Abstracts

Group 7: Fluid Power Components – Pumps

7-0 The Piston Cylinder Assembly in Piston Machines – a long Journey of Discovery

M. Ivantysynova

This paper summarizes the main contributions of researchers and engineers to the discovery of physical phenomena defining the fluid film properties and the operational conditions of the piston cylinder interface in hydrostatic piston machines. The main focus of this paper is the piston cylinder assembly of designs, where the design principal is based on torque generation requiring a large side load of the piston. Since 1965 more than 20 dissertations have been completed on theoretical and/or experimental studies of the piston cylinder interface. Listing all of the papers published worldwide on analysis of piston kinematics and dynamics, modelling and simulation of piston/cylinder interface and experimental studies would exceed the allowable length of this paper. Therefore only major milestones in discovery will be discussed.

7-1 Design of Hydrostatically Balanced Bearings of Radial Piston Pumps by the Use of FE Computation with Interaction of Multibody and EHD Simulation

T. Kentschke

In the actual MOOG R&D projects a new computation software tool was used for the verification of bearing capacity of pre-designed geometries of hydrostatically balanced bearings of radial piston pumps RKP in prototype phase. This software tool combines multibody computation and elasto-hydrodynamic theory (EHD) with a sequenced solution of Newton's Equation of motion and Reynolds Equation of flow. The computation considers both geometrical boundary conditions such as bearing clearance and surface roughness of the contact partners and operational conditions such as relative velocity, forces resulting from pressures, friction coefficients and fluid viscosity. Local deformations of surfaces resulting from multibody computation are directly used as boundary conditions for the solution of the Reynolds Equation of flow. The results of the computation for the bearing geometry are for example the distribution of bearing gap width, the local bearing pressures and, if mixed friction occurs, the local contact pressures. For verification of the software the model of a proven bearing with accordingly substantial knowledge regarding operational and wear behaviour was set up and calculated.

7-2 A Fluid – Structure Interaction model to analyze Axial Balance in External Gear Machines

S. Dhar, A. Vacca, A. Lettini

This paper presents a novel approach for studying the lubricating gap between lateral bushes and spur gears in external gear machines. Pressure compensated lateral bushes are important elements for efficient operation of an external gear pump or motor, being responsible for functions such as sealing the displacement chambers, and limit the local pressure peaks and cavitation associated with the teeth meshing process. Due to the complexity of creating a dynamic model of fluid film lubrication for this kind of machine, efforts thus far have stopped short of analysing the axial balance of the lateral plates and the hydrodynamic squeeze effect of fluid film lubrication has not been considered. The current study describes an original method of modelling the axial balance of the lateral bushes considering full hydrodynamic and elasto-hydrodynamic effects coupled to the motion equation of the bushes. The pressure field in the gap is solved using a finite volume solver of the Reynolds Equation. The fluid flow in the lateral gap is fully coupled with the deformation caused in the lateral bushing, which is solved using a finite volume stress solver. Details of the developed solution for solving this complex Fluid – Structure Interaction problem are reported in the paper, and results are presented for a representative gear machine design.

7-3 An innovative external gear pump for low noise applications

M. Lätzel, D. Schwuchow

The reduction of noise in stationary and mobile applications is becoming more and more important. In this paper a new type of an external gear pump is presented. In order to understand the design features of the pump, first an overview of the relevant sources of noise in an external gear pump is given. Subsequent to that different ways to reduce the noise are shown and finally combined to achieve the new SILENCE PLUS pump. Afterwards results of the new pump are presented, before the paper concludes with an outline which applications will benefit from the new type of pump.

