Abstracts

Group E: Control of Fluid Power Systems

E1 Analysis of Adaptive/Learning Control Methods in Cyclic Hydraulic System

M. Herranen, J. Enlund, J. Uusisalo, K. Huhtala

By using hydraulic actuators, it is often problematic to design controller that fulfills good control accuracy and stability in wide operation area. Objective of this paper is to design robust adaptive model-based controller. By combining adaptive control law with MBC (Model-Based Controller), it is possible to achieve good performance under varying conditions. In this study the adaptive control law is attained by using the gain scheduling technique with adaptation mechanism. An environment parameter sensitivity analysis is performed to the MBC system. Also the comparison between two different control strategies, ILC (Iterative Learning Control), and adaptive control with MBC, is done. The comparison examines control accuracy and repeatability of control algorithm. These strategies are studied by means of simulations. The simulations are done with co-simulation between AMESim and Matlab Simulink programs, and the model was verified by the experimental tests. As a result, model-based controller is found to fulfill the tracking requirements. The performance with ILC is still slightly better than with MBC. While tuning of the ILC is easier, the calculation load of the MBC is better. This would affect in timing accuracy of the target system.

E2 Iterativ learning control for an injection unit of a plastic injection moulding machine

D. Dorner, B. Wagner, T. Radermacher, J. Weber

This paper deals with the application of an iterative control structure for the injection cycle of a displacement-controlled industrial injection moulding machine. Conventionally used controllers for mould filling and packing are feedback structures switching between controlling ram velocity and hydraulic pressure. The algorithm presented in this paper uses an iterative feedforward approach for both injection and packing phase together, thus overcoming the difficulties of pressure peaks resulting from the switching action of the controllers. This inversion-based iterative approach uses a nonlinear mathematical model of the injection unit which is used for an error minimization on the basis of a quadratic next-iteration cost criterion.
The application of the algorithm to a machine with a clamping force of 1600kN and injection unit size 650 leads to a significant error reduction with an exponentially decreasing error level. In addition, the algorithm demonstrates a way to recall the maximum dynamic potential of the displacement-controlled hydraulic drive system without reaching the stability limit.

E3 Energy Saving in Injection Molding Machine

S. Ikeo, J. Ogawa, K. Ito

In the field of household appliance, it is required to produce very thin and wide parts (e.g. the thickness is less than 1mm, width is 0.3m and lengh 20mm) by injection molding machine. In order to produce such thin parts, it is necessary to use pressure control even in injection process instead of speed control for the sake of energy saving. In this paper, using simplified experimental setup the energy saving effects of hydraulic drive and electric drive are compared for various conditions in which the length of speed control phase and the pressure control phase are changed. And the advantage of the hydraulic drive is shown for producing such thin parts. Also the advantage is confirmed by numerical simulation.

E4 Miniaturized Control Electronics for a Piezoelectric Minivalve

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

Among the alternative actuation principles piezoelectric actuators have the greatest potential for application in small and miniature valves. Despite their benefits, like low power consumption, good energy efficiency and high mechanical stiffness, piezoactuators typically need a high driving voltage of UPA > 100 V to achieve their maximum stroke and nonlinear characteristics have to be compensated. Available control electronics are usually designed for laboratory demands and are not suitable for application in small valves. Therefore, the development of a specific miniaturized control electronic was necessary to overcome the disadvantages and to achieve complete capability of piezoelectric actuation.
This paper presents a control electronic that consists of a two-stage switching converter and realises the precise proportional charging and discharging of the piezoactuator including energy recuperation. Two control methods for charge control are implemented and validated in the proposed electronic. High linearity, a small hysteresis and great dynamics at low power consumption are achieved.
Furthermore a single stage control electronic for switching applications is presented. This electronic is small sized and shows fast actuation at very low power consumption. It enables the user to operate a piezoelectric valve in the same way as a conventional solenoid valve by applying a supply voltage..

E5 Design of a Modular Hydraulically Driven Variable Geometry Truss Structure and its Nonlinear Controller Architecture for Highly Dexterous Motion

S. Rost, Y. Sklyarenko, F. Schreiber, W. Schumacher

In the paper, a design of novel 3-DOF octahedron-shaped modules for hydraulically actuated variable geometry truss manipulators and its nonlinear control architecture will be introduced. The main features of the design are the optimized multiple collocated spherical joints and a structure-integrated supply of the drive fluid for the hydraulic actuators. Based upon the presented structure, a family of highly maneuverable light-weight hyper-redundant manipulators can be derived.
Furthermore a model-based nonlinear control architecture is introduced for the hydraulically driven manipulator to ensure high control performance all over its workspace, in spite of the pronounced nonlinearities of the hydraulic drives and the structures kinematics. The advantages of the presented control approach are demonstrated by a comparison with well-known control designs for hydraulic drives using a virtual model of the manipulator.

E6 Innovative Control Concepts for Mechanical Stroke Generators with Integrated Overload Protection and Considerable Energy Saving Potential

B. Freissler

Mechanical stroke generators are used in a wide number of industries. One of the most important applications are oscillating displacement pumps.
From the kinematic point of view mechanical stroke generators are a quite discontinuous system when it comes to torque and power. During the execution of a stroke the load differs permanently. Example: Piston-type pumps need a much smaller torque during the suction stroke than during the discharge stroke. It is common practice, that the energy amount required is designed for the maximum load, although it is only necessary during a very short time.
In this report the theoretical basics are shown as well as the development steps of the singular topics. Furthermore, new technological solutions in this sector are presented.

E7 Two Stage Flow Regulation Valve Control Optimization by Software Techniques and Mathematics of Digital Systems Approach

M. Ruggeri, M. Fracassi, M. Martelli, M. Dian

The increased systems complexity and performance request for electro-hydraulic applications, ask for more performing electronic systems and control functions. The new more performing microcontrollers and efficient cross compilers, encourage the floating point mathematics usage in the software control routines, useful to directly reuse the routines generated by the simulation tools, despite the lack of control for precise resulting routine execution time. The paper describes the improvements in performance of a practical experience carried out on an electronic system optimization managing an electro-hydraulic two stage directional valve for vehicular applications. A deeper analysis done on the software side of the application, revealed that a custom firmware setup and local mathematical software impolementation optimizations, led to an optimal system configuration for performance. Here it is shown that, without lack of precision, fixed point mathematics, locally optimized, and a higher attention paid to tasks timing, results in a more performing software schedule executed by the embedded hardware, even if more instructions are executed due to the necessary escaling of factors needed by the requested precision and if and more control tasks are activated.

E8 Analysis of Control Methods for Switching Valve Configurations that Control Die Casting Machines as an Example

I. Schepers, D. Weiler, J. Weber

This article describes how switching valves can be used in the closed loop control. After studying the requirements of die casting machines, the requirements for a new valve with a switching valve configuration will be derived. In the valve configuration four switching valves are connected among each other, which mean one switching valve per metering edge. So the valve configuration differs to the typical digital valves with commonly four or five valves per metering edge. The switching valves in the valve configuration could not be controlled like normal directional valves. To control the switching valves, digital control methods are used. Commonly the pulse width modulation (PWM) is used. Another approach is the optimized pulse modulation (OPM), which is developed for hydraulic switching valves. In this article the switching valve configuration is used as a pilot for a two way directional valve size 63. The pilot will be controlled with the OPM and PWM, which will be compared in detail.