Abstracts

Group 8: Fluid Power Components – Valves

8-0 Actual trends in the design and development of valves and actuator control

C. Boes

The development of motion control technology during the last years has been driven by different requirements from the application markets as increased dynamic performance, low energy consumption, higher power density or easy to use features. The publication shows how the leading companies react on these technical market requirements. This article responds also to the trend towards electric and hybrid motion control systems due to their low energy consumption.

8-1 Design of an Internally Pilot Operated Proportional Valve by Use of the Floating Spool Principle

P. Mejsnar, E. Englberth, G. Schuster

Nowadays, hydraulic systems are an integral part of various machines and equipment, both in stationary and mobile applications. Earth-moving machines like excavators of various sizes and designs use the benefit of hydraulic drives to a great extent.
One possibility to extend operation capabilities of excavators and loaders significantly is the use of a special adapter-head enabling the rotational and swinging movement of the working tool (roto-tilt). The adapter is installed between the excavator arm and the bucket and can be seen as a controllable joint.
Based on this context, the development of a CETOP03 proportional valve with an internal pilot stage is described in this paper. Therefore the boundary conditions have been given due to the application of an excavator rotational-tilting adapter.
During the development phase a Matlab/Simulink model has been built up to enable a better understanding of the valve behaviour. By an example, which occured during the development phase, it will be shown how well measurement and simulation technique complement each other and help to find the solution of side effects in a shorter period of time.

8-2 Compact, Lightweight Valve Actuators with Polymer Gears Using the Harmonic Principle

F. Pöhlau

Traditional electromechanical actuators for fluidic systems (hydraulics, pneumatics, processing technology) use (metallic) spur and planetary gears. The multitude of components of those gears have a negative impact on space, accuracy and cost. Harmonic Drive steel gears have long been known for their precision and power density, also in valve acutators. By employing a flexible gear element, the Flexspline, high precision and high reduction ratios can be achieved in a small envelope with few components and low weight.
Transferring the gear principle into moulded plastics makes it possible to use its advantages also for large series, integrating additional functions in cost-efficient, lightweight components with tight tolerances. Fluidic applications include thermostatic valveheads, but also pumps for very small liquid volumes as in medical devices.
This paper presents the principle, application examples and some research results on improving gear efficiency and durability by varying materials and design.

8-3 Novel piezoelectrical drive mechanism for small valves

R. Tautenhahn, T. Dreher, J. Weber, M. Fuchs

Piezo actuators show several advantageous properties which make them interesting as drives for fluid power components. However, using these actuators poses a technological challenge. In order to use commercially available piezoelectric stack

actuators as drives in small valves, a new piezoelectrical drive mechanism was developed. This paper presents a concept to ensure proper valve operation, independent of manufacturing variations and temperature influences. The tolerance to manufacturing variations is realised by an adjustable design. For the temperature stability a compensation mechanism is shown, which helps suppress the thermally induced deflections. The required miniaturization is achieved by a load-specific design.

8-4 Performance Optimization of a Two-Stage Piezohydraulic Servovalve

D. Sangiah, A. Plummer, C. Bowen

This paper describes the performance optimization of a two stage piezohydraulic servovalve developed for use in aerospace. The valve uses a piezoelectric multilayer actuator in the pilot stage and a conventional main stage spool. The actuator moves a deflector which directs a jet to to create a differential pressure at the pilot control ports which drives the main stage spool. A mechanical feedback wire provides position feedback of the main stage spool to the deflector. The valve has been developed in an attempt to reduce servovalve manufacturing cost.
From a simplified model it can be shown that the maximum spool displacement and the frequency response of the valve are directly influenced by the relative stiffness of the piezoelectric actuator and the feedback wire. In this paper, the model is used to predict this design trade-off and hence optimise the performance of the valve. Two versions of the valve are tested to validate the prediction method.

8-5 Fault Detection and Diagnosis Method for a Process Control Valve

T. Manninen

In this paper is presented a simple fault detection and diagnosis (FDD) method. This model based method is especially suitable for embedded systems because need for computing power is minimal. The static model scheme is utilized to model inherent system nonlinearities in the method. Model is obtained during system normal operation after the explanatory variables are specified. Separate fault learning is not need. The introduced method is applicable for all the systems where feedback control is utilized and some of system's internal variables are measurable.
In this method the faults can be detected through detecting internal variables operation point changes. These operation point changes are consequences of the faults since feedback control tries to compensate them.
Eight typical faults (leakages, friction changes and backlash) for a process control valve were simulated in the process control valve fault simulator and proposed method tested. The results indicate that all the faults can be detected and diagnosed before severe impact to control performance of the system. Some of the faults were tested also in the real process control valve test bench in the laboratory. The results in the real environment are consistent with the simulator results.

8-6 Sensor-Less Position Detection at Electromagnetic Actuators

J. Heinzmann, P. Tappe

In this presentation a new patented procedure is described which allows to detect the armature position of an actuator by means of the variance of a turn-off pulse depending on the stroke point.
In order to generate the turn-off pulse the current flow is interrupted by the coil for a short time as a result of which the magnetic coil generates a voltage pulse in dependence of the coil inductance. The voltage pulse depends on the position of the solenoid armature, so there is a clear connection between the armature position and the time sequence of the turn-off pulse. This temporal change of the voltage reduction can be detected by means of an electronic device. A big advantage of sensor-less position detection is that no electronic device or additional mechanism has to be applied directly at the actuator resp. no loss of installation space will occur. Furthermore this procedure allows the use of the actuator coil as pure sensor coil, the position detection hence may be realized also at a “force-less” armature by the use of short measurement pulses.

8-7 Identification of Critical Operating Conditions for Robust Evolutionary Optimization of Hydraulic Valve Controllers

J. H. Braun, J. Krettek, F. Hoffmann, T. Bertram

The design and optimization of complex technical systems is an important task in engineering and development. Evolutionary hardware-in-the-loop (HIL) optimization constitutes a powerful method as it performs robust search in complex and high dimensional search spaces. The operating conditions severly influence the quality and performance that a solution subject to an HIL evaluation is able to achieve. Thus it is essential to properly control and select these operating conditions in the context of HIL optimization in order to accomplish robust valve performance across a large range of processes and applications. The identification of crucial operating conditions in terms of stimuli, disturbances and external parameters such as hydraulic load and pressure constitutes an optimization task by itself. The approach presented in this paper employs evolutionary optimization to identify test scenarios at the boundaries of the operating envelope under which regulation of the valve position is particular difficult. The parametrization and optimization of these conditions are illustrated and experimental results under realistic valve operation conditions are provided.

8-8 Improving the Performance of an Electro-Hydraulic Load-Sensing Proportional Control Valve

R. Babbone, M. Milani, F. Paltrinieri, L. Montorsi, M. Bartoli

The paper deals with the simulation and the experimental verification of the hydraulic behavior of an electro-hydraulic load-sensing proportional control valve. An innovative CAE methodology, developed combining CFD simulations with lumped and distributed numerical modeling, is firstly introduced and tailored by comparing the numerical results with measurements coming from an experimental campaign performed for a wide range of pressure loads and metered flow rates. Then, both the reliability and the limits of the numerical approach are highlighted through a detailed numerical vs. experimental comparison, involving the pressure of the main hydraulic lines, the flow rate through the first section and the local compensator displacement. Finally, the CAE methodology has been applied for assessing the internal ducts hydraulic permeability and the local compensator spring pre-load influence on the control valve metering curves. At the end of this analysis, an optimized design configuration, featuring a maximum controlled volumetric flow rate increased of more than 25%, has been proposed.