International Journal of Fluid Power

Volume 10
Number 1
March 2009

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 2009, but the journal is moving towards quarterly publication.

International Journal of Fluid Power is abstracted and indexed in: Cambridge Scientific Abstracts, European Environmental Information Database, CEDEFOP-Training Village, Fachinformation Technik, Elsevier Compendex Engineering Information.

International Journal of Fluid Power

ISSN 1439-9776

Volume 10
Number 1
November 2009

CONTENTS

The International Journal of Fluid Power homepage can be found at:
http://journal.fluid-power.net

The Fluid Power Net homepage can be found at:
http://fluidpower.net

The TuTech homepage can be found at:
http://www.tutech.de

Please note:
The International Journal of Fluid Power is now available online. For details please visit the journal homepage: http://journal.fluid-power.net

Submissions
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.

Publication information
International Journal of Fluid Power (ISSN 1439-9776) is moving towards quarterly publication. Currently, three issues are planned for 2009. Annual 2009 subscription 98 € (print or digital version). Subscriptions are automatically extended every year. Cancellation is possible by fax or mail. For an additional version (digital or print) the subscription rate is 49 €. (All prices are with postage and packaging, not including VAT). All subscriptions are payable in advance. Payment may be made by credit card with VISA or Mastercard. Payments with Euro cheque, Dollar cheque or by international bank transfer (all bank fees to customers account) with 13 € handling charge. Issues are sent by standard mail. Further information is available on journal's website http://journal.fluid-power.net.

Orders, claims and product enquiries
Please contact TuTech Innovation GmbH, Harburger Schloßstraße 6-12, 21079 Hamburg, Germany; Phone: +49 40 76629-6555; Fax: +49 40 76629-6559; email: fpni.journal@tutech.de. An order form is also available on the journal's website http://journal.fluid-power.net.

Publishing and production
TuTech Innovation GmbH, Harburger Schloßstraße 6-12, 21079 Hamburg, Germany.

This journal is printed by Schüthedruck GmbH, Hamburg on acid-free paper, which meets the requirement of the ANSI Standard Z39.48-1984 specification for performance of paper and library materials.

ISSN 1439 9776

MODELLING AN ELECTRO-HYDRAULIC POPPET VALVE

Patrick Opdenbosch[1], Nader Sadegh[2], Wayne Book[2], Todd Murray[3], and Roger Yang[3]

[1]Machine Technologies Research, Technology and Solutions Division, Caterpillar Inc., Peoria, IL 61656
[2]The George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, 813 Ferst Dr., Atlanta, GA 30332
[3]HUSCO International, 2239 Pewaukee Rd, Waukesha, WI 53188
opdenbosch_patrick@cat.com, nader.sadegh@me.gatech.edu, wayne.book@me.gatech.edu, todd.murray@huscointl.com, roger.yang@huscointl.com

Abstract

This paper develops the dynamic modelling of a novel two-stage bidirectional poppet valve and proposes a simplified model that is more suitable for control purposes. The dynamic nonlinear mathematical model of this Electro-Hydraulic Poppet Valve (EHPV) is based on the analysis of the interactions among its three internal systems: the mechanical, hydraulic, and electromagnetic system. A discussion on the employed experimental methodology is included along with the validation of this model. When the pressure differential across the valve is sufficiently high and does not vary considerably, the model for this valve can be simplified substantially. More specifically, the EHPV can be modelled as a linear second order system with a static input nonlinearity. This nonlinearity is realized from the valve's steady state characteristics. The advantage of this separation between valve dynamics and nonlinearities is that an inverse linearisation approach (to cancel the nonlinearity) can be used to facilitate the control task for the valve.

Keywords: nonlinear model, proportional control valve, poppet valves, bidirectional valve, flow conductance factor

APPLICATION OF EXTENDED KALMAN FILTER IN A METERING POPPET VALVE SYSTEM

Chang Li and Roger Fales

Rolf Fluid Power Lab
Mechanical and Aerospace Engineering University of Missouri-Columbia Columbia, Missouri 65211
clbk6@mizzou.edu, FalesR@missouri.edu

Abstract

This work focuses on an accurate Extended Kalman Filter (EKF) estimator, which is applied to a forced-feedback metering poppet valve system (FFMPVS). The EKF estimator is used to estimate the position and velocity of the main poppet valve, position and velocity of the pilot poppet valve and pressures within the pilot stage of the valve. The EKF estimator takes advantage of its recursive optimal state estimation to estimate the states of this metering poppet valve by using one pressure signal measurement. The results from the EKF are compared with the simulation results from the model and also compared with the states which can be measured from the physical system set up in the lab. It is shown that the EKF estimator tracks the states accurately for both the steady-state and transient performance. The EKF estimator has robustness to parameter variations. It is shown specifically that the EKF estimator has robustness to an example of model uncertainty, variations in the spring stiffness parameter.

