CONFERENCE PROGRAMME MONDAY, 19TH OF MARCH

08:45 OPENING BY PROF. MURRENHOFF [CR 2]

09:15

CR 2	CR 4/5	CR 7/8/9
GROUP A Mobile Applications	GROUP B Energy Management	

10:45 [BREAK]

11:15

GROUP C SYSTEMS	GROUP D DESIGN PROCESS	GROUP E COMPONENTS

13:00 [LUNCH CR 1]

Opening Scientific Poster Session

14:00

GROUP F MOBILE APPLICATIONS	GROUP G TRIBOLOGY & FLUIDS	GROUP H PNEUMATICS

15:45 [BREAK]

16:15

GROUP I NEW APPLICATIONS	GROUP J TRIBOLOGY & FLUIDS	

18:00 [BREAK]

18:30 OPENING EVENT AT EXHIBITION

Shuttle to IFAS

Shuttle to IFAS

Scientific Poster Session

CONFERENCE PROGRAMME TUESDAY, 20TH OF MARCH

09:00 OPENING ADDRESS [EH]

09:30 PLENARY LECTURES [EH]

10:30 [BREAK / EXHIBITION]

11:00

EH	BH
GROUP 1 DIGITAL., CONNECT. & COM.	GROUP 2 COMPONENTS

12:30 [LUNCH CR 1/2]

13:30

GROUP 3 INDUSTRIAL APPLICATIONS	GROUP 4 MOBILE APPLICATIONS

15:00 [BREAK / EXHIBITION]

15:30

GROUP 5 ENERGY MANAGEMENT	GROUP 6 COMPONENTS

17:00 [BREAK / EXHIBITION]

17:15 PLENARY LECTURE

17:45 BREAK/ EXHIBITION

19:00 CONFERENCE BANQUET

22:00 AFTERSHOW PARTY

Shuttle to IFAS

Shuttle to IFAS

Exhibition & Scientific Poster Session

CONFERENCE PROGRAMME WEDNESDAY, 21ST OF MARCH

EH	BH	CR 4/5

09:00

GROUP 7 SYSTEMS	GROUP 8 TRIBOLOGY & FLUIDS	GROUP 9 COMPONENTS

10:30 [BREAK / EXHIBITION]

11:00

GROUP 10 DIGITAL., CONNECT. & COM.	GROUP 11 PNEUMATICS	GROUP 12 COMPONENTS

12:30 [LUNCH CR 1/2]

13:30

GROUP 13 DESIGN PROCESS	GROUP 14 PNEUMATICS	GROUP 15 COMPONENTS

15:00 [BREAK / EXHIBITION]

15:30

GROUP 16 SYSTEMS	GROUP 17 MOBILE APPLICATIONS	

17:00 [BREAK, AFTERWARDS WITH ALUMNI & GUESTS]

17:15 ANNIVERSARY LECTURES

18:30 WALK / SHUTTLE TO DEPOT

19:00 ANNIVERSARY PARTY (DEPOT)

Shuttle to IFAS

Shuttle to IFAS

Exhibition & Scientific Poster Session

CONFERENCE

SYMPOSIUM
Monday, 08:45 a.m. - 06:00 p.m.

OPENING

CR 2
8:45 - 9:15 a.m.

By Univ.-Prof. Dr.-Ing. H. Murrenhoff
Head of IFAS
RWTH Aachen University
Germany

NOTES

CONFERENCE PROGRAMME MONDAY, 19TH OF MARCH

GROUP A: MOBILE APPLICATIONS

CR 2
9:15 -10:45 a.m.

CHAIR Univ.-Prof. Dr.-Ing. H. Murrenhoff
RWTH Aachen University
Germany

Presenter Nicolas Brötz — 09:15 - 09:35

TU Darmstadt
Germany

Topic Integrated Fluid Dynamic Vibration Absorber for Mobile Applications

The setup of a suspension always leads to a compromise between comfort and safety. In order to counteract this in a passive approach, one could attach a structural extension in the form of a dynamic vibration absorber to the axle. Thus, energy of the wheel vibrations is diverted into the vibration absorber instead of the body. In comparison to a classic dynamic vibration absorber, which is not in the sense of lightweight construction due to the additional mass, our Fluid Dynamic Vibration Absorber (FDVA) reduces the dynamic mass by using a hydrostatic transmission.

