Simulation Analysis of Vibration Fault of Hydraulic System in Rolling Mill

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Abstract

Based on the front pipe system of the four-high rolling mill hydraulic valve, the physical model is established, and the simulation parameters are then carried out after the simulation parameters are determined by the actual production process.Set respectively under different proportional gain step impact quality, different load, different initial volume, on these three factors to simulation process, exploring their influence of vibration of rolling mill hydraulic line, and according to the simulation results put forward the concrete method of relief valve before the line pressure fluctuations.This study is of great significance for solving similar problems in engineering.

Keywords

Rolling mill;Hydraulic system;Pipeline vibration fault;Simulation analysis.

1. Introductory remarks

With the rapid development of science and technology, hydraulic system is widely used in engineering practice. The mill is the key equipment for producing steel plate in industrial production, and the hydraulic system plays an important role in controlling the rolling precision of the steel plate. But when rolling mill hydraulic system control work is affected by its working environment easily happened system and the vibration of the pipeline, the fault will not only influence steel plate accuracy even pipeline vibration burst of serious accident will happen. In order to avoid the unexpected consequence of the vibration accident of the rolling mill hydraulic pipeline, the mechanism of vibration failure of the hydraulic pipeline of the mill is particularly critical[1].

For four high mill hydraulic valve before the line as the research object, from the proportional gain, load quality, three influence factors in the initial volume of the case for simulation, and put forward the corresponding solving measures.

2. The physical model of rolling mill is established

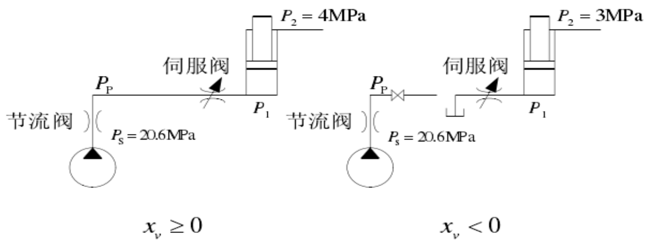

Figure 1 The simplified physical model of servo valve control cylinder of force motor

As shown in figure 1, due to the pipeline vibration occurred often in front of the electrohydraulic servo valve valve position[2], namely between the hydraulic pump and servo valve line (as shown in figure in

p_p near the location of the servo valve), because of this, simulation focuses on exploring the hydraulic servo system in many factors of influence on p_p size.There are four pressure parameters in this physical model: the pressure value of the non-bar cavity of the hydraulic cylinder is p_1, the pressure value of the hydraulic cylinder is p_2, the power source pressure p_s and the pipeline pressure p_p.

3. Derive the physical equation

The following is the basic equation of valve control cylinder system:

(1)Throttle valve

$$Q = K \cdot \sqrt{\left|p_s - p_p\right|} \cdot sign\left(p_s - p_p\right) \quad (x_v \geq 0) \tag{1}$$

(2)Electro-hydraulic servo valve

$$Q_s = \begin{cases} K_q \cdot x_v \cdot \sqrt{\left|p_p - p_1\right|} \cdot sign\left(p_s - p_1\right) \\ K_q \cdot x_v \cdot \sqrt{\left|p_1\right|} \cdot sign\left(p_1\right) \end{cases} \tag{2}$$

(3)The pipe flow in front of the electro-hydraulic servo valve

$$Q_1 = \frac{V_p}{E_y} \cdot \dot{p}_p + Q_s \quad (x_v \geq 0) \tag{3}$$

(4)The accumulator before the electro-hydraulic servo valve

The formula between pressure value p_p and flow value q_m of accumulator:

$$\dot{p}_m = \frac{kp_0}{V_0} q_m + \frac{R_m}{S^2_m} \dot{q}_m + \frac{M_m}{S^2_m} \ddot{q}_m \tag{4}$$

Non-rod cavity flow of hydraulic cylinder:

$$Q_s = \frac{V_p}{E_y} \dot{p}_1 + A_1 \dot{x} + k_{ci} \cdot \left(p_1 - p_2\right) \tag{5}$$

Comprehensive external carrying capacity:

$$A_1 p_1 - A_2 p_2 = M\ddot{x} + B\dot{x} + Kx + F \tag{6}$$

4. Improvement algorithm of BP neural network

4.1 Simulation model of hydraulic servo system

The hydraulic servo system block diagram shown in FIG. 2 is obtained by taking the Laplace transform of the physical equation in the upper section and arranging the merge[3]:

