MATLAB Simulation Analysis in the Strip Running Offset Control System

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Abstract

In order to prevent deviation problems produced in such as strip, belt and other winding process, designed strip deviation control system control program. The main device is determined according to the main design parameters. The control system is calculated in detail, and the Simulink model is established with MATLAB to analyze the system quality of the control system. Through the theoretical analysis, the scheme is practical and shows good robustness, and it is a kind of high precision anti - deviation control system.

Keywords

Anti - deviation control, MATLAB, hydraulic servo control.

1. Introduction

In industries such as metallurgy, textiles, paper and machinery manufacturing, strips are often processed and processed, and in the processing and processing, strip "offset" control (EPC) is quite important. Extensive use of the prospects. The strip deviation control system consists of a hydraulic energy device, an electro-hydraulic servo valve, a servo amplifier, a hydraulic cylinder, a coiler and a transmission.

2. System Working Principle and Parameters

2.1 Principle of System Work

The photodetector of the system consists of a light source and a photodiode. It is rigidly connected to the reel. When the controlled edge (such as strip) runs normally, the photocell receives half of the light and its resistance value is R. When the controlled edge deviates from the center of the detector, the illumination received by the photocell changes. The voltage signal is amplified by the amplifier to generate a differential current ΔI input to the electro-hydraulic servo valve, which generates a flow proportional to the input signal, and controls the hydraulic valve tow. The moving reels move together to form direct position feedback [1].

According to the work requirements, the electro-hydraulic servo valve and hydraulic cylinder control scheme were decided. The functional block diagram of the system is shown in Figure 1.

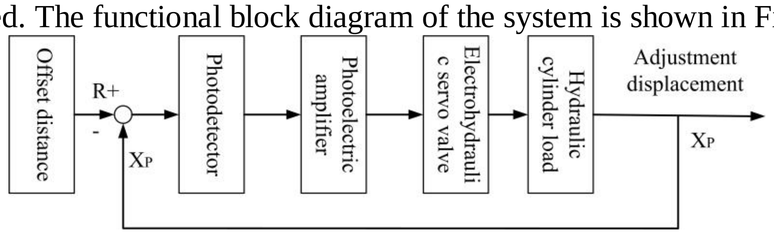

Fig.1 Deviation control system function block

2.2 Design Requirements and System Parameters

(1) The maximum speed of the strip: $v_m=2.2\times10^{-2}$m/s

(2) Load quality: M=35000（kg）

(3) Working distance: L=150mm

(4) Maximum adjustment speed: $v_m=2.2\times10^{-2}$m/s

(5) System bandwidth:w_m=20rad/s

(6) Maximum acceleration: $a_m=0.47\times10^{-2}$ m/s

(7) Maximum system error: $e_p\leq\pm2\times10^{-3}$m

3. Systematic Mathematical Model

3.1 Determine the Main Device Based on the Main Design Parameters

The pressure compensation variable pump is used to protect the servo valve. Measures should be taken to prevent oil contamination. According to the working requirements, the oil source pressure is taken as ps=4MPa.

Total load force:

$$F_L = F_s + F_f = Ma_m + Gf = 19145N \tag{1}$$

Usually take the load pressure as

$$p_l = \frac{2}{3}p_s = 2.6Mpa \tag{2}$$

Since $p_L=F_L/A_p$

$$A_p = \frac{F_L}{p_L} = 0.72\times10^{-2}m^2 \tag{3}$$

According to the needs of the work, the load pressure of the device is mainly suitable for dragging. The load pressure should not be too large, and the load pressure can be made smaller, that is, the working area is taken as

$$A_p = \frac{F_L}{p_L} = 1.68\times10^{-2}m^2 \tag{4}$$

so $p_L = \frac{F_L}{A_p} = 2.02MPa \leq \frac{2p_s}{3} = 2.6MPa$ is reasonable.

The maximum speed of the system:

$$v_m = 2.2\times10^{-2}m^2 \tag{5}$$

The required load flow:

$$q_L = A_p v_m = 3.396m^3/s \tag{6}$$

The pressure drop of the selected servo valve is Δp=1.9Mpa, According to the load flow rate and the servo valve pressure drop, according to the valve sample, select the servo valve of $\frac{25}{60}\times1000 = 4.16\times10^{-4}m^3/s$ Can meet the load flow requirements.

