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Simulation and control of Dynamic Parameters for Hydraulic Systems – A Case Study

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Abstract
In this study the investigatied the length and diameter of the piston on the performance of the hydraulic control system. The dynamic parameters of hydraulic system research, that the performance of the hydraulic piston and all kinds of valve and other equipment influence the performance of the hydraulic system. This paper can procure references for studying of other hydraulic system performance in the simulation results obtained. This study used the matlab-simulink methods used software for simulation, can easy the designers flexible simulation of hydraulic system for stability and high accuracy of the simulation results.

Keywords: Simulation, Control, Hydraulic system, Dynamic parameters

Introduction
Hydraulic system assembly is to connect the various hydraulic assembly in hydraulic system, so as to constitute a hydraulic circuit. The performance of the hydraulic piston and all kinds of valve and other assembly impact the performance of the hydraulic system, theory and practice has proved that the hydraulic parameters on static and dynamic parameters of the hydraulic system has a big influence, such as vibration, pressure loss and lags in response[1]. To be known used methods of modeling and simulation are the state space method, transfer function method, the power bond graph method, etc. At present the vast majority of software modeling by using state equation, these for general hydraulic workers the demand is higher, there are quite a difficult. In order to further understand the piston parameters influence on static and dynamic parameters of hydraulic system, we can take the method of modeling and simulation [2].

Matlab
Matlab can create and run multiple physical simulation model, to analyze complex system parameters. Matlab is multidisciplinary integration system simulation platform which the original French ashion company developed it[3]. Matlab has developed 4 level modeling method: steady state simulation model, the dynamic simulation model, simulation model of assembly, continuous simulation model, at the same time has a variety of software interface: 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[4].

Simulation of piston control system
Processing of the position of the machine tool working platform, and the steering gear control of aircraft and ships, etc have hydraulic position servo system position servo system is one of the most basic and the most commonly used. İn military radar and artillery control systems and machinery piston vacuum [5]. One of the most commonly used has the position feedback control valve hydraulic piston as an example to study the parameters of piston will impact the performance of the system. The system can automatically adjust the output

position, until the deviation is zero. Its working principle for as long as the output position of the actuator with a given signal bias [6].

Simulation modeling

Hydraulic system modeling in the Matlab 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[7]. If the hydraulic circuit does not complete, can't go into the next child model mode as followe 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 assembly [8]. Position control system through Matlab software modeling and simulation[9]. Through the above three steps position control system simulation model is established, as shown in Figure 1.

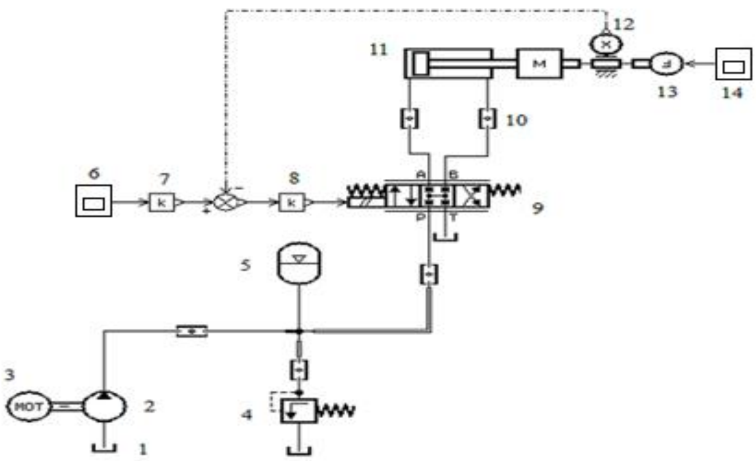

Fig. 1: Simulation model of hydraulic control system

1- Hydraulic tank, 2- Pump, 3- Electrical motor, 4- Flow control valve, 5- Accümülator, 6- Scope1, 7- Reference gain, 8- Error gain, 9- Directional control valve,10- Piston,11- Piston,12- Position transducer,13- Force/velocity transformation block,14- Scope 2

Thus generally study the hydraulic piston influences on performance of hydraulic position control system, so choose can consider fluid compressibility, reynolds number and piston friction HRL03 hydraulic piston submodel, other connected to the fuel tank of hydraulic piston choose DIRECT submodel, the rest of the elements in the system to choose premier submodel.

