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Application of Auto Disturbance Rejection Control in Fuze Rotation Speed Control

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Abstract. The motor is considered as the carrier and driving the precision control of rotation speed of the fuze, which is an effectiveway to simulate the centrifugal environment of the realistic simulation fuze. In order to precisely control the rotation speed of fuze, motor is used as the research object, a mathematical model of fuze rotation motion is built. Based on that, the ADRC design of fuze rotating is completed, and the ADRC and PID comparison simulation of fuze rotation speed is carried out. The simulation results show that ADRC technology has better dynamic performance compared with the PID control.

1. Introduction

Accuracy control fuze rotation speed is the best way and method of fuze centrifugal environment simulation. As a carrier of fuze centrifugal simulation, high-speed motor is realized by means of rotating speed control of motor to complete rotary speed control of fuze. Therefore, high precision rotation of high speed motor is the key to simulate the centrifugal environment of fuze fuze. It is of great significance to study the speed control of high speed motor [1].

According to the poor model of motor speed control precision, difficult problem, the motor is used as the research object, the model analysis method of constructing motion mathematical model of the motor is applied, on this basis, the self-rotation control ADRC control technology is applied to high speed motor, the ADRC controller design of fuze rotation speed control is carry out, and its control performance is verified.

2. Motion Mathematical Model of Fuze Rotating Motor

For the typical permanent magnet synchronous motor, the motor should be driven by DC drive. Its system are used by DC torque motor drive form and is one of the three closed-loop negative feedback control model[3] . Based on working principle of the system, its structure diagram is shown in Fig 1.

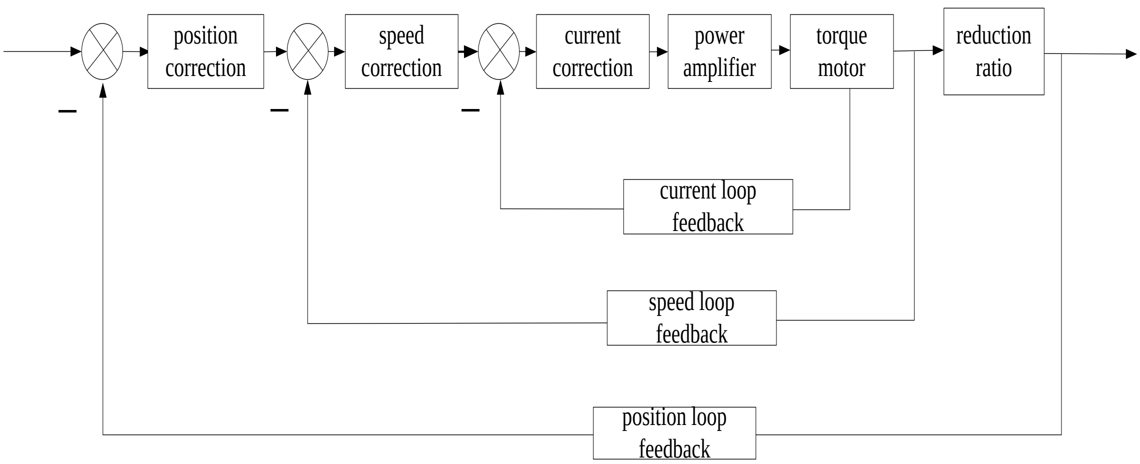

Fig. 1 Block of motor system function structure

In Fig.1, μ as the voltage driving of armature, y_θ as the displacement angle of motor. In the actual simulation modeling, a typical two order transfer function usually is used to approximate the mathematical model of motor system, the mathematical model can be described as [4]:

$$G_\theta(s) = \frac{Y_w(s)}{U(s)} = \frac{K}{s^2 + T_1 s + T_2} \tag{1}$$

The T_2, T_1, K as parameters for identification.

3. ADRC Application

3.1 ADRC Control Principle

The auto disturbance rejection controller (ADRC) is the essence of the traditional control technology PID controller, and breaks through the new controller of the absolute invariance principle and the internal model principle. The motor model based on the construction is the two order model. Here, the two order ADRC controller is introduced as an example, the control block diagram is shown in Fig 2.