Since the time constant of the detector and the amplifier is small, the gain of the photodetector $k_i = 188.6A/m$ is equal to$k_\alpha A/V$ to be included in Ki.

3.2 Mathematical Model of the Control System

Transfer function of power components

$$\frac{x_p}{q_L} = \frac{\frac{1}{A_p}}{s\left(\frac{s^2}{w_h^2}+\frac{2\varepsilon_h}{w_h}+1\right)} = \frac{59.5}{s(\frac{s^2}{88}+\frac{2\times0.3}{88}+1)} \tag{7}$$

Where: A_p—the effective area of the servo cylinder;

w_h—the natural frequency of the power mechanism;

ε_h—Hydraulic damping ratio.

Servo valve transfer function:

$$\frac{q_L}{\Delta i}=\frac{K_{sv}}{s\left(\frac{s^2}{w_{sv}^2}+\frac{2\varepsilon_{sv}}{w_{sv}}+1\right)} \tag{8}$$

$$=\frac{1.96\times10^{-3}}{s(\frac{s^2}{157^2}+\frac{2\times0.7}{157}+1)}$$

Where: K_{sv}—the no-load average flow gain of the servo valve;

w_{sv}—the natural frequency of the servo valve;

The time constant of the detector and amplifier is small, and the gain K of the photodetector is to be determined. Through the above analysis, we get the transfer function of each link in the system, so we can draw a block diagram of the system, as shown in Figure 2.

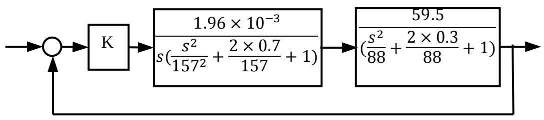

Fig.2 System transfer function block diagram

The open loop transfer function of the system:

$$G(s)H(s)=\frac{K_v}{s(\frac{s^2}{157^2}+\frac{2\times0.7}{157}+1)s(\frac{s^2}{88}+\frac{2\times0.3}{88}+1)} \tag{9}$$

where: $K_v = K\times59.5\times1.96\times10^{-3}$.

4. MATLAB Simulation and Analysis

4.1 SimulikModel and Simulation

According to the above calculation data, the drawing of the Simulink graph is shown in Fig. 3, and Fig. 4 is the operation result graph of the Simulink model.

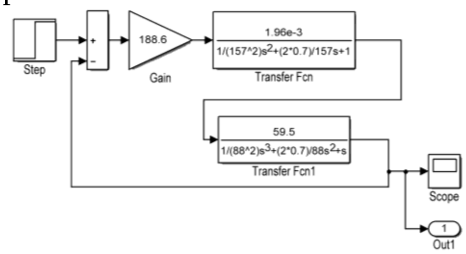

Fig.3 Simulink model

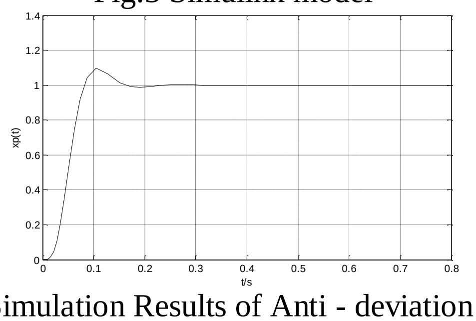

Fig.4 Simulink Simulation Results of Anti - deviation Control System

Analysis of Figure 4 shows that the curve has a rise time of about 0.1s, and overshoot occurs. However, with time, the curve converges to 1 after 0.3s, so the system is stable.

4.2 System Quality Analysis

Time domain analysis is one of the important methods to analyze system characteristics through the mathematical model of the system. Programming in MATLAB, time domain analysis of the strip anti-running control system, the typical input signals selected are unit step signals and unit pulse signals. The results of the system's time domain response analysis are shown in Figure 5.

