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AIMS AND SCOPE

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

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MODELLING AND CONTROL OF PNEUMATIC VANE MOTORS

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Abstract

There is a broad area of applications where pneumatic vane motors offer unique advantages: high power-to-weight ratio, indifference to overload and stall, cool operation, indifference to dirty or explosive atmospheres. Typically, they are chosen from manufacturers' diagrams such that the torque needed is provided by the motor at the required speed. If necessary, a nozzle is used to reduce speed. Some guidelines have been published about how to design these motors and how to use them in a position control loop, e.g. for robotic applications. This study derives a mathematical model suited to time-domain simulation of the motor, both in an open-loop or closed-loop system. Using geometrical data and the theory of thermodynamic processes the model of an ideal motor is given. In a second step leakage paths and friction are added to describe the behaviour of real motors. This model is implemented in the modelling language Modelica with the help of the domain library PneuLib and used to estimate values for the conductance of the nozzles or the friction terms. Comparisons between the model and measurements are given, both for open-loop and closed-loop operation.

Keywords: reversible pneumatic vane motor, mathematical model, Modelica, PneuLib, PI control, speed control

PROPOSAL OF A NEW BOND-GRAPH METHOD FOR MODELLING PNEUMATIC SYSTEMS

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Abstract

This paper proposes a new bond-graph method for modelling pneumatic systems, which have compressible fluid-flow and thermal fields. In constructing bond-graph models for such systems, fluid and thermal power bonds have been employed. Furthermore, multi-port C and multi-port R elements have been used. Therefore, the resulting bond-graph models become complicated, and it is difficult to understand how energy flows branch off or join together. From these viewpoints, a new bond-graph method for modelling such systems is proposed in the present study by introducing a new concept of effort and flow applied to both compressible fluid-flow and thermal fields. In this bond-graph method, the product of effort and flow is power, which means that the true bond-graph is employed. Furthermore, 1-port C and 1-port R elements are used for modelling. Therefore, the energy flows can be easily understood from the resulting bond-graph. A simulation example is shown to confirm the usefulness of the proposed bond-graph method.

Keywords: pneumatics, compressible fluid-flow field, thermal field, bond-graph method, simulation

AN INVESTIGATION INTO MICRO - AND MACROGEOMETRIC DESIGN OF PISTON/CYLINDER ASSEMBLY OF SWASH PLATE MACHINES

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Abstract

This paper presents main results of an investigation of the tribological system formed by the piston/cylinder assembly of swash plate axial piston machines. Main focus has been given to the influence of a piston macro and micro geometry variation on energy dissipation generated by piston/cylinder assembly. Using the simulation tool *CASPAR*, which has been developed at the institute for Aircraft Systems Engineering, an optimization of the piston shape has been realized to achieve minimum energy dissipation in a wide range of operating parameters of the axial piston machine. Micro geometry stands for surface roughness here. Its influence has been investigated within a second task especially in the area of low speed, where full lubrication is not achievable and therefore mixed friction occurs. For the investigation a special friction force measurement test rig has been developed, which has also been used for verification of the simulation tool *CASPAR*.

Keywords: axial piston machine, piston cylinder assembly, pressure field, friction force, gap flow, surface roughness, friction force measurement

MODELLING OF SPOOL POSITION FEEDBACK SERVOVALVES

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Abstract

Based on a critical review of the previous research and the comprehensive theoretical analysis of all functional parts of two-stage electrohydraulic servovalves with a spool position feedback (a current amplifier, a torque motor, the first and the second stage of hydraulic amplification) a detailed mathematical model of the servovalves was created. The analysis was based on the fundamental laws of electromagnetism, fluid mechanics and general mechanics. The model parameters are physical quantities and the complexity of the model is only limited by the possibility of the correct numerical integration. It includes phenomena and quantities that are of influence on the behaviour of the servovalves, so it can predict their function in a wide range of expected working regimes. Results obtained with the numerical modelling on a personal computer were compared with the appropriate experimental data and the validity of the proposed model was confirmed with satisfactory accuracy.

Keywords: electrohydraulics, spool position feedback servovalves, mathematical model

INVESTIGATION OF FLOW STRUCTURE INSIDE SPOOL VALVE WITH FEM AND PIV METHODS

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Abstract

In this paper, the finite element method (FEM) and particle image velocimetry (PIV) techniques are utilized to obtained the flow field along the inlet passage, chamber, metering port, and outlet passage of a spool valve at several different geometrical dimensions. For numerical simulation, the stream function ψ and vorticity ω forms of continuity and Navier-Stokes equations are employed, and the finite element method is applied to discretize the equations. Self-developed simulation codes are executed to compute the values of the stream function and vorticity at each node in the flow domain. Then, according to the correlation between the stream function and velocity components, the velocity vectors of the entire field are calculated. For particle image velocimetry experiments, a pulse Nd: YAG laser is exploited to generate a laser beam. Convex and concave lenses are combined with each other to produce a 1.5-2 mm thickness laser sheet to illuminate the desired plane. Polystyrene spherical particles with a diameter of 30-50 μm are seeded into the fluid as tracing particles. A Kodak ES1.0 CCD camera is employed to capture the images of interest. The images are processed by FFT cross-correlation algorithm, and the processing results are displayed in the form of velocity vector plots. Numerical simulation results and PIV experiments both show that there are three main areas in the spool valve where vortices are formed. Numerical results also indicate that the valve opening and the chamber dimensions have some effects on the flow structure of the valve. The investigation is helpful for qualitatively analyzing the energy loss, noise generation, and steady state flow forces. It can even help in designing the geometrical structure and flow passage.

Keywords: flow field, spool valve, finite element method (FEM), particle image velocimetry (PIV)