Keywords: Extended Kalman Ffilter, metering poppet valve, robustness

Development of Standard Testing Procedure for Experimentally Determining Inherent Source Pulsation Power Generated by Hydraulic Pump

Eiichi Kojima[1], Toru Yamazaki[1], Kevin Edge[2]

[1] *Department of Mechanical Engineering, Kanagawa University, 3-27-1 Rokkakubashi, Kanagawa-ku, Yokohama, Japan*
[2] *Centre for Power Transmission and Motion Control, University of Bath, Bath BA2 7AY, United Kingdom*
kojime01@kanagawa-u.ac.jp, toru@kanagawa-u.ac.jp, enskae@bath.ac.uk

Abstract

This paper reports on the experimental determination of the level of inherent pulsation power generated by a hydraulic pump, using both a test method newly developed for the measurement of fluid pulsation power in a pipeline and a theoretically derived conversion equation for eliminating the influence of a hydraulic circuit on the measurement. The suitability of the test procedure as a standard method for assessment of the inherent source pulsation power of a hydraulic pump is confirmed.

First, it was determined that the pulsation power in a pipeline can be measured using a pressure sensor unit called the "pulsation intensity probe", which utilizes the same measurement principle as a conventional "sound intensity probe", with good repeatability and with sufficient accuracy for practical usage. Next, a standard test procedure for determining the inherent source pulsation power of a hydraulic pump, which is independent of the hydraulic circuit, from the measurements of a pulsation power in a reference pipe was proposed. Finally, it was verified from the experimental measurements and simulations that this proposed standard test method is very useful for both absolute and relative assessments of the level of source pulsation power of a hydraulic pump.

Keywords: hydraulic pump, fluid-borne vibration, pressure pulsation, pulsation power, standard test method

EXPERIMENTAL INVESTIGATION OF FRICTION FORCE BETWEEN VANE TIP AND CAM-RING IN OIL VANE PUMPS

Mohamed El Ashmawy[1] and Hubertus Murrenhoff[2]

[1]*Suez Canal University, Engineering Science Department, Faculty of Petroleum and Mining Engineering, Suez, Egypt*
[2]*RWTH Aachen University, Institute for Fluid Power Drives and Controls, Steinbachstr. 53, 52074 Aachen, Germany*
arafat_696@yahoo.com, mh@ifas.rwth-aachen.de

Abstract

An experimental investigation was conducted to measure the friction forces between a vane tip and cam-ring in oil vane pumps. The incentive of this work is to study the effect of important parameters on the friction coefficient between a vane tip and cam-ring. Such parameters are relative speed between the vane tip and cam-ring, normal vane force, pressure difference between the two sides of the vane, and coating of the vane tip. A comparison was performed between five different (**P**hysical **V**apor **D**eposition) PVD-coated vane tips and the normal vane without coating. To satisfy such requirements a special test rig was designed and constructed in the lab. The results show that the effect of the vane force and the pressure difference between the two sides of the vane are very small compared to the relative speed. The coating material shows no significant effect on the friction force in vane pumps. Therefore the wear properties of the coating materials should be considered in future studies. For friction measurements in oil vane pumps a simple test rig design with no pressure difference between the two sides of the vane is proposed.

Keywords: vane pump, friction, PVD, hydraulic, power steering, coating

FINITE ELEMENT ANALYSIS OF 3D VISCID PERIODIC WAVE PROPAGATION IN HYDRAULIC SYSTEMS

R. Scheidl, B. Manhartsgruber and M. Mohamed Ez El Din

Johannes Kepler University Linz, Institute of Machine Design and Hydraulic Drives, Altenbergerstr. 69, 4040 Linz, Austria

Abstract

A very compact description of viscid wave propagation in straight transmission lines with a circular cross section in frequency domain by a transcendental transfer matrix is known since several decades. The corresponding research results show that fluid friction is limited to small dynamic boundary layers whereas the remaining fluid domain exhibits practically no friction effect and has bulk flow characteristics. An explanation how this boundary layer transfers its dissipative effect to the bulk flow has been given by Gittler et al. using asymptotic expansion techniques. They found that the effect of the boundary layer on the bulk flow in the centre is given by radial velocity components. The authors have shown that the findings of Gittler et al. are generally valid in the 3D case exploiting matched asymptotic expansions.

In this paper these results are developed further to exploit this dynamical boundary layer theory for an efficient Finite Element (FE) computation of viscid waves. Standard acoustic elements without viscosity as available in many FE codes combined with frequency dependent acoustic boundary conditions can be used to simulate 3D viscid wave propagation in frequency domain. Comparison with the analytical transmission line theory shows the validity and wide applicability of this approach. It is much more efficient than a direct resolution of the viscid boundary layer by a fine FE grid.

Keywords: 3D viscid wave propagation, Finite element analysis, Singular perturbation, Boundary layer theory