Abstracts

Group D: Fundamentals and Simulation

D1 Analysis and Emulation of Actuating Forces on Wind Turbine Pitch Drives

F. E. Gonzalez, V. J. De Negri, J. M. C. Soares

This paper presents the study and modeling of the actuating forces at pitch control systems of wind turbines as well as the development of a loading emulation system as part of a test rig for experimental evaluation of pitch control systems. The force modeling presented is based on the wind blade geometry, which is one of the parameters of greatest influence in the actuating force magnitude. Consequently, the Blade Element Momentum theory (BEM) and the equations that model friction, gravitational, inertial, and wind resulting dynamic forces are took into account. The hardware in the loop simulation technique (HIL) is being applied where the actuating force is calculated by a real-time software considering several parameters such as wind speed, blade geometry, pitch angle, etc. A hydraulic force control system consisting of a hydraulic cylinder controlled by two high response proportional pressure reducing valves tracking the force reference signal is presented. This test rig emulates forces in agreement to turbines up to 700 kW but the study presented in this paper can be used for the design of pitch drivers in general.

D2 Dynamic Analysis of a Hydraulic Drive for a Lifting Bridge

U. Grätz, J. Garret

Large applications in field of hydraulic steel construction are mostly driven by oil hydraulic systems. Especially in case of bascule bridges the small required space for hydraulic cylinders is an advantage of this technology. Because of the influence of such kind of civil engineering products to minimum two crossing traffic flows there are increasing requirements to fulfill limited opening and closing times. Connected to this the acceleration during start and stop procedures becomes higher. The dynamic behavior and properties of the hydraulic drive connected to the mechanical system is more and more important. Owner and manufacturer of such kind of bridges are interested to see the required and convenient behavior before realization. This presentation shows the complete process beginning with the task, derivated from the requirements of the bridge designer, the development of system and component level models and the results leading in some hints for circuit design. Very helpful for the solution is the possibility to consider hydraulic system models connected to 3D mechanics.

D3 New Plain Bearing Concept for Support of the Propeller Shaft in Pod-Drives of Large Ships

S. Gold, J. Weber

A new concept for drive-end bearings in pod-drives is presented. As roller bearings fail ahead of time, a dependable alternative for them is in demand. So the project aims at the combination of the hydrostatic with the hydrodynamic plain bearing principle in order to exploit their advantages. In addition to the requirement of high load-carrying capacity and reliability, good emergency operating features are needed. The paper describes the approach to develop the new bearing concept by means of numerical simulations as well as experimental investigations at a true-to-scale bearing test rig. New calculation methods were necessary to compute a combined hydrostatic/ hydrodynamic bearing flow. The simulation models are evaluated by test results.

D4 Innovative Hydraulic Cylinder Concept for Cold Regions with a Piston from frozen Water

M. Kötteritzsch, W. Hagemeister, H. Gernandt

A method to create sustainable support for general assemblies under arctic conditions is presented in this paper. A plunger cylinder is used to generate an ice piston out of frozen water using a repeating sequence of heating, raising and cooling. Laboratory testing by means of a physical model has been performed. Providing new insights in this area of research, the results are presented in terms of feasibility and controllability.

D5 Trajectories of Solid and Gaseous Particles in a Hydraulic Reservoir

V. Tic, D. Lovrec

Contaminants of hydraulic fluid are broadly defined as any substance that impairs the proper functioning of the fluid. Hydraulic fluid can be contaminated by air, particles, water, and foreign fluids. Fluid contamination can cause numerous problems in a hydraulic oil system including component damage, unacceptable noise, poor component response and severe fluid degradation. The paper is focused on two major contaminants which should be considered when designing a hydraulic reservoir: air and particle contamination. Proper reservoir design can prevent the occurrence and help solve solid and air contamination in hydraulic fluid. Hydraulic reservoir should be designed in such a way to stabilize and direct the oil flow, so the oil has enough time to extract air bubbles and solid particles from the fluid. To see and understand flow patterns inside the reservoir, the advantage of using simulation techniques in the field of reservoir design will be explained. The paper investigates trajectories of solid and gaseous particles in an hydraulic reservoir. Research is based on transient simulation using Ansys Workbench. Results obtained focuses on sedimentation of solid particles and elimination of gaseous particles in a hydraulic reservoir.

