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Pipeline to Hydraulic Pressure Position-Control System Performance Research

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ABSTRACT :*Take the pipeline of hydraulic position control system as research objects, and by using hydraulic simulation software AMESim to establish the simulation model of hydraulic position control system and carries on the simulation analysis. To study the effect of the length and pipe diameter of the pipeline on the performance of the hydraulic position control system. The simulation results obtained in this paper can provide references for studying of other hydraulic system performance.*

Keywords: *Pipeline; AMESim; Position control; Simulated analysis*

I. INTRODUCTION

Pipeline is a kind of auxiliary hydraulic system components, it's main function is to connect the various hydraulic components in hydraulic system, so as to constitute a hydraulic circuit. With the dynamic characteristics of hydraulic system research, we learned that the performance of the hydraulic cylinder and all kinds of valve and other components affect the performance of the hydraulic system, Theory and practice has proved that the pipeline characteristics on static and dynamic characteristics of the hydraulic system has a big impact, such as vibration, pressure loss and lags in response[1]. In order to further understand the pipeline characteristics influence on static and dynamic characteristics of hydraulic system, We can take the method of modeling and simulation. Commonly used methods of modeling and simulation are transfer function method, the state space method, the power bond graph method, etc[2]. Currently the vast majority of software modeling by using state equation, these for general hydraulic workers the demand is higher, there are quite a difficult[3]. This article used the AMESim software for simulation analysis, can facilitate the designers flexible simulation of hydraulic system for stability and high precision of the simulation results.

II. AMESim are briefly introduced

AMESim is multidisciplinary integration system simulation platform which the original French fashion company developed it. It can create and run multiple physical simulation model, to analyze complex system characteristics[4]. AMESim has developed 4 level modeling method: steady state simulation model, the dynamic simulation model, simulation model of batch, continuous simulation model, at the same time has a variety of software interface[5]: such as programming language interfaces (C or Fortran), control software interfaces (Matlab/Simulink and MatrixX), real-time simulation interface (RTLVab, xPC, dSPACE), multidimensional software interface (Adam and Simpack, Virtual Lab Motion, 3 d Virtual), optimization of software interface (iSIGHT, OPTIMUS), FEM software interface (Fluux2D) and the data processing interface (Excel), etc[6].

III. Pipeline of electro-hydraulic position control system simulation analysis

Electro-hydraulic position servo system is one of the most basic and the most commonly used hydraulic servo system[7]. As in military radar and artillery control systems and machinery production and processing of the position of the machine tool working platform, and the steering gear control of aircraft and ships, etc have electro-hydraulic position servo system. As one of the most commonly used has the position feedback control valve hydraulic cylinder as an example to study the characteristics of pipeline will affect the performance of the system. Its working principle for as long as the output displacement of the actuator with a given signal bias, the system can automatically adjust the output displacement, until the deviation is zero[8].

3.1 Simulation modeling

The electro-hydraulic position control system through AMESim software modeling and simulation. Hydraulic system modeling in the AMESim simulation is divided into the following steps: First of all, in the sketch mode we build the electro-hydraulic position control system simulation diagram, the process of building model mainly use the standard library and HCD libraries to built in hydraulic system[9], if the hydraulic circuit does not complete, can't go into the next child model mode;Second, in submodel mode we can select electro-hydraulic position control system submodel, usually the first to use premier submodel can also be set sub models for each component; Third, in the parameter mode we can set submodel parameters or to specify a module to run the batch. Through the above three steps electro-hydraulic position control system simulation model is established, as shown in Figure 1.

