Abstract

Proportional solenoid controlled pilot operated two-stage pressure relief valves overcome the problem of chattering and pressure override characteristics associated with single stage pressure relief valve. The use of proportional solenoid driven through a control card as a proportional linear actuator enables precise control of system pressure. In addition to that the electronic drive card of the valve along with PC/microprocessor interfacing makes it possible to implement the valve in hydrostatic transmission (HST) system for closed loop control. Due to such versatile possibilities along with cost effectiveness, these valves are gradually replacing costlier servovalves in several industrial applications like steel mills, plastic industry and earth moving equipments, defence machinery, etc. There are several pragmatic computer aided design approaches to facilitate intelligent controller design without knowing much of the hardware details of the devices. However, when the hardware improvement of the device is concerned, detailed study of the component with modelling through fundamental approach becomes necessary.

The main objective of the present work is to evaluate the valve design and performance with specific reference to its proportional solenoid application through the development of a comprehensive mathematical model from which the steady state as well as the transient state predictions of the valve performance can be made theoretically. The nonlinear transient model is also solved using MATLAB facilities. The model is supported by rigorous experimental results obtained from an indigenously developed test set-up.

The estimation of the flow coefficients of different orifices and flow gates are targeted as a major work. The coefficients are obtained through the use of

experimental results. A rigorous experimental study is aimed to understand the role of intermediate orifices and damping orifice sizes on the valve performance. Other than the damping orifice, it is found that the intermediate orifices affect the transient response of the valve at low voltage range.

An attempt is made, to understand the relationship between the driving force and input current to the solenoid without the knowledge of the design intricacy of the proportional solenoid, which is a sealed unit in the present case. Based on experimental results an empirical relationship between the above-mentioned parameters is proposed.

The sensitivity analysis of the pilot stage main spring is presented using the established mathematical model. The analysis suggests that the scope of increasing the performance of the valve through changing pilot main spring stiffness is limited to a certain command voltage range.

The characteristics of the flow forces involved in both the stages are obtained using the analytical model.

Finally, the transient state model is aimed to develop in such a way that it can be incorporated in the control strategy for real time PC based control of a system. Although, the developed model could not be tested in such a system, the simulation results establish the potential for successful implementation of the model.