In parameter values of simulation model of hydraulic control system of main assembly set parameter values are The hydraulic piston diameter is 20 mm, The overflow valve opening pressure is 25 Mpa, Main frequency of three position four-way servo-valve is 75 Hz, rated current of three position four-way servo-valve is 220mA, damping ratio of three position four-way servo-valve is 0.8, The oil density is 995 kg/m^3, The oil bulk modulus is 16500 Mpa, Kinematic viscosity is 0.047 Pa.s, Motor speed is 1200 r/min, Volume of pump is 35 ml/r.

Scope 1 within 0~1s is 0, within 1~4s varying from 0 to 0.6, within 4~6s is 0.8, within 6~10s varying from 0.6 to 0.3 and remain the same; Scope 2 set to a constant 100, through force conversion block hydraulic piston will get a constant resistance that is 110 N; In order to improve the hydraulic lever position measurement accuracy, the position sensor gain is set to 7, In order to ensure that the predictions of the input signal and the actual position of the hydraulic lever changes in the same scope, gain is also set to 7; Preamp gain 8 is set to 360; The piston stroke is 1 m, piston diameter is 10 mm, The hydraulic piston diameter is 30 mm.

Parameters of simulation

The simulation time is 15 s. The sampling period is 0.5 s. The system of performance indicators are the steady state error is less than 0.005 m. Dynamic tracking error is not more than 0.058 m. Start to the simulation.

Piston lengths

Hydraulic piston diameter d is 10 mm in figure 2, figure 3, figure 4 and table 1 respectively hydraulic piston length L is 3 m respectively, 7 m, 10 m, the dynamic error graphic, the hydraulic pole position graphic, hydraulic pistons velocity graphic and hydraulic pistons steady-state error value.

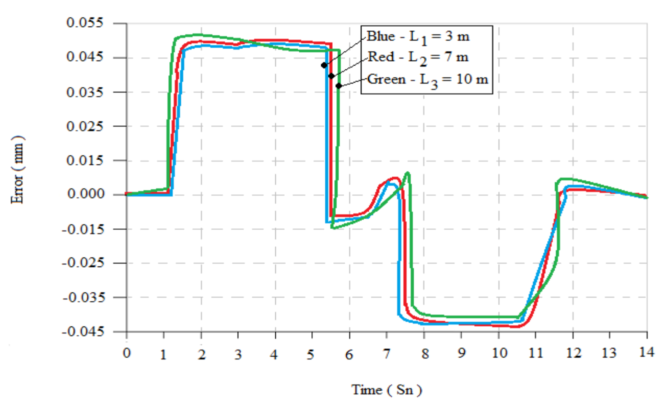

Fig. 2: Error compared to piston lengths

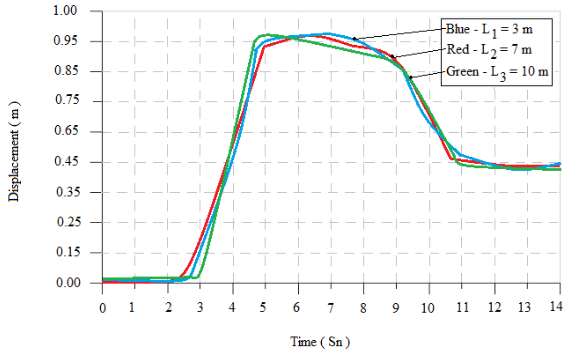

Fig. 3: Position compared to pistons lengths

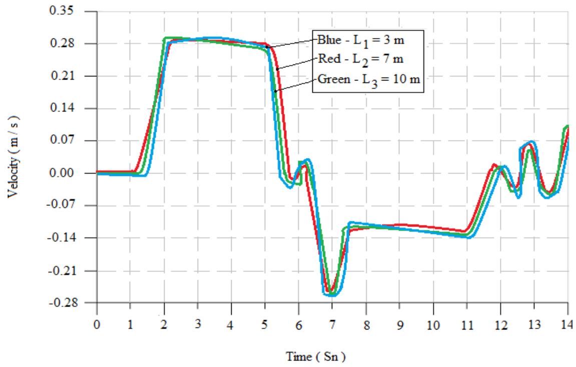

Fig. 4: Velocity compared to piston lengths

Table 1: Gain values of the pistons in different length

Piston Length (m)	Position (m)	Steady state error (m)
3	0.400189	0.000126
7	0.401121	0.001312
10	0.403157	0.005284