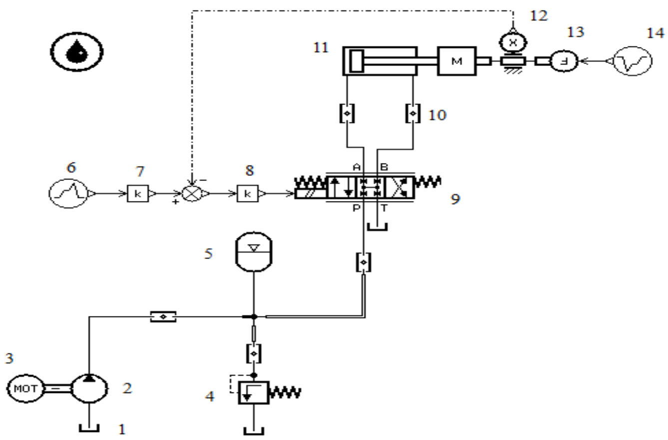

Figure 1 Electro-hydraulic position control system simulation model

1 Fuel tank; 2 Fluid pump; 3 Motor; 4 Flood valve; 5 Energy storage; 6 Segmented signal source 1;7 Gain;8 Preamplifier gain;9 Three four-way electromagnetic directional valve;10 Pipeline;11 Hydraulic cylinder；12 Displacement transducer；13 Force conversion block;14 Segmented signal source 2

Due to mainly study the hydraulic pipe impacts on performance of electro-hydraulic position control system, so choose can consider fluid compressibility, reynolds number and pipe friction HRL03 hydraulic pipe submodel, other connected to the fuel tank of hydraulic pipe choose DIRECT submodel, the rest of the elements in the system to choose premier submodel.

In parameter mode of simulation model of electro-hydraulic position control system of main components set parameter values are as follows: The oil density is $1040\,\mathrm{kg/m^3}$; The oil bulk modulus is $17000\mathrm{MPa}$; Absolute viscosity is $0.051\mathrm{Pa\cdot s}$; Motor speed is $1000\,\mathrm{r/min}$; Capacity of pump is $25\,\mathrm{ml/r}$; The hydraulic pipe diameter is 25mm; The overflow valve opening pressure is $15\mathrm{MPa}$; Inherent frequency of three position four-way servo-valve is 80Hz, rated current of three position four-way servo-valve is 200mA, damping ratio of three position four-way servo-valve is 0.8; Segmented signal source 1 within $0\sim1\mathrm{s}$ is 0, within $1\sim5\mathrm{s}$ varying from 0 to 0.8, within $5\sim7\mathrm{s}$ is 0.8, within $7\sim10\mathrm{s}$ varying from 0.8 to 0.4 and remain the same;

Segmented signal source 2 set to a constant 100, through force conversion block hydraulic cylinder will get a constant resistance that is 100N; In order to improve the hydraulic lever displacement measurement accuracy, the displacement sensor gain is set to 7, In order to ensure that the expectations of the input signal and the actual displacement of the hydraulic lever changes in the same scope, gain is also set to 7; Preamp gain 8 is set to 360; The hydraulic cylinder piston 30 mm in diameter, piston rod diameter of 20 mm, the piston rod stroke 1 m; Other parameter settings are the system default.

3.2 Simulated analysis

Enter simulation mode, set up the simulation time is 14s, the sampling period is 0.2s, the system of performance indicators are the steady state error is less than 0.003m, dynamic tracking error is not more than 0.046m. You can click to start the simulation button simulation.

3.3 Pipeline length on the system impact analysis

Because between hydraulic pump and hydraulic cylinder pipe, especially between control valve and hydraulic cylinder pipes along with environmental requirements can be arbitrarily lengthened, so the dynamic performance and steady-state performance of the hydraulic cylinder is bound to be affected. Hydraulic pipe diameter D is 25mm in figure 2, figure 3, figure 4 and table 1 respectively hydraulic pipe length L is 3m respectively, 10m, 15m, the dynamic error curve, the hydraulic pole displacement curve, hydraulic rod speed curve and hydraulic rod steady-state error value.

