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Experimental and Theoretical Investigation for Electro-hydraulic Servovalve Systems Control

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Abstract:

The control concept on the electro-hydraulic servovalve system focuses on the pressure control, position control and velocity control. The servovalve and the system components are needed to be considered in the proposed control strategy. The control concepts on the electro-hydraulic servovalve systems in this work are divided into two parts:

1. Theoretical and experimental investigation for pressure control on the electro-hydraulic servovalve systems.

The pressure control study in this work is concerned with the modeling and controlling of the hydraulic fluid pressure value at the end of long transmission line (TL) by using the electro-hydraulic servovalve. The input voltage signals to the amplifier, designed by C^{++} program, are used to control the pressure reference signal at the end of TL. The electrical analogy method is used to simulate the effect of the TL, as well as the first order transfer function to simulate the servovalve effect. Therefore, the whole system is represented mathematically in MATLAB *m-file* program. The mathematical model is seen as a good simulation approach compared with the experimental open loop control test. The on-line adjustable control strategy, Ziegler & Nichols method and Astrom & Hagglund method, can be used experimentally to find the proportional and integral control gain values for acceptable control system behavior. The servovalve succeeds to reduce and overcome the negative effect of the TL on the hydraulic fluid pressure value at the chosen control point.

2. Theoretical and experimental investigation for velocity and position control by the electro-hydraulic servovalve system.

The C^{++} language programs are designed to control the position and velocity of the road simulator (single-rod, double acting linear cylinder actuator) with variable load (quarter car suspension system). The whole system is analyzed mathematically and experimentally. The mathematical model of the electro-hydraulic servovalve system is represented and analyzed successfully by designing the SIMULINK program.

The dynamics modeling of the servovalve and the single road cylinder actuator under variable load which are controlled as a closed loop position control method with existence of the actuator internal leakage is done successfully by using the SIMULINK environments. So, the transfer function and the state-space model of the system in open and closed loop control are presented. Also, the Bode diagram is done for the system as well as the stability characteristics are found for the system by the Nyquist Diagram.

The on-line adjustable PID control tuning is employed experimentally to find the best control gain values which are applied to the system. In the mathematical SIMULINK program, the PID gains values are tuned manually and automatically by computing a linear model of the plant. The tuning strategies are done automatically for the P, PI and PID strategies for three different response time values. The comparison figures in the P strategy show that the simulation programs give a good and accurate prediction results and enhance the system behavior. On the other hand, the PI strategy shows incompatible results between the actual test and the simulation program. The PID strategy shows a good prediction results. To analyze the actual fully system behaviors for a large spectrum frequency, the numbers of sinusoidal voltage input signal are used with unity compensator to create actual Bode plot. The tracking closed loop control method is done experimentally by designing C^{++} program and it is done theoretically by the SIMULINK simulation program for the system. The comparison result with the previous research clarifies that the mathematical solution method proposed in this dissertation shows that the prediction of the system behavior is acceptable and improve the system behavior.

Keywords: Electro-hydraulic, Servovalve System**,** PID**,** Ziegler & Nichols method, Pressure control, Position control and velocity control.