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Special Journal Issue in Memory of:
ROBERT E. KOSKI
(1929-2008)
Founder and Chairman Emeritus, Sun Hydraulics

This special issue of the International Journal of Fluid Power is dedicated to the fond memory of Robert E. Koski, Founder and Chairman Emeritus of Sun Hydraulics.

Robert “Bob” Koski passed away on October 11, 2008, at his home in Sarasota, Florida, USA. He was 79 at the time of his passing.

A graduate of Dartmouth College (Class of '51), Bob moved to Sarasota in 1967 while working for Fluid Controls, Inc., one of the first hydraulic cartridge valve manufacturing companies. In 1970, along with John Allen, Bob founded Sun Hydraulics in Sarasota. Sun has become a multi-national corporation with worldwide operations.

Bob Koski has long been recognized not only as an innovative leader in industry, but is also unanimously known by academia and the entire fluid power community. He is a past Chairman of the National Fluid Power Association and a fellow of the American Society of Mechanical Engineers (ASME). He was instrumental in forming the ASME Fluid Power Systems and Technology Division.

Throughout his life, Bob continuously encouraged education and research in fluid power. He actively pursued the advancement of fluid power in engineering education. He traveled to many international conferences to support fluid power, where he enthusiastically gave invited lectures stressing the importance of higher-level fluid power education. He supported Fluid Power Net International (FPNI) and many of the FPNI initiatives including the International Journal of Fluid Power and the establishment of PhD symposia. The fluid power community will remember the 4th FPNI PhD Symposium held in June 2006, which he generously sponsored.

Recently, Bob worked diligently with ASME to establish an award to “recognize individuals who have advanced the art and practice of fluid power motion and control through education and/or innovation.” ASME established and appropriately named

this award the ASME Robert E. Koski Medal. Very recently, in September 2008, in spite of his progressing illness Bob traveled to Bath, UK to attend the Bath/ASME Symposium on Fluid Power and Motion Control where the inaugural 'ASME Robert E. Koski Medal 2007' was awarded to Dr. Wolfgang Backe and 'ASME Robert E. Koski Medal 2008' was awarded to Dr. Clifford R. Burrows.

While Bob is known to the world for his professional and philanthropic accomplishments, his friends and colleagues remember many other aspects of his life. Bob was an avid golfer and wine enthusiast. In addition to his success as a businessman and manager, he was a skilled engineer in his own right. As a leader, Bob had an exceptional ability to reach out to people regardless of their background and gain their confidence and respect.

Words cannot express Bob's generosity and passion for fluid power. His life's work has left a permanent impression on our community. As the field of fluid power continues to grow, he will forever be remembered as a great colleague, a great friend and an inspiration to all of us.

We will miss you, Bob.

Monika Ivantysynova

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.

In addition, the journal commissions and publishes state-of-the-art reviews on both existing and emerging technologies, and with a philosophy of maintaining scientific rigour and the practical realities of fluid power. The International Editorial Board is composed of leading members of the fluid power community having expertise covering the broad spectrum of fluid power, and all papers are peer reviewed by at least two experts. Technical quality and integrity are considered crucial to the review process. The Associate Editors and the Editorial Board also undertake an active role in ensuring that this is achieved.

Currently, three issues are planned for 2008, but the journal is moving towards quarterly publication.

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Authors wishing to submit a paper for publication should send their manuscript in electronic form to Professor Monika Ivantysynova, Purdue University, Department of Agricultural and Biological Engineering, 225 South University Street, West Lafayette, IN 47907-2093, USA (email: Mivantys@purdue.edu). Detailed notes for authors appear on the inside back cover of the journal.

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EQUIVALENT TIME-INVARIANT MODELLING OF ELECTROHYDRAULIC ACTUATORS WITH APPLICATION TO ROBUST CONTROL SYNTHESIS

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Abstract

An important aspect of robust control development around hydraulic actuators is establishing a set of equivalent linear time-invariant (LTI) models that describe the dynamics of the system over the desired envelope of operation. The nonlinearities inherent in the hydraulic functions must be recast into an equivalent linear form in order to make the robust control problem amenable to solution by linear techniques. This paper develops a simple model-based approach for evaluating equivalent LTI frequency response functions of an electrohydraulic actuator by Fourier transformation of acceptable actuator input-output data. The efficacy of the numerical procedure is compared with two other available methods, namely small-signal analysis and Golubev's least-squares approach. It is shown that the proposed approach can describe large signal effects and at the same time properly characterize the features of the hydraulic actuator frequency response that are important for robust control design, without the need for *a priori* information about the asymptotic behaviour or structure of the equivalent LTI transfer function. The applicability of the proposed numerical technique towards development of practical controllers for fluid power systems is demonstrated by the results of a typical robust control design example for an experimental electrohydraulic positioning system.