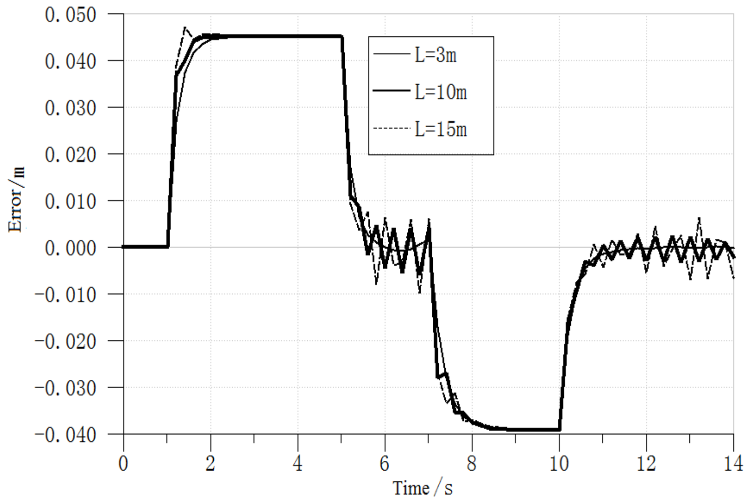

Figure 2 Hydraulic rod displacement error curve

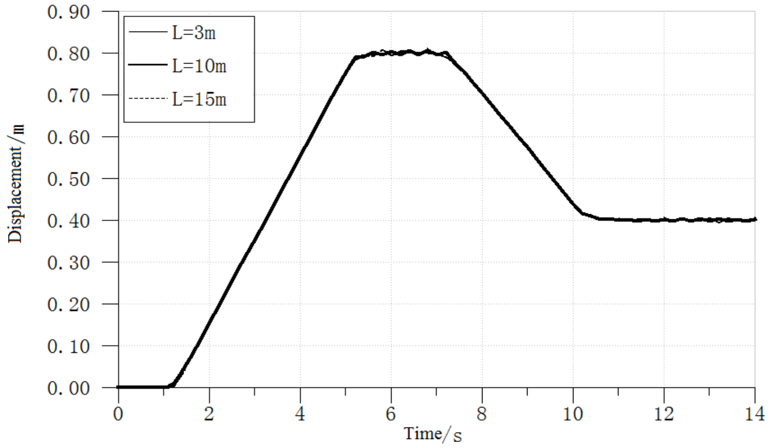

Figure 3 Hydraulic rod displacement curve

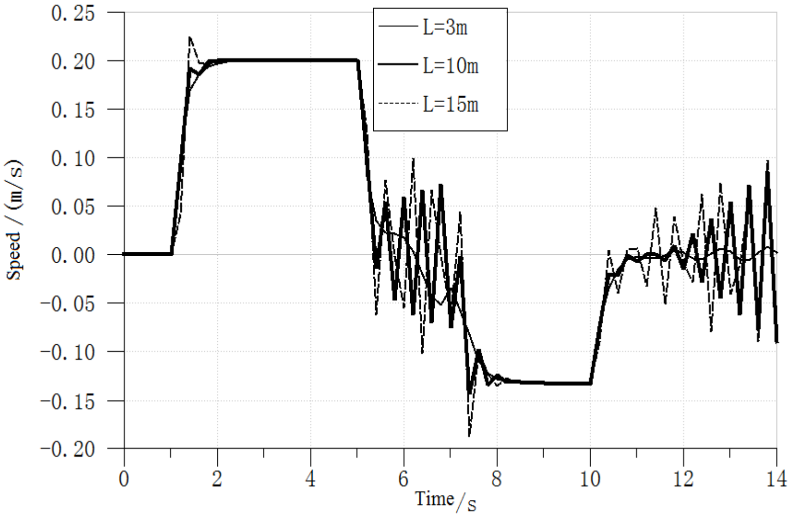

Figure 4 Hydraulic rod speed curve

Table 1 Steady-state error when the pipeline in different length

Pipeline length L/m	Hydraulic lever displacement /m	steady state error/m
3	0.400245	0.000245
10	0.401983	0.001983
15	0.406575	0.006575

We can be seen from figure 2, the longer the length of pipe, the system dynamic tracking error and the greater the tracking error can appear overshoot or oscillation, make the hydraulic system is not stable. In figure 3, 4 can be seen that even though the increase of the pipeline length L, hydraulic lever displacement has a little influence, the speed of the hydraulic lever has a great influence. Through the table 1, the longer the length of pipe, the greater the steady-state error of the system. Therefore, when designing the system, selecting appropriate pipe length L can affect the performance of the whole system.

3.4 Pipeline diameter on system impact analysis

Between hydraulic pump and hydraulic cylinder pipe length L chosen to 10m, choose different diameter D: 15mm, 25mm and 35mm pipeline to make simulation, we can get figure 5, figure 6 and figure 7 respectively: hydraulic lever displacement curve, system dynamic error curve and hydraulic rod speed curve.

