Simulation for Fuzzy PID Temperature Control System

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Abstract. For the current general heating control system tracks the set temperature hysteresis heating device to automatically adjust the real-time problem of poor design a fuzzy self-tuning proportional-integral-derivative (PID) controller parameters. Scoop out using PID control and fuzzy control algorithm combined method; fuzzy PID control parameters are adjusted. Use Matlab to model in simulink, the aryl the controller simulation analysis. The results show that the fuzzy self-tuning PID controller overshoot $\sigma \approx l\%$, steady-state error Island e_s=0. This method can improve the performance of the temperature control system.

Introduction

Fried heating process such as the study of tea machine , tea machine fried heating system must be adapted to process fried tea , temperature control accuracy and efficiency directly affects the quality of tea , such a heating system is very time-varying system , the required temperature small hysteresis control system to keep track of the set target temperature.

Proportional Integral Derivative (Proportion Integration Differentiation, PID) control is still the most widely used control law , it is because of the simple PID controller structure to meet the requirements of industrial process control , PID control especially strong so that it can be more robust changes good fit a wide range of process conditions . However , PID may be because they belong essentially linear control [1-4], and large overshoot of the heating system such a big lag , nonlinear, time-varying systems , parameter tuning to optimize the value of the value of just having some localized , so the overall effect is not controlled ideal . PID control can get better control effect, required by adjusting the proportional, integral and derivative three kinds of control, the formation of both the mutual cooperation between the amount of control and mutual checks and balances. When pure fuzzy control deviation and the deviation in the rate of change as input, the control process is not smooth phenomenon sometimes occurs, there are steady-state error. This paper presents fuzzy self-tuning PID controller parameters, the fuzzy control PID controller parameters for heating temperature control system tuning.

Fuzzy control theory

Fuzzy controller is based on the knowledge of the controller, which uses fuzzy rules to control the expression of experiences and constitute the rule base, through the use of fuzzy logic or fuzzy inference rule base control experience and knowledge, so as to achieve the purpose of control. Specifically includes three components: fuzzy processing, reconciliation fuzzy reasoning.

Fuzzy processing is to determine the value of the fuzzy controller input conversion process variable values [5-7] in response to vague language, the language of these response variable values [8] by the corresponding membership function OK.

Uncertainty reasoning methods for fuzzy system called fuzzy inference methods. Fuzzy reasoning is often used an approximate reasoning method, also known as the "likelihood inference "is a fuzzy set membership function transformation and calculation process. It is a prerequisite for making vague, fuzzy control rules generated by the theory. Baldwin reasoning is used here. Since fuzzy sets can not be precise analog or digital control systems, and therefore must be precise calculation. The fuzzy set in these most significant representatives of the determined value [9], as the system output control. In this paper, the center of gravity method is the weighted average method.

Fuzzy self-tuning PID controller design

Fuzzy self-tuning PID Controller Structure. Fuzzy self-tuning PID controller is the fuzzy control rules for PID parameters to modify an adaptive control system. To error and error rate of change of E EC as input to meet the different moments of E and EC on PlD parameter self-tuning requirements. Using fuzzy control rules on PID parameters changed, they constitute the adaptive fuzzy PID controller, the structure shown in Fig. l.

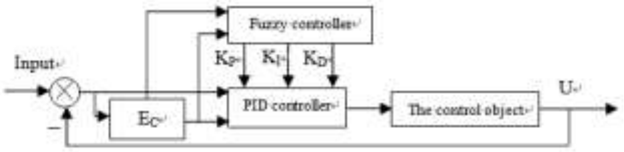

Fig. 1. adaptive fuzzy controller structure

PID Impact on System Performance. From the system's stability, speed of response, overshoot and steady state accuracy and other considerations, K_p K_i and K_d role is as follows :

(1) Scale factor K_p role is to accelerate the response speed of the system and improve the regulation accuracy of the system. K_p bigger, faster response speed of the system, adjust the accuracy of the system is higher, but easy to overshoot, and even lead to system instability. K_p value is too small, it will reduce the adjustment precision, the response is slow, thus extending regulation time, the system is static and dynamic characteristics deteriorate.

