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AIMS AND SCOPE

The *International Journal of Fluid Power* is dedicated to the latest advances in the science and technologies associated with hydraulics and pneumatics. The aim of the journal is to provide the engineering community with high quality information concerning developments in research, design and application of fluid power technology. Special emphasis is placed on papers concerned with components and system integration by embracing key aspects of:

- analysis, modelling and control,
- monitoring and fault diagnosis,
- artificial intelligence applications,
- component and systems design,
- computer software and hardware interfacing,
- computer aided engineering for both static and dynamic analysis of fluid power systems.

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PNEUMATIC ACTUATOR WITH CONSTANT VELOCITY MODE IN RECIPROCATING MOTION

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Abstract

Motion systems with speed control mode are widely used in industry. This paper reports on an open loop pneumatic actuator that provides reciprocating motion with constant velocity mode. Computer simulations of the dynamic behavior of these actuators show their acceptable performance and high robustness. In addition, the estimation method, which allows performing the calculation of the actuator key parameters, is described. Design of the pneumatic actuator for a printing machine has been considered as the practical example.

Keywords: pneumatic actuator, open loop, reciprocating motion, constant velocity, printing machine

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DESIGN AND ANALYSIS OF A TWO-STAGE POPPET VALVE FOR FLOW CONTROL

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Abstract

This paper explores dynamic modelling and design of a typical two stage metering poppet valve system. In particular, nonlinear and linear models of a spring force feedback configuration are developed and parameters tuned through the use of root locus techniques. Typical steady state conditions as well as extreme high and low pressure drops are simulated in attempts to uncover instabilities and other possible undesirable performance characteristics of the valve. Finally the nonlinear model is used to produce Bode magnitude plots at various pressure drops in order to estimate the system bandwidth. Results indicate that increasing the size of the orifice at the inlet of the pilot stage of the valve increases performance in terms of rise time at the cost of a more oscillatory response. High pressure differences between the inlet and outlet of the valve were found to cause performance to increase significantly as well as move poles into a region indicated less damping. A scheme for controlling the inlet orifice area to the pilot stage is presented and shown to improve performance capability (bandwidth) of the valve while maintain a damped response.

Keywords: metering poppet valve, root locus design, valve design

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EXPERIMENTAL IDENTIFICATION OF THE DEAD ZONE IN PROPORTIONAL DIRECTIONAL PNEUMATIC VALVES

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Abstract

This work presents a new methodology for dead zone nonlinearity identification in proportional directional pneumatic valves. It is based on observing the dynamic behaviour of the pressure in the valve gaps. Dead zone is common in hydraulic and pneumatic valves because the spool blocks valve orifices with some overlap, so that for a range of spool positions there is no fluid flow. The dead zone nonlinearity is a key factor that limits both static and dynamic performance in feedback control of fluid power systems. The usual method to cancel the harmful effects of dead zone is to add its fixed inverse function into the controller. This inverse is modelled by a set of parameters that need to be identified. The classic dead zone parameter identification uses expensive flow transducers and special test rig, while our proposed methodology needs only pressure transducers. Experimental results illustrate the efficacy of this methodology that is cheaper and faster.

Keywords: dead zone nonlinearity, pneumatics, proportional directional valves, dead zone identification

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OPTIMAL MODE SWITCHING FOR A HYDRAULIC ACTUATOR CONTROLLED WITH FOUR-VALVE INDEPENDENT METERING CONFIGURATION

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Abstract

A spool valve is a single degree of freedom system that has coupled 'meter in' and 'meter out'. Decoupling of meter in from meter out provides for more controllability and potential for energy saving in overrunning load cases when compared with a conventional spool valve controlled hydraulic system. A four-valve configuration controlling a hydraulic cylinder is emphasized in this paper. The four-valve configuration can operate in several two-valve discrete modes because each of the four valves is controlled separately from the others. Five distinct (or discrete) metering modes that exist in the literature are initially studied: Powered Extension, High Side Regeneration Extension, Low Side Regeneration Extension, Powered Retraction, and Low Side Regeneration retraction. Each of these modes has different force and speed capabilities and the operating mode should consequently be selected based on the load and the commanded speed. Proper switching between these modes is crucial for efficient and productive performance.

The problem of switching between these five modes is treated as an optimal control problem of a switched dynamic system. General theory for the optimal control problem is derived and then applied to the hydraulic system of interest. The results are then interpreted and explained by looking into the force-speed capability of modes, and a closed form solution for the quasi static case is presented.

Keywords: hydraulics, independent metering valves, metering modes, mode capability curve, mode switching

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A NEW EFFICIENCY INDEX FOR ANALYSING AND MINIMIZING ENERGY CONSUMPTION IN PNEUMATIC SYSTEMS

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Abstract

In pneumatic systems the consumption of electrical energy depends almost linearly on the production of compressed air. Hence, the operation of the pneumatic line in any application plant has an enormous effect on the overall energy efficiency. In analysis the compressed air system can be divided into three subsystems: production, after treatment (storage and transmission) and consumption. These systems interact with each other and strongly affect overall system energy requirements. Starting from the dynamical models of the subsystems a new generic energy efficiency index (CA-index) is introduced in the paper. It can be used both in one compressor and multi-compressor systems. The fact that the consumption of compressed air may be either pressure dependent or pressure independent is taken into account in the basic equations and in the energy efficiency index. The maximization of the index is carried out by defining and solving a mathematical optimization problem, which then gives the best possible operation policy of the pneumatic line.

Keywords: compressor, energy efficiency, CA index, pneumatic systems, compressed air, dynamic model, optimization

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