D6 CFD Simulation and Optimization of Hydraulic ON/OFF Valve for Small Volume Flow

M. Simic, N. Herakovic

High response on/off hydraulic valves with small volume flow represents in combination with digital control technique a promising approach to get higher dynamics of hydraulic drives. One of the development stages presented in the paper is CFD (Computational Fluid Dynamics) simulation and optimization of an on/off valve geometry in order to achieve the proper fluid forces in closing position and minimal fluid forces acting on the moving valve needle in the opening position independent on the needle displacement. The first part of the paper presents the theoretical determination of the influence geometry parameters. The second part of the paper includes CFD simulation and optimization method according to the predefined influence parameters. The compensated on/of hydraulic valve geometry is presented at the end as the dependence of the resultant axial fluid force on valve geometry and needle displacement.

D7 Cylinder Block / Valve Plate Interface – a Novel Approach to Predict Thermal Surface Loads

M. Zecchi, M. Ivantysynova

In this paper a novel simulation model for the cylinder block / valve plate interface is described. For the first time, precise estimations of thermal and elasto-hydrodynamic effects are fully coupled together in order to have an accurate description of the fluid film thickness as a function of the main operation parameters. A comparison between simulation predictions and actual measurements of the valve plate surface temperature of a 100 cc unit is presented for different operative conditions. Cylinder block, valve plate and end case body temperature and thermal deformations are also shown, explaining their impact on the fluid film and the interface performance.

D8 Efficiency Improvement by Air Recuperation through the Use of Ejectors

C. v. Grabe, H. Murrenhoff

Pneumatic systems are very common in industrial automation, because they feature good dynamic properties as well as a simple and flexible system setup. The main disadvantage of pneumatics compared to electrical systems is the effort required to achieve the same level of energy efficiency. Air recuperation to increase the efficiency of pneumatic systems usually requires a complex system setup, thus diminishing the advantage of pneumatics. In scope of this paper a newly developed system design is presented, which allows operating pneumatic systems in a virtually closed loop circuit. Thereby a complex circuitry is avoided and a flexible system layout with all its benefits is preserved. An optimization of the ejector which is used to recharge the closed loop circuit is presented. Furthermore, the potential energy savings of the new system design are approximated.

D9 Research on Distribution Method With Check Valve of Axial Piston Pump

Z. Junhui, Y. Huayong, X. Bing

The development of axial piston pump more and more focuses on efficiency and noise emission. Noise reduction in axial piston pumps has been attempted by many researchers with different design approaches and techniques. But most traditional structures on valve plate for noise reduction is at the cost of efficiency to different extent. In this paper, a new distribution method with pressure equalization mechanism is proposed, and analyzed in details. The analysis shows that the natural frequency of check valve and the size of PRC are vital for the pressure equalization mechanism. Compared with present commercial axial piston pump, the results indicate that with the pressure equalization mechanism composed of check valve and pressure recuperation chamber the flow ripple and the torque pulsation is sharply reduced. Moreover, the volumetric and mechanical efficiency of axial piston pump is improved, and because the mean value of torque on swash plate is reduced by more than 60%, the power of variable-displacement control mechanism will be reduced and the control accuracy can be improved easily. Therefore, the pressure equalization mechanism is quite promising in the design of high-performance axial piston pump with low noise level.

D10 Experimental and Theoretical Studies of the Displacement and Bending of a Hydrodynamic Supported Idle Spindle of a Three- Spindle Screw Pump

J. Thurner, P. Pelz, F. Holz

The displacement and elastic bending of a hydrodynamic supported idle screw of a 3- spindle screw pump is measured by a set of inductive sensors with a resolution of less than a micro meter. The thus gained experimental results serve to validate a coupled fluid and structure model (FSI) of the pump developed by the authors. The idle screw is modeled as a Bernoulli beam interacting with a hydrodynamic lubrication film. The research task is to predict the operation limit of the screw pump. In fact that research task is nearly reached by our approach.

