

MODELING, SIMULATION AND STABILITY OF A HYDRAULIC LOAD-SENSING PUMP SYSTEM WITH INVESTIGATION OF A HARD NONLINEARITY IN THE PUMP DISPLACEMENT CONTROL SYSTEM

ZACHARY DANIEL WAGNER

ROGER FALES, THESIS SUPERVISOR

ABSTRACT

Certain types of Load-Sensing (LS) pumps utilize a hydro-mechanical control system designed to regulate the pressure difference, or margin pressure, between the inlet and outlet of a flow control valve. With a constant margin pressure, predictable flow control and improved efficiency can be achieved by controlling the orifice area of the flow control valve. Instability due to limit cycles (sustained oscillations) that sometimes stem from nonlinearities within the system is a common issue related to hydraulic LS systems. In this work, the stability of the pressure control system was investigated using describing function analysis. Describing function analysis is a method used to approximate a nonlinearity within a nonlinear system and was conducted to predict the existence and stability of limit cycles that occur due to saturation nonlinearities within the mechanical components of the LS system. A comprehensive nonlinear (NL) model was developed as the foundation for this research as it was used for validation in direct comparison to experimentally acquired data and proved to be precise and accurate in matching to the experimental test bed response. A linearized model was developed based on the NL model as it was necessary for stability analysis using describing functions. The results of the describing function analysis demonstrated an accurate diagnosis of the system stability through three separate scenarios. Each scenario indicated that describing function analysis can be very useful in predicting the stability for a NL hydraulic LS system such as the one presented in this research. Using describing functions a better understanding and characterization of the unstable nature of LS systems can be obtained.