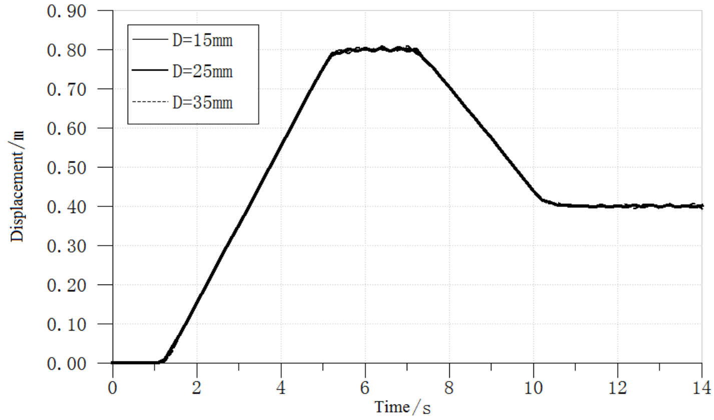

Figure 5 Hydraulic rod displacement curve

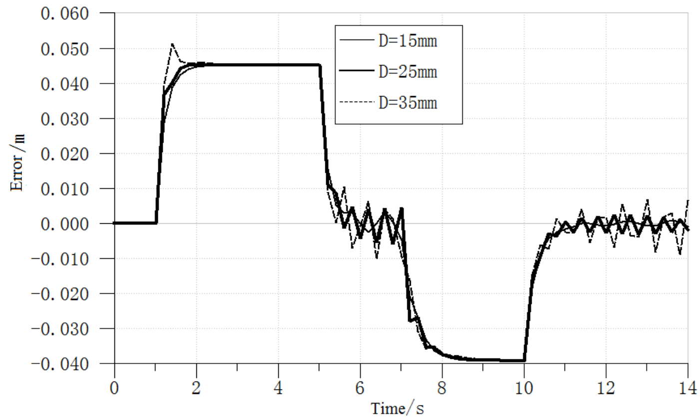

Figure 6 Hydraulic rod displacement error curve

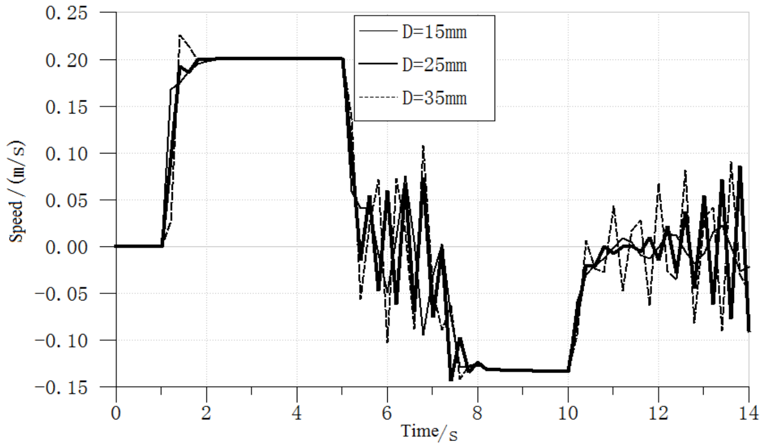

Figure 7 Hydraulic rod speed curve

We can see from the figure 5, even though the increase of the pipeline diameter, hydraulic lever displacement has a little influence. From the figure 6, the bigger the pipe diameter D, the greater the dynamic tracking error of system and will lead to the tracking error can appear overshoot or oscillation, make the hydraulic system is not stable. From the figure 7, the bigger the pipe diameter D, the great influence on the speed of the hydraulic lever, therefore, when designing the system, selection of pipe diameter D whether it's appropriate can affect the performance of the whole system.

IV. Conclusion

Through the study of the simulation analysis of pipeline, we can see the parameters of the pipeline has the obvious effect on hydraulic system, so in the design of servo hydraulic system must be considered when the effect of hydraulic pipes. AMESim batch function can make the results of simulation process is simple, under different parameters results contrast more clear, At the same time using AMESim software to modeling and simulation the hydraulic position control system, not only can avoid the tedious mathematical model, and the results of simulation image intuitive and easy to understand.

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