Keywords: electrohydraulic actuators, robust control synthesis, equivalent linear time-invariant modelling, frequency response functions, Fourier transformation.

DESIGN ANALYSIS AND CONTROL OF A MAGNETORHEOLOGICAL FLUID BASED TORQUE TRANSFER DEVICE

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Abstract

In this paper, a magnetorheological (MR) torque transfer device is presented. Design, modeling and control aspects are particularly emphasized. MR fluids possess the unique ability to undergo dramatic and nearly completely reversible changes in their rheological properties under the application of a magnetic field. These controllable fluids can serve as quiet, rapid interfaces between electronic controls and mechanical systems. One area of application is to use these fluids as actuators. The MR torque transfer device proposed here can function as either a clutch or a brake. A model providing torque output as a function of magnetic field and rotational speed is proposed and verified experimentally. An acceptable correlation is found between model predictions and clutch performance. A PID controller is designed and experimentally evaluated. In the experimental control setup, the output variables are the position, velocity, and torque at the output shaft and the control input is the electromagnet current. The closed loop performance of the system was studied for torque regulation and torque tracking. Both regulation as well as tracking torque control were successfully achieved with this controller.

Keywords: Magnetorheological (MR) fluid, clutch, control

DEVELOPMENT OF A WATER HYDRAULIC PRESSURE-COMPENSATED FLOW CONTROL VALVE

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Abstract

This paper submits a new design of pressure-compensated flow control valve for water hydraulics. The operating pressure difference range and flowrate range of the developed valve are 1-14 MPa and 2.7-17 l/min, respectively. A pressure-compensator valve and a metering valve are connected in series, placing the former at the upstream side. The major features of the designed valve are that the pressure-compensator valve has two throttles to prevent cavitation, a ring for flow force compensation, and a viscous damper to stabilise the motion of the valve. Valve dimensions were determined based on dynamic and static analysis. Experimental study was carried out for a produced valve. No cavitation noise was observed for operating pressure up to 14 MPa. Mounting the flow force-compensating ring reduced flowrate variation from 8 % to 4 % of reference flowrate, while it increased hysteresis from 0.5 % to 2.5 % of reference flowrate.

Keywords: Water hydraulics, Flow control valve, Pressure compensation, Double throttle, Flow force compensation, Cavitation, Hysteresis

ENHANCED MODEL OF FOUR WAYS VALVES CHARACTERISTICS AND ITS VALIDATION AT LOW TEMPERATURE

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Abstract

This paper deals with the modelling of sliding spool valves that are used in hydraulic actuation systems. A new model of continuity between opened and closed orifice configurations is proposed and validated from -40 to +32 degrees Celsius. It aims at reproducing accurately the experimental pressure gain, flow gain and leakage flow for a wide range of operating temperatures and without a very detailed knowledge of the valve design. The proposed unified model of flow at valve orifices considers the mode of operation (opened or closed orifice) and the flow conditions (laminar or turbulent) with special attention to continuity around the hydraulic null. The leakage flow in closed orifice configuration is modelled with reference to a short orifice instead of a laminar gap between infinite planes. The parameter identification and model validation processes are presented in detail and the results are displayed for an aerospace flight control servovalve.

Keywords: Flow gain, hydraulic, identification, low temperature characteristics, modelling, orifice, pressure gain, servovalve, spool valve

AIR BEARING TESTING

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Abstract

This article provides an overview of experimental air bearing testing at the Politecnico di Torino Department of Mechanics. The types and design features of the air bearings investigated at the Department are illustrated together with the test benches and instrumentation used to determine their performance. Several examples of the experimental results obtained through this work are presented.

Keywords: pneumatics, air bearings, air pads, test bed