7-4 Noise reduction of hydraulic systems by axial piston pumps with variable reversing valves

T. Nafz, H. Murrenhoff, R. Rudik

Noise reduction is one of the main targets in the development of hydraulic systems. Hereby, hydraulic pumps are often considered to be the leading noise source. The main criteria for noise generation of hydraulic piston pumps are the flow ripple, the pulsating piston force and the pulsating swash plate torque.
Common methods to reduce noise of axial piston pumps are grooves or boreholes to smoothen the reversing process. More recently, pre-compression volumes are used which mainly focus on flow ripple reduction. However, these methods only have the ability to reduce noise and flow ripple significantly in a designed operating range.
Using special reversing valves, a variable approach to reduce noise is investigated in this paper. Hereby, the valve openings can be adapted to the actual operating point of the pump, which is defined by the rotational speed, the pump displacement and the system pressure. Furthermore, this variability allows different control strategies, so that the focus can be shifted between the different noise criteria and optimized for a specific hydraulic system. The required valve openings for different control strategies and operating points were determined by simulation runs and verified by measurements.
Depending on the applied control strategy and the investigated operating point, flow ripple reductions of up to 50% and swash plate torque ripple reductions of up to 70% were measured. Furthermore, different cylinder pressurization slopes are presented along with the resulting pump noise. Depending on the operating point, sound power level of the pump itself can be reduced by up to 2dBA compared to a highly optimized standard pump.

7-5 Analysis of the Flow Conditions in a Dosing Pump with Regard to New Fuels

M. Petzold, J. Weber, E. Dautry, O. Ohligschläger, A. Müller

Conveying new fuels with a high proportion of ethanol leads to an increased cavitation tendency inside a pump. This paper presents investigations of the flow conditions in a dosing pump using Computational Fluid Dynamics (CFD). For accurate spatial resolution of fluid mechanical details, a three-dimensional computational analysis of fluid-structure interaction in the outlet valve is surveyed. Comparisons are made by experimental testing. Noteworthy is a technique based on a laser Doppler vibrometer for examining the dynamics of the piston inside the fluid. The applied CFD cavitation model is parameterized and validated by experimental (optical imaging) and numerical investigations of the cavitating flow in an orifice flow. The objective of the developed method is to identify and reduce the potential locations for cavitation in order to ameliorate the high level of delivery accuracy.

7-6 Radial Piston Engine with Cone Valve Plates

J. Berbuer, D. Schulze Schencking

The Radial Piston Unit with Axial Cone Valve Plate (RAC) is a new type of hydraulic displacement unit, generated by the recombination of established and well controllable functioning principles. It uses a tilted piston design that enables direct torque generation in the cylinder star without inducing transverse forces on the piston. Moreover, the entire rotational group is hydrostatically supported and as a result no hydraulic forces act on the shaft and the shaft bearings.

7-7 A hydraulic transformer with a swash block control around three axis of rotation

P. Achten, T. van den Brink

A new design of a hydraulic transformer is presented. The design combines the floating cup principle and the three-port hydraulic transformer concept of Innas. The design resembles the design of the variable displacement, floating cup pump. An important difference is the bearing of the swash block. In the variable displacement pump, the swash block has a cylindrical bearing, and has only one degree of freedom. In the new transformer design, the swash block is supported by a spherical bearing, which results in three rotational degrees of freedom.
This paper describes the fundamental design principle of the new 'Oiler' transformer, its design constraints and the most important design solutions. The new design allows an unlimited control range of the hydraulic transformer, combined with large, unrestricted oil passages for all operating conditions.

7-8 Dosing pumps - revisited

V. Peters, O. Ohligschläger, A. Müller

Initially used for auxiliary parking heaters for mobile automotive systems, the range of applications for electromagnetically driven dosing pumps has been widely enlarged during the past few years. Whereas originally only diesel fuel had to be delivered, nowadays all kinds of liquid media have to be pumped. These, diesel and petrol fuels and a lot of additives, require verification and improvement of the design for optimal usage and low energy consumption. Thus, the dosing pump has been improved to efficiently deliver and admeasure more or less any kind of liquid media. One of the most innovative operational areas of such compact metering units is the fuel cell reformer technology, wherein a constant flow of a certain amount of fluid is required.
This contribution is concerned with the principal design of such pumps, functioning, potential of accuracy and lastly with some specific features (valve function, dry run behaviour and self-priming potential) as well as the potential for optimization (installation space, part reduction).