should be kept constant;Then, at the later stage of regulation, the K_d value should be reduced to reduce the braking effect of the controlled process and to compensate for the prolongation of the adjustment process due to the large K_d value at the beginning of the adjustment process.Based on the above analysis, the fuzzy control rules of K_d are listed in Table □.

TABLE III. THE FUZZY CONTROL RULES OF KD

K_d e_c e	NB	NM	NS	ZO	PS	PM	PB
NB	PS	NS	NB	NB	NB	NM	PS
NM	PS	NS	NB	NM	NM	NS	ZO
NS	ZO	NS	NM	NM	NS	NS	ZO
ZO	ZO	NS	NS	NS	NS	NS	ZO
PS	ZO	ZO	ZO	ZO	ZO	ZO	ZO
PM	PB	NS	PS	PS	PS	PS	PB
PB	PB	PM	PM	PM	PS	PS	PB

D. Inverse fuzzy treatment and the calculation of output

K_p,K_i and K_d obtained by fuzzy control rule table are subjected to inverse fuzzification by gravity method[7]. Fuzzy control system through the fuzzy logic rules of the treatment, look-up table and calculation, and then K_p, K_i, K_d can be online self-tuning and fuzzy self-adjustment.The adjustment parameters are:

$$\begin{cases} K_p = K_{p0} + \{e, ec\}_p \\ K_i = K_{i0} + \{e, ec\}_i \\ K_d = K_{d0} + \{e, ec\}_d \end{cases} \tag{1}$$

In the formula, K_p,K_i and K_d is the initial set value of each parameter of PID, $\{e,ec\}_p$,$\{e,ec\}_i$ and $\{e,ec\}_d$ is the result of fuzzy reasoning.

IV. Research and Analysis of Fuzzy PID Controller Simulation

Combined with the actual situation of subway station air conditioning,compared with the general air-conditioning system, subway station air-conditioning system has many types of interference,so accurate mathematical model is difficult to determine.If you use the usual PID control system, because the adjustment time constant is large, the capacity lag is also large, the control effect is not timely, can not meet the control requirements. I established an approximate mathematical model and simulation[8]. The simulation model of PID control and fuzzy PID control is established by simulation software, and the input is step response.The mathematical model established in this paper only considers the temperature control part of the air conditioning system of the subway station. Through the experiment, the transfer function of the temperature object is established as follows:

$$G(s) = \frac{e^{-s}}{s^2 + 3s + 1} \tag{2}$$

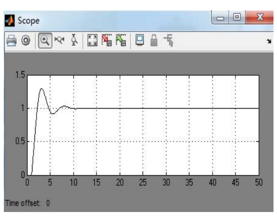

Figure 4. PID control simulation chart

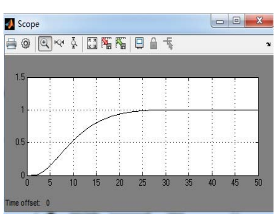

Figure 5. Fuzzy PID control simulation

It can be seen from the simulation results that the mathematical model of the system is more effective than the traditional PID control under the fuzzy PID control, which has the advantages of smaller overshoot, faster response and better control performance. So that the air conditioning system has good dynamic performance and steady state performance.

V. Conclusion

In this paper, the fuzzy control and PID control are combined to obtain fuzzy PID control for the shortcomings of traditional PID control and simple fuzzy control. The simulation results show that the fuzzy PID control application has good robustness, fastness and accuracy in air conditioning and ventilation system. It is not only conducive to energy conservation, but also for passengers to provide a comfortable and safe ride environment.

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