(2) Integral coefficient K_i is role is to eliminate the steady-state error. Static error K_i bigger, the faster elimination system, but K_i is too large, the initial response process will produce windup phenomenon, causing a large overshoot response process. If K_i is too small, K_i will make the system difficult to eliminate static error, adjustment precision affected system.

(3) The role of the differential control is an issue worthy of discussion. Differential coefficient K_d is role is to improve the dynamic characteristics of the system , its main function is to suppress the deviation in any direction change in the response process, the deviation change in advance forecast. But Kd advance over the General Assembly to make the process of braking response, thereby extending regulation time , and will reduce the anti-jamming performance of the system.

Input and Output Membership Functions. Fuzzy parameters regulator is a dual input and three output fuzzy controller, input fuzzy variable most heated oven temperature and the temperature difference between the rate of change of the deviation E EC; output fuzzy variable scaling parameter K_p, integral parameter K_i, differential parameter K_d. Input variables E and Ec fuzzy subset of the language by the seven large negative value of the variable composition of { NB, negative in NM, negative small NS, zero ZO, are small PS, middle PM, CP PB}, { -3 on the domain , 3}. 3 output fuzzy subset {negative large NB, negative in NM, negative small NS, zero ZO, are small PS, middle PM, CP PB}, 3 outputs universe fuzzy variables are {O, 6).

Considering the extent of coverage of the universe , sensitivity and robustness, the membership function of each fuzzy subset are used triangular membership function , with high accuracy , in the form of simple, high efficiency is calculated , taking into account the membership function affect the size of the width of the system, the error is small when compared with the steep shape using the membership function , it has a higher resolution , the error is relatively large when compared with gentle shapes using the membership function , allowing the system to obtain better robustness. The following were given E, EC and three output variables K_p, K_i, K_d membership function distribution.

Fuzzy Control Rules. Fuzzy control rules elbow fuzzy control system plays a key role. Design principles of fuzzy control rule is : When the error is large, the control should be such that the error is reduced halo ; When the error is small , you should try to eliminate errors while preventing larger overshoot phenomenon . Specifically, it is time to find out PID3 between different parameters and E and EC fuzzy relationship, that run continuously detect E and EC, according to the fuzzy control principle of three -line parameters modified to meet different E EC control parameters and different requirements , leaving the controlled object has a good dynamic and static performance . Control rules of fuzzy controller is based on the manual control strategy is generally controlled by the operator observing the object from the stability , response speed, overshoot, steady precision and PID system to the system shadow

Ring and other considerations, to establish appropriate fuzzy rule table based on actual experience, because of space limitations , here △ K_p fuzzy control rule, as shown in Table 1

Fuzzy Reasoning and Fuzzy Decision. Fuzzy reasoning is actually an approximate reasoning, fuzzy reasoning based on fuzzy conditional statement. In the fuzzy control, fuzzy reasoning is the premise of fuzzy decision, but also the theoretical basis of the formation of fuzzy control rules.

Simulation results and analysis

In order to confirm the reasonableness of the control algorithm, using Matlab, Simulink to build adaptive fuzzy PID controller and a standard PID controller model, and simulation. By using two kinds of different control algorithms, respectively, their respective simulation results obtained, the structure of the system shown in Fig. 2.

Table 1. Fuzzy control table of K_P

K_p		ec						
		NB	NM	NS	ZO	PS	PM	PB
	NB	PB	PB	PM	PM	PS	ZO	ZO
	NM	PB	PB	PS	PS	ZO	ZO	NS
	NS	PM	PM	PM	PS	ZO	NS	NS
e	ZO	PM	PM	PS	ZO	NS	NM	NM
	PS	PS	PS	ZO	NS	NS	NM	NM
	PM	PS	ZO	S	NM	NM	NM	NB
	PB	ZO	ZO	NM	NM	NM	NB	NB

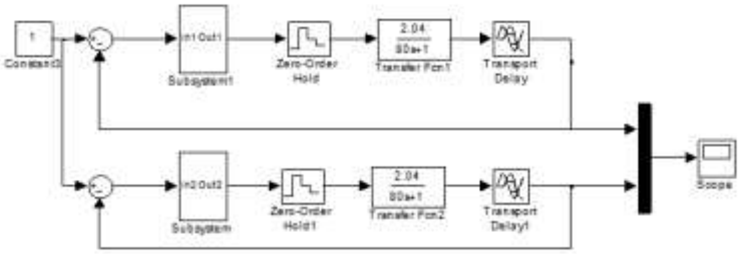

Fig. 2. Fuzzy PID system structure and standard.

