Temperature Control System of Screw Air Compressor Based on Fuzzy PID Control Theory

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Abstract

In order to improve the inaccuracy of the traditional screw compressor PID controller parameters when initial set. To improve the speed and accuracy, raises a theory of determination on the PID controller based on fuzzy control theory and the first method of Ziegle•Nichols, applied to determine the initial value of PID controller. And the theory is applied on new controller. Then the PI D controller parameters are obtained which can meet the control requirements. The validity and reliability of this determination method is verified.

Keywords: The PID controller, Fuzzy control theory, The PID controller parameters, Initial parameter setting

1. The design of whole system

The AVR ATmega16L Single chip microcomputer is the core controller of Temperature control system of screw air compressor based on fuzzy PID control theory, based on fuzzy PID control theory .The structure as shown in Figure1. The single chip microcomputer gives orders to all components to start and stop, including motors, valves and frequency converters. Temperature closed loop control and Automatic control can be done after setting temperature and starting master switch. AC servo motors includes variable speed motors and constant speed motors. According to the collection of temperature sensor, single chip microcomputer makes control judgment. System makes adjustment of air compressor group of variable speed and constant speed control in order to get the entire system in a specified temperature value within the range of normal operation. And, it's using the frequency conversion velocity modulation way effectively to save electric energy.

2. Implementation of fuzzy PID control

PID controller is widely used in industrial production as simple calculation. But the control parameter of PID is determined by trying. According to the experience in engineering and the specific circumstances of the problem to adjust the parameters, it cost much time to adjusTable parameters. It is difficult to select the parameters. To improve the speed and accuracy, raises a theory of determination on the PID controller based on fuzzy control theory and the first method of Ziegle•Nichols, applied to determine the initial value of PID controller. According to the control system response curve of the speed and accuracy of using fuzzy control theory to adjust the PID parameters and get effective PID parameters.

2.1 The PID parameter initialization

When the unit step response of open loop controlled object is not overshoot, the response curve presents S. The tangent of max slope of response curve of point, where can get parameters T, L, K. Shown as Figure 2. Proportion parameter Kp, Integral parameter Ki and Differential parameter Kd are Kp0, Ki0, Kd 0:

$$\begin{cases} Kp0 = 1.2\,T/L \\ Ki0 = 0.6T/L2 \\ Kd0 = 0.6T \end{cases} \quad \text{.....} \quad \text{.....} \quad \text{.....} \quad \text{....} \quad \text{.....} \quad (1)$$

2.2 Fuzzy PID control of theory

schematic diagram of PID parameter tuning. The max input of two-input and three-output controller is the max overshoot Mp and adjustment time is Ts, the output is correction factor of PID controller is r1, r2 and r3. The corresponding relationship as follows:

$$\begin{cases} Kp = Kp0 + \Delta K\,p = Kp0(1 + r1) & \text{……} \quad \text{……} \quad \text{……...} \quad (2) \\ Ki = Ki0 + \Delta K\,i = Ki0(1 + r2) & \text{……} \quad \text{……...} \quad (3) \\ Kd = Kd0 + \Delta K\,d = Kd0(1 + r3) & \text{……...} \quad \text{……} \quad (4) \end{cases}$$

$\Delta K\,p$, $\Delta K\,i$, $\Delta K\,d$ is the increment of Kp, Ki, Kd

In Figure 3, the setting of physical domain of Mp and Ts is: when the parameter of PID control system is set Kp= 1, Ki= Kd= 0, the dynamic performance index are [0, Mp0], [0, Ts0]. The fuzzy domain value of Mp and Ts0 are divided into ten part on. [0, 2], shown as{0, 1/16, 1/8, 3/16, 1/4, 3/8, 1/2, 3 4 , 1, 2}. The linguistic variable is {A0, A1, A2, A3, A4}.The A0 is appropriate value. A1 ~ A4 is the dgree of increased value and the value is not little. r1,r 2 and r3 are divided into nine part, shown as {-4, -3, -2, -1, 0, 1, 2, 3, 4} . The linguistic variable is {NL, NS, ZE, PS, PL}, NL is negative max, NS is negative min, ZE is zero, PS is min, PL is max.

This thesis uses the Triangular membership function, which is widely used in industrial production and explained the system of value of a quantity in the control of fuzzy control.

Membership function curve of Mp, Ts shown as Figure 4

Membership function curve of α shown as Figure 5

We can use fuzzy language represent control rules

If Mp is Ai and T s is A j, then r1 is r1i j

And r2 is r2i j and r3 i s r3i j

Using the formula

$$\frac{Xmax - Xmin}{X - Xmin} = \frac{Ymax - Ymin}{Y - Ymin}$$ the exact amount X can be reverse out through using the fuzzy weight

$$X = Xmin + \frac{(Xmax - Xmin)}{(Y - Ymin)} \quad \text{……} \quad \text{……} \quad (5)$$

The output of fuzzy controller can be get by the above formula, so the correction factor r1, r2 and r3 can be corrected precise. Then the value of Kp, Ki and Kd can be get by calculating (2) ~ (4).

3. The value of Simulation experiment and analysis

Using the SIMULINK Modular of MATLAB analysis and simulate system. So the method of determining the parameter of PID controller can be verified. The simulation model has been shown as Figure 6. This method is better than conventional PID controlling. This method can finish temperature regulation task better than others.