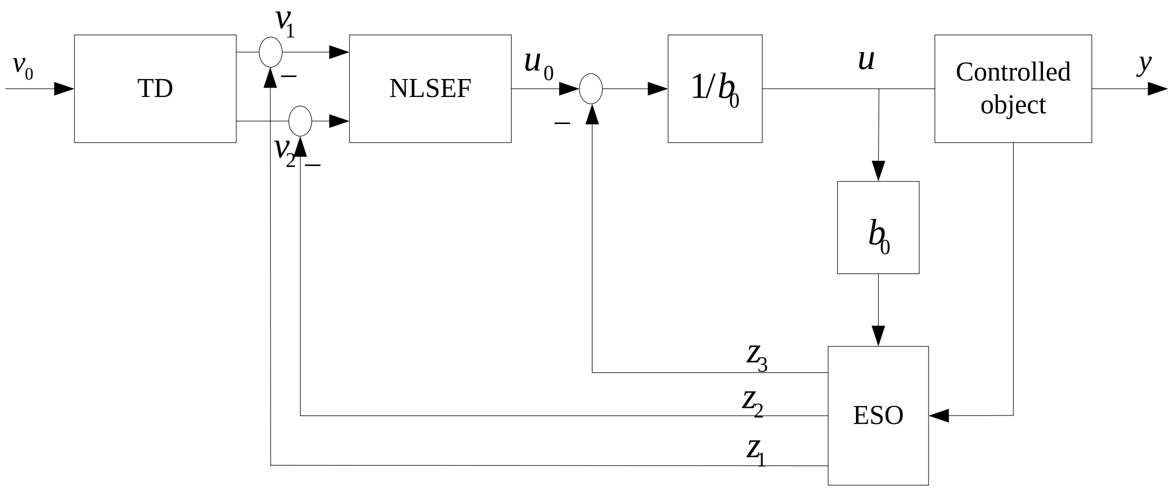

Fig. 2 The control block diagram of temperature control device

In the diagram, a self-disturbance rejection controller consists of three parts: a tracking differentiator (TD), an extended state observer (ESO), and a nonlinear feedback combination (NLSEF).

(1)Tracking Differentiator (TD)

For a two order system, the discrete form of the nonlinear tracking differentiator is expressed as:

$$\begin{cases} x_1(k+1) = x_1(k) + Tx_2(k) \\ x_2(k+1) = x_2(k) + Tu(k) \\ u(k) = fst\left(x_1(k) - x_0(k), x_2(k), r, h\right) \end{cases} \tag{2}$$

In the formula, FST () is the fast optimal synthesis function of the two order discrete system. It is the transition signal, which is the differential signal of the transition process. The T is the sampling period, and the R determines the tracking rate of the input signal, which is called the speed factor.

(2)ESO

The expression of the extended state observer for the two order auto disturbance rejection controller is as follows:

$$\begin{cases} \dot{z}_1 = z_2 - \beta_1 \varepsilon \\ \dot{z}_2 = z_3 - \beta_2 fal(\varepsilon, a_1, \delta) + b_0 u \\ \dot{z}_3 = -\beta_3 fal(\varepsilon, a_2, \delta) \\ \varepsilon = z_1 - y \end{cases} \tag{3}$$

$fal(\varepsilon, a, \delta)$ is defined as:

$$fal(\varepsilon,a,\delta)=\begin{cases}\varepsilon/\delta^{1-\alpha} & |\varepsilon|\le\delta\\ |\varepsilon|^{\alpha}\operatorname{sgn}(\varepsilon) & |\varepsilon|>\delta\end{cases} \tag{4}$$

In the formula, z_1, z_2, z_3 is respectively the state variable of the tracking object x_1, x_2, x_3, β_1, β_2, β_3 is the gain of the observer.