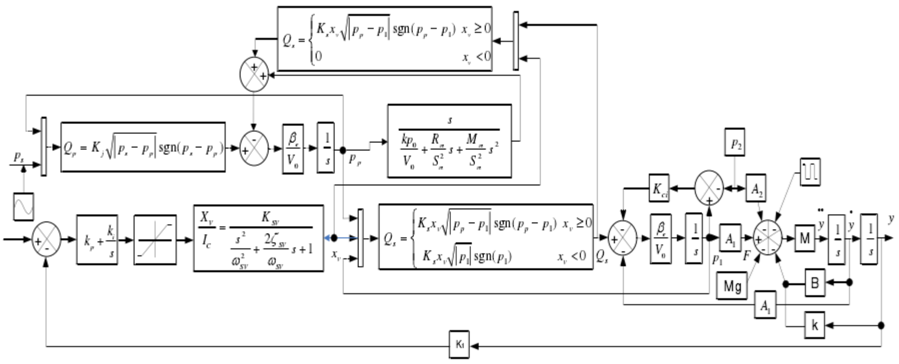

Figure 2 Consider the hydraulic servo system simulation model of servo valve front dynamic characteristics

4.2 Parameter formulation and operation

The parameters required in the simulation are as follows:

The pressure of the pump p_s:20.5Mpa;

The back pressure value of hydraulic cylinder cavity p_1:3~4MPa;

No rod cavity area of hydraulic cylinder: $A_1 = \frac{\pi}{4}D^2 = \frac{\pi}{4}0.95^2 = 0.7085m^2$;

The cavity area of the hydraulic cylinder is: $A_1 = \frac{\pi}{4}\left(D^2 - d^2\right) = \frac{\pi}{4}\left(0.95^2 - 0.8^2\right) = 0.2062m^2$;

Initial volume of hydraulic cylinder: V_0 is parameters that can be debugged;

Equivalent elastic modulus of servo valve $E_y = 0.7\times10^9 Pa$; Response frequency $100Hz = 628rad/s$; The damping ratio $\xi = 0.3$; Servo valve gain coefficient $K_{sv} = 2.5\times10^{-6}$ (as $150L/\min$ pressure drop 4Mpa calculating); The flow gain $K_q = 3.83\times10^4$

Accumulator entrance $l_m = 160mm$; Entrance diameter $D_m = 28mm$; Effective volume modulus of elasticity $\beta_e = 400MPa$; Dynamic viscosity coefficient: $\eta = 29.75\times10^{-2} Pa\cdot s$;

Leakage factor: $K_{ci} = 1.33\times10^{-14} m^3/s/Pa$;

The equivalent mass of the load $m = 11879Kg$; Equivalent stiffness $K = 2.92\times10^9 N/m$;

The equivalent damping $B = 2.4\times10^7 Ns/m$;

The load deformation force produced when the hydraulic cylinder displacement is 2mm $F = 2.92\times10^9 \times 2\times10^{-3} = 5.84\times10^6(N)$

The transfer function between the displacement of the servo valve core and the input current [4-5]:

$$H(s) = \frac{X_v}{I_c} = \frac{K_{sv}}{\frac{s^2}{\omega^2_{sv}} + \frac{2\xi_{sv}}{\omega_{sv}}s + 1} \tag{7}$$

4.3 Simulation analysis of the hydraulic system Simulink

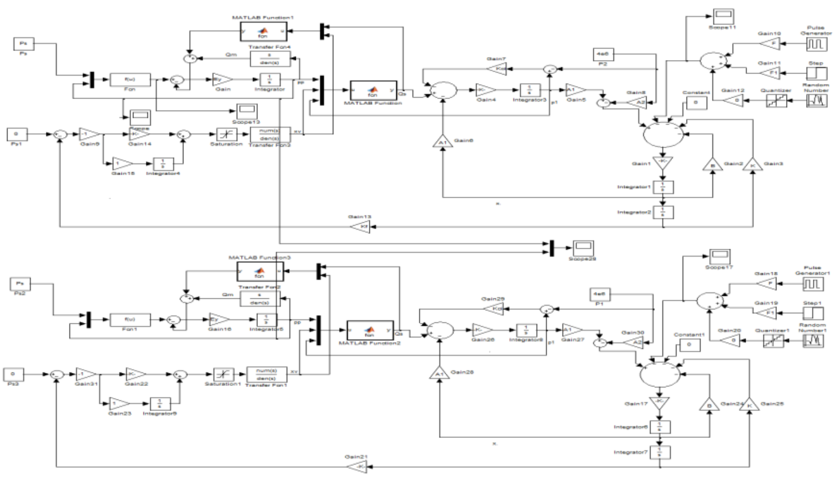

Figure 3 Simulink simulation program

According to the simulation model given in figure 3, the simulation parameters are substituted into each simulation parameter, and the Simulink model is simulated, and the simulation block diagram is shown in figure 4 [6].