During the debugging of material object, the temperature control system of air compressor transform the actual operation temperature signal into a standard electrical signal through the equipment exports and input to the PID regulator compared with the given signal. After the fuzzy PID controller turning, the optimal control parameters can be get. Then the whole system output can be controlled by the optimal control parameters. The field equipment commissioning results show that temperature control system of screw air compressor based on fuzzy PID control theory make the optimal control according to the air supply devices and field environment changes and improve the system dynamic response speed and reducing the overshoot and effectively improve the system

reliability, stability and energy saving effect.

4. Conclusion

The controller has been run on the Ingersoll Rand company air compressor. The application of this method to determine the parameters of the PID controller can make the servo control system in a short period of time to determine the accurate Kp, Ki and Kd value and The better control effect. The temperature system in determining PID parameters of controller the controller is a new application of better control effect.

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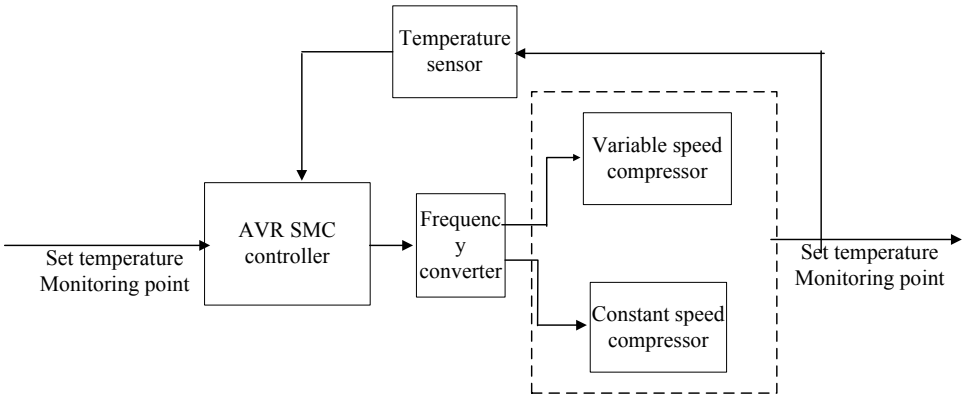

Figure 1. Based on the fuzzy PID controller in temperature control system of air compressor

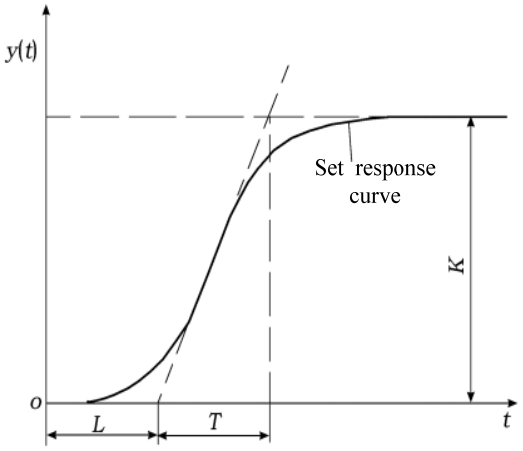

Figure 2. Ziegler Nichols first method

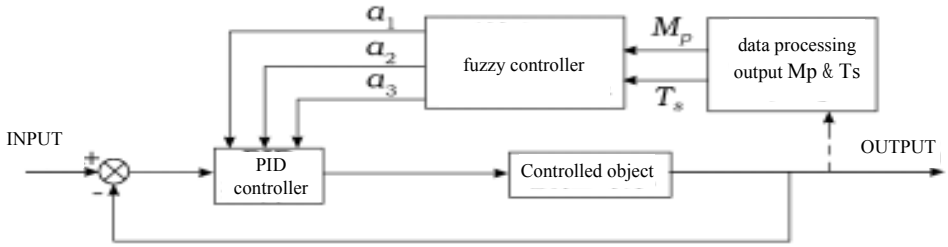

Figure 3. The PID parameter tuning control principle diagram

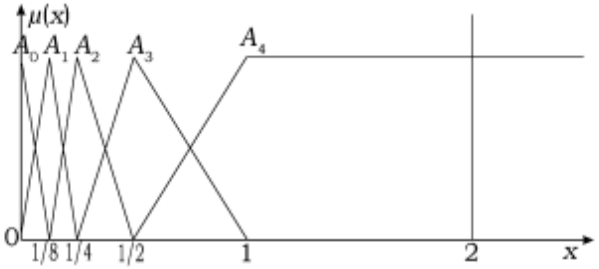

Figure 4. Mp and Ts membership function curve

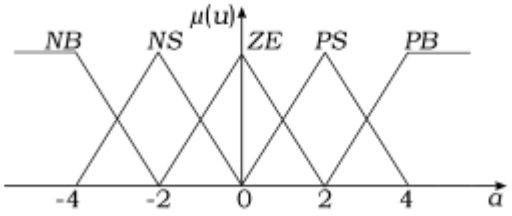

Figure 5. Membership function curve of α

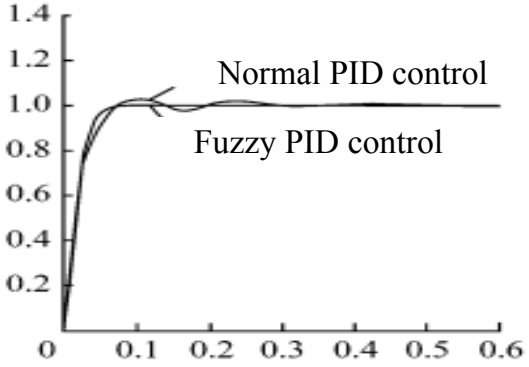

Figure 6. Step input of the conventional PID controller and fuzzy PID controller simulation waveform