(3)NLSEF

The feedback control rate of the nonlinear state error is as follows:

$$\begin{cases}e_1 = x_1 - z_1\\ e_2 = x_2 - z_2\\ u_0 = k_1 fal(e_1,a_1,\delta)+k_2 fal(e_2,a_2,\delta)\\ u = u_0 - z_3/b_0\end{cases} \tag{5}$$

In the form, u_0 is the control rate; z_3/b_0 is the compensation for the disturbance; u is the control signal output for the controller; a the range of value: $0<a_1<1<a_2$.

3.2 Control Design of Fuze Rotation Speed.

According to the ADRC mathematical model, the mathematical model speed of the transfer function is used as ADRC input, Fuze is regarded as the carrier of the motor speed control, the control voltage of the motor drives the rotation of the rotating speed of the fuze fuze [4], ADRC controller design diagram is shown in Fig3.

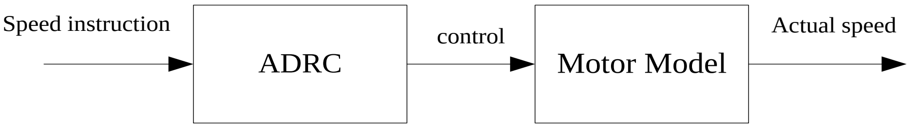

Fig.3 ADRC controller design diagram

4. Simulation Verification of Control Effect

In order to verify the control effect of the self-disturbance rejection controller (ADRC) on the speed of the fuze rotation speed. In order to better show the control effect of ADRC on Fuze rotation speed, the PID controller is introduced to control the rotation speed of fuze to complete the comparison of control effect. Using the two controllers for unit step response input, the simulation results are shown in Fig4.

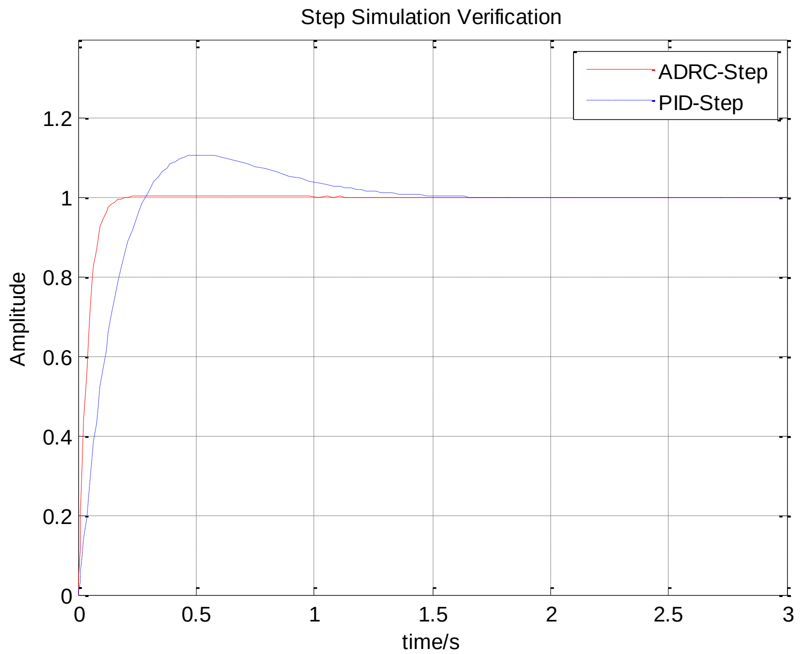

Fig. 4 the comparison diagram of temperature

Comparison of two kinds of controller data which is obtained from the simulation can be seen as: the control effect of dynamic disturbance controller in fuze rotational speed is obviously better than the PID controller, and reflect that when the fuze rotational speed fluctuates, ADRC has better dynamic performance, faster response that is compared with the PID controller.

5. Conclusion

The motor is taken as the research object, based on the motor model, the construction of mathematical model of motor is completed and the rotation control ADRC control technology is applied to high speed motor, the ADRC controller of fuze rotational speed control is designed, through the comparison of the simulation results, the ADRC has the control performance is very more strong. In the future research, the motor model and the parameters of the ADRC will be further optimized.

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