SYSTEM MODELING AND CONTROL DESIGN OF A TWO-STAGE METERING POPPET-VALVE SYSTEM

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ABSTRACT

The goal of this work is to develop mathematical models, stability criteria, and control designs for a two-stage poppet valve system with a simple back-side pipeline condition that may be used in a valve stack to create an independent metering function for a hydraulic circuit.

First, this system is modeled as a nonlinear open-loop model as well as a linear one. The completely linear form of the flow force acting on the poppet head is derived from simplified Navier-Stokes Equations. Second, four control methods that comprise modified PI control, LQG control, H_∞ control, and nonlinear feedback control are used to make a closed-loop poppet system. The nonlinear controller is only applied to the nonlinear system and certified by Lyapunov theorem to be globally asymptotically stable. The basic guidelines for selecting control gains are derived by Routh-Hurwitz method. Finally, important system parameters, especially the transient flow force and two leakages, are discussed to reveal their effects on the open-loop system stability. Simulations results illustrate that the closed-loop poppet system with either the modified PI controller or the nonlinear controller can track the desired poppet displacement represented by a sine wave with 10 HZ frequency. The LQG controller and the H_∞ controller having fixed weighting functions or matrices are not flexible enough to satisfy the global nonlinear systems, though they exhibit the acceptable regulation behavior.