Seen from figure 2, the longer the length of piston, the system dynamic tracking error and the greater the tracking error can appear overshoot or vibration, make the hydraulic system is not stable. Through the table 1, the longer the length of piston, the greater the steady-state error of the system. So when designing the system, selecting appropriate piston length L can impact the performance of the all system. In figure 3, 4 seen that even though the increase of the piston length L, hydraulic lever position has a little influence, the velocity of the hydraulic lever has a great influence.

Piston diameters

Between hydraulic pump and hydraulic piston length L chosen to 7 m, choose different diameter d: 10 mm, 20 mm and 30 mm piston to make simulation, we can get figure 5, figure 6 and figure 7 respectively: hydraulic lever position graphic, system dynamic error graphic and hydraulic pistons velocity graphic.

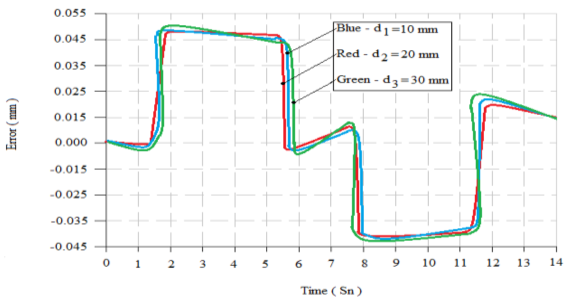

Fig. 5: Error compared to piston dıameters

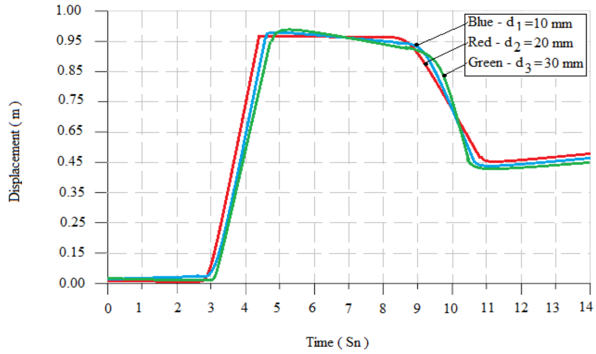

Fig. 6: Position compared to pistons diameters

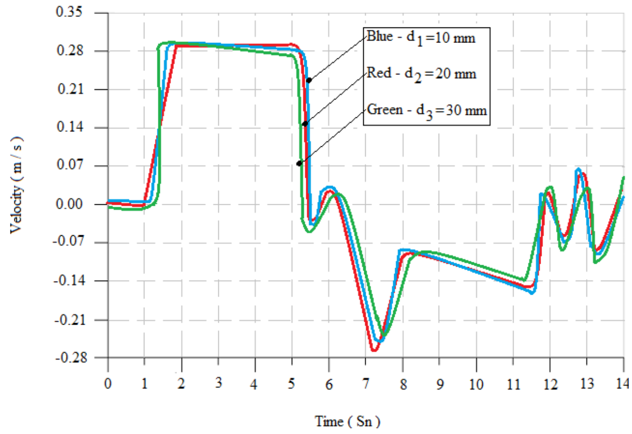

Fig. 7: Velocity compared to piston dıameters

From the figure 5, the bigger the piston diameter d, the greater the dynamic tracking error of system and will lead to the tracking error can appear overshoot or vibration, make the hydraulic system is not stable. From the figure 6, hydraulic lever position has a little influence even though the increase of the piston diameter. From the figure 7, the bigger the piston diameter d, the great influence on the velocity of the hydraulic lever, thus when designing the system, selection of piston diameter d whether it's appropriate can impact the performance of the all system.

Conclusion

Matlab assembly function can make the results of simulation process is simple, under different parameters results contrast more clear. Therefore using Matlab software to modeling and simulation the position control system, the results of simulation image intuitive and easy to understand and not only can rescue the complex mathematical model. In the design of servo hydraulic system must be considered when the effect of hydraulic pistons, so through the study of the simulation analysis of piston, see the parameters of the piston has the obvious effect on hydraulic system.

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