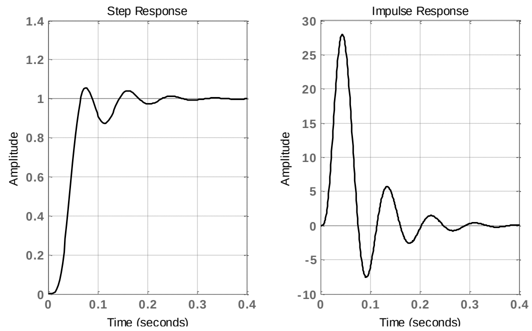

Fig.5 Time domain response result

It can be seen from Fig. 5 (left) that the unit step response curve of the system is convergent, the rise time of the system is about 0.08 s, the peak time is 0.09 s, the adjustment time is about 0.24 s, and then the curve is stable, so the system is stable. of.

From Fig. 5 (right), the unit impulse response curve of the system is also convergent. After 0.3 s, the curve tends to be stable and stable at 0, so the system is stable.

Frequency characterization is the main method for studying and analyzing system characteristics in classical control theory. Using this method, it is an extremely effective method to analyze the characteristics of the system by transferring the transfer function from the complex domain to the frequency domain with a clear physical concept [2].

Programming in MATLAB, drawing the Nyquist and Bode diagrams of the system, realizing the drawing of the simulation results and error analysis. The key statements of the program are as follows:

```
sys_open=Ki*sys1*sys2
sysclose=feedback(sys_open,1);
pzmap(sys_open)
nyquist(sys_open)
w=logspace(-1,2);
margin(sys_open)
[mag,phase,w]=bode(sysclose,w);
[l,c]=size(mag);
mag1=zeros(c,1);
for i=1;c
mag1(i)=20*log10(mag(1,1,i));
end
disp('-3dB frequency:');
W_3dB=abs(interp1(mag1,W,-3,'spline'))
```

The Nyquist diagram of the obtained system is shown in Figure 6, and the Bode diagram of the system is shown in Figure 7.

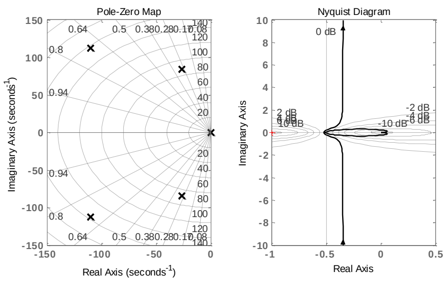

Fig.6 The system's Nyquist diagram

Analysis of Figure 6 shows that the open-loop transfer function G(s)H(s) of the system has no pole in the right half plane of the [s] plane, so P=0, and G(jω)H(jω) does not surround the point (- 1, j0), so the system is stable.

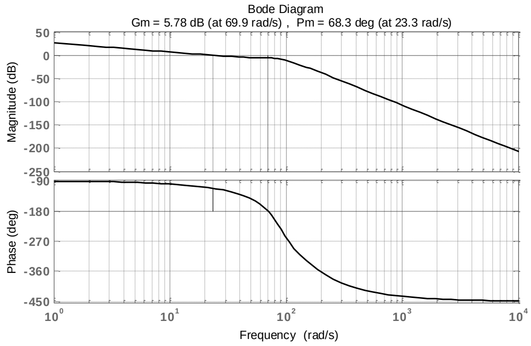

Fig.7 The Bode diagram of the system

As can be seen from the Bode diagram of the system of Fig. 7, in the Bode diagram, when ω is changed from 0 to +∞, the open-loop logarithmic phase-frequency characteristic is -180 in the frequency range in which the open-loop logarithmic amplitude-frequency characteristic is positive. . The difference between the line crossing and the negative crossing times is p/2, Kg=Gm=4.34dB, γ=74.7deg, ω=23rad/s, so the system is stable.

From the above calculation results, we can know:

$$W_{-3dB} = 921.1034 rad/s \geq 20 rad/s \quad (10)$$

The visible bandwidth fully meets the design requirements. The total error of the system is e=0.0010<0.002, so the accuracy requirements of the system are met.

5. Conclusion

A mathematical model is established for each component of the strip electro-hydraulic servo control system, and the transfer function of the whole system is established. Through the simulation analysis of the Simulink model, it can be known that all aspects of the system meet the design requirements, and the conclusion of the study And methods provide reference value for subsequent related research.

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