D11 Rapid Parameterisation of a Sealing Friction Model for Hydraulic Cylinders

M. Kühnlein, H. Murrenhoff, R. v. Dombrowski, et al

This paper presents experimental results of a sealing friction test rig for different cylinder sizes, sealing types, pressure conditions, and load cases. The test rig, the test procedure, test parameters, and measurement results are shown. Based on the obtained measurements a physically based sealing friction model is set-up which accounts for the investigated parameter variations. The friction model and the respective parameters are given. In the last part of the paper the developed sealing friction model is compared to measured results for various parameter sets. The presented model is appropriate to consider sealing friction for hydraulic cylinders. From an engineering point of view the major advantage is the instant accessibility of all required parameters to fit the model for the specific case.

D12 Friction Investigations in a Water Hydraulic Cylinder

F. Majdic, J. Rezdirnik, M. Kalin

Environmental protection regulations are becoming increasingly strict. Using water instead of a hydraulic mineral oil in power-control hydraulic systems we can make a very positive step in complying with these regulations. In this paper we present measurement results of a water hydraulic cylinder on a newly developed water hydraulic test rig. The new water hydraulic cylinder (specimen) was simulated, constructed and tested. This construction was such that we could simply exchange its sealings and/or guiding to investigate the tribological and hydraulic behaviour of the sliding contacts. Combinations of two different types of special, serial produced sealings for the water hydraulics cylinder were first simulated, tested and then compared. Some important results about the dynamic responses of the water hydraulic system at different combinations of sealings, different combinations of the assembled water cylinder, different loads and positions of the hydraulic cylinder rod, different inlet pressures and different inlet flows are presented and compared. The results show significant differences between the different sealings in the water hydraulic cylinder.

D13 Numerical Simulation of Transient Characteristics of Water Hammer before Proportional Directional Valve of Ship Steering System

Y. Qiu, B. Li, G. Yang

With the development of hydraulic technology, hydraulic steering gears have been widely used on the ship. However, the fluid-borne noise of hydraulic steering gear system is one of its fatal flaws, which not only affects working and resting environment of the crew, but also lead to various accidents. Water hammer which is caused by opening or closing the proportional directional valve abruptly is a vital noise source in the ship steering system, so reducing the effect of water hammer is important to improve work environment and the performance of the ship steering system. The wave equations of non-constant flowing of the pipeline of the ship steering system were established in the paper. The numerical simulate of the transient characteristics of water hammer which was caused by closing the proportional directional valve abruptly was done by the method of characteristics and finite difference method ((MOC-FDM) using Fortran language. The simulation took into account not only the steady-state friction loss of the pipeline, but also the dynamic friction loss of the pipeline. The effects of reducing water hammer by using the single accumulator and multi-accumulator with different inflation pressures and nominal volumes were compared in the paper, too. The results show that the capacity to reduce the water hammer or hydraulic shock is related to the nature frequency and the ratio of damping of the system.

D14 Multi-Threaded Real-Time Simulations of Fluid Power Systems Using Transmission Line Elements

R. Braun, R. Krus

The demand for large-scale real-time simulations of fluid power systems is increasing, due to growing demands for added functionality. Real-time simulations can be used in for example hardware-in-the-loop experiments and embedded control systems. In order to achieve real-time performance, it is often necessary to use small or simplified models, reducing the usefulness and accuracy of the results. This article proposes the use of transmission line modelling (TLM) for exploiting multi-core hardware in real-time and embedded systems. The characteristics of the TLM method are analysed to identify difficulties and possibilities. A method for how to parallelise TLM models is then presented. Subsequently, a programming interface for implementing the parallel models in the target systems is introduced. Practical experiments show that the approach works and that the method is applicable. So far, however, it has required great effort on the part of the engineer, both when it comes to programming, compiling and importing the model into the target environments, although some attempts to automate the procedure have been successful, reducing the level of complexity.

D15 Fundamentals of Digital Microhydraulics

M. Linjama

Digital hydraulic valve systems have been studied much during the last decade. Typical approach is to use 4-9 on/off valves in parallel and to adjust the volume flows of the valves according to powers of two. This paper discusses an alternative approach in which a big number of miniaturized on/off valves are used. Analysis show that the approach have a lot of benefits. The main challenge is the requirement for small and low-cost on/off valves.