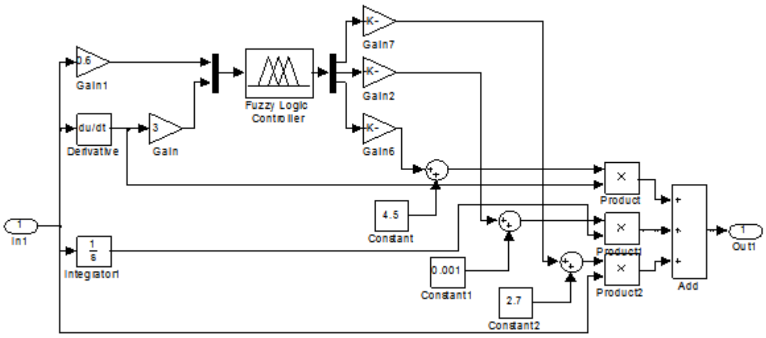

Fig. 3. Fuzzy PID system structure

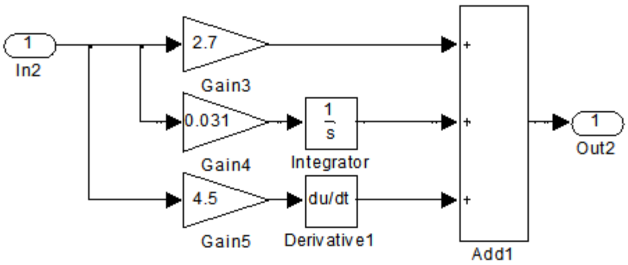

Fig. 4. Standard PID system structure

Figure 3 shows Fuzzy PID system structure. Figure 4 shows Standard PID system structure. Figure 5 shows system step response. In this paper, the system transfer function of the controlled object is 2.04e-9s/80s + l, respectively, to take fuzzy self-tuning PID algorithm and PID algorithm simulation. Parameters are set as follows: $K_p0 = 2.7$, $K_i0 = 0.031$, $K_d0 = 4.5$; fuzzy self-tuning PID error and error change rate of the algorithm were taken Ke = 0.6, Kec = 0.3, scale factor, respectively hp = 1.2, hi = 0.3, hd = 1.7; system step response simulation results shown in Figure 5, PID control overshoot stare σ = 5%, the fuzzy PID overshoot stare σ = l%; settling time ts 2 kinds of control methods = 100s, the steady-state phase error Island es = 0

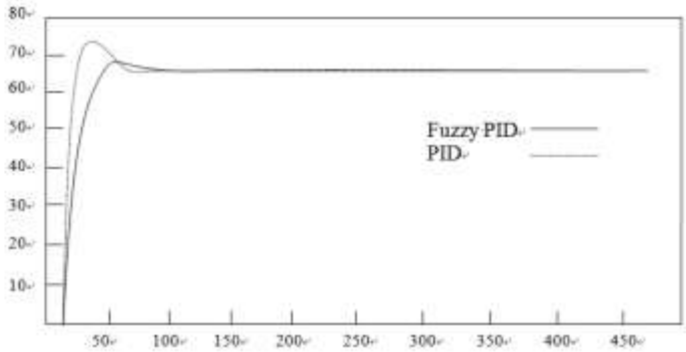

Fig. 5. System step response curve

Conclusion

When using conventional PlD control system has a large overshoot, while pure fuzzy control itself can not eliminate the steady state error. This article will be two kinds of control methods organic junction station, using fuzzy self-tuning PID algorithm overcomes the disadvantages of the PID control, to achieve the ideal performance of the system to adjust short time, small overshoot and steady-state error small

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