5. Simulation results and analysis

(1) comparison of proportional gain variation

Reduce the proportional gain value by half, and the simulation result is shown in the figure below:

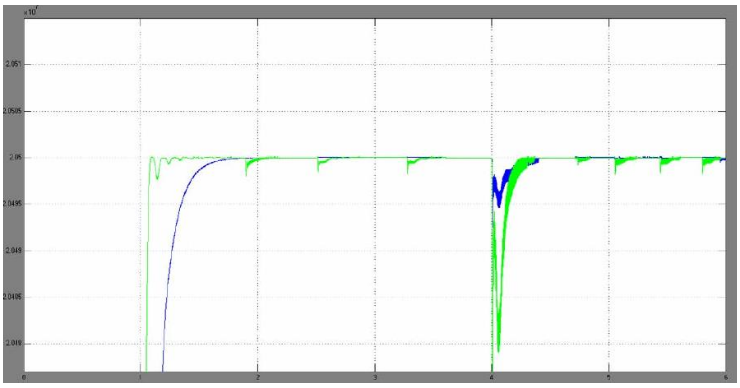

Figure 4 A partial magnification of the pre-valve pressure signal under the load interference square wave(blue for small gain)

The blue part shown in the figure represents the reduction of the gain. The simulation results show that the change of the proportional gain is one of the factors that affect the pressure value of the front pipeline. The reduction of proportional gain value can reduce the amplitude of pipe vibration.

(2) comparison of load quality changes

When the load quality is increased to 2 times, the comparison of the pressure pulsation of the front line of the valve is shown in figure 5:

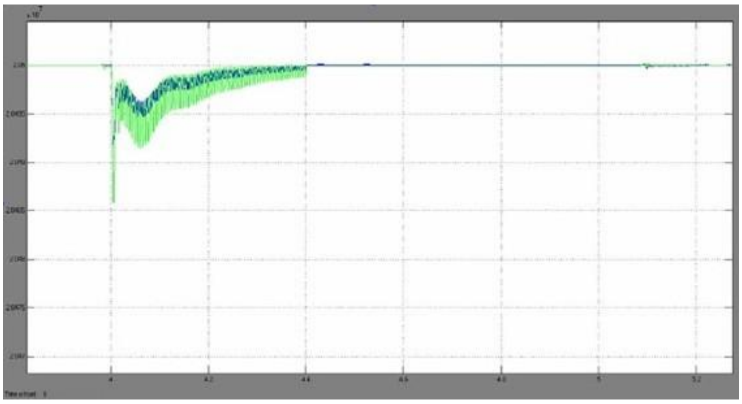

Figure 5 Pipe pressure at twice the mass difference.

The green part in the figure is the condition that the mass increases to twice. When the load quality is large, the pressure fluctuation of the front pipe line caused by the valve will be slightly larger. In theory, it can be understood that the change of load quality will affect the natural frequency value of the system, and when the load quality increases, the natural frequency of the system will decrease.

(3) the comparison of the elongation of the hydraulic cylinder (that is, the volume of different no-bar cavity)

Increase the volume of the no-bar cavity to the initial 1.5 times, and the dynamic fluctuation of the front line pressure of the valve is shown in figure 6:

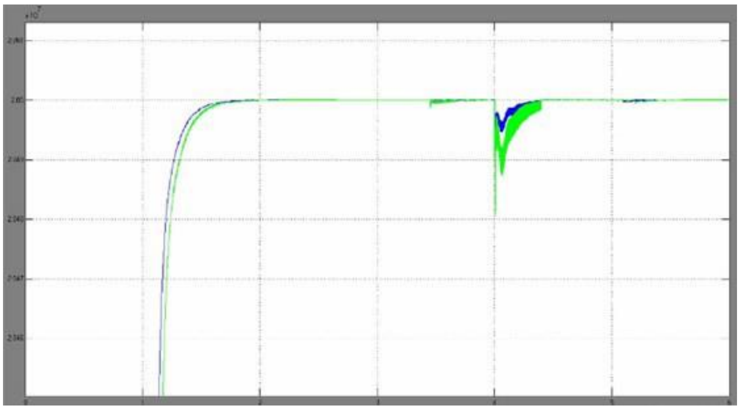

Figure 6 Pipe pressure at 1.5 times change in working chamber volume

The green part of the figure is about 1.5 times the volume. The simulation shows that the change of the outstretched quantity means the volume change of the no-bar cavity. It will cause the relative change of the pressure of the front line of the valve. The extension of piston rod is helpful to reduce the fluctuation of pipeline.

6. Conclusion

The simulation physical equation, simulation frame and relevant parameters are set up for the rolling mill hydraulic system. By setting different step impact under proportional gain, the load of different quality, different initial volume of the three factors in the Matlab simulation, and can be obtained from simulation: in the appropriate range, load reduction percentage gain quality, the value of the initial volume can achieve the goal of relief valve before the line pressure fluctuations.

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