Keywords: dynamic vibration absorber, driving safety, suspension strut, hydraulic transmission

Presenter Jun.-Prof. Ajit Kumar — 09:55 - 10:15

Indian Institute of Technology
India

Topic Performance Investigation of a Hydro-pneumatic type Accumulator used in a Hydrostatic Drive System of Off-road Vehicles

The performance characteristics of a hydro-pneumatic type accumulator on the responses of the hydrostatic drive system are studied in this article. The physical system considered for the analysis consists of fixed displacement pump, hydro-motor coupled with a loading unit and an accumulator. By varying the capacity and precharge pressure of the hydraulic accumulator and load torque on the hydro-motor, the performance behaviour of the accumulator is determined. In MATLAB/Simulink® environment, the simulation studies are made. By comparing the simulation results with the test data, the model is validated. The studies made in this article may be useful for the proper selection of accumulators in typical mining equipment.

Keywords: Hydro-pneumatic type accumulator, MATLAB/Simulink® environment, performance characteristics, hydrostatic drive

Presenter Jun.-Prof. Jörg Edler — 09:35 - 09:55

Techn. Universität Graz
Austria

Topic A new Approach on a Hydrostatic Motor for Applications in Mobile Cranes

Mobile hydraulic linear actuators are a fixed part of many applications. Especially in mobile cranes, they are used for the movement of the booms and are characterized with a light power to weight ratio. The kinematics can be seen as a restriction of linear motor in mobile cranes. On one side the possible range of the motion and on the other side the unfavourable constellations of the triangle of force are essentially restrictions in the construction of mobile cranes. For the avoidance of these restrictions exists approaches by in the joints arranged hydrostatic rotational motors. At present these solutions fails by a to high weight to force ratio, or they give no benefit in the kinematics. In this article, a new approach of a hydrostatic rotational motor will be presented, which is characterized by low weight and high torque. By the possibility to rotate endless these rotation hydrostatic motors are predestined as a direct drive in the joints of mobile cranes, to get new possibilities...

Keywords: mobile cranes, hydrostatic rotary motor

Presenter Dr. Min Cheng — 10:15 - 10:35

Chongqing University
China

Topic Active damping improvement of the electrohydraulic control system with dual actuators for mobile machinery

Low damping property of hydraulic systems has been a remarkably troublesome issue for a few decades. The poor damping with two actuators or more is still intractable and pendent due to the complex coupling effect of different loads. A decoupling compensator based on pump/valve combined control is proposed for the system with dual actuators for mobile machinery. Using decoupling control of different load branches, the coupling hydraulic circuit with dual cylinders is transformed into two separate single-cylinder circuits with dynamic compensation. Compound motion tests on a 2-ton hydraulic excavator were carried out. The results indicated that the proposed compensator reduced velocity and pressure oscillations under different working conditions.

Keywords: Decoupling compensation; Damping control; hydraulic system; mobile machinery

GROUP B: ENERGY MANAGEMENT

CR 4/5
9:15 - 10:45 a.m.

CHAIR Prof. Viktor Sverbilov
Samara National Research University
Russian Federation

Presenter Dr. Bin Yu
Yanshan University
China
09:15 - 09:35

Topic Accurate Control Method of Vane Direction Based on Pressure Difference Feedback in Active Yaw System for Wind Turbines

In this paper, an active yaw system with valve-controlled hydraulic motor is designed. Correspondingly, the accurate control method of vane direction based on pressure difference feedback is presented. Then the simulation analysis is conducted in AMESim. The simulation results show that the control method presented in this paper is efficient. Moreover, the control accuracy can be improved by decreasing the friction torque or adding a friction compensation link into the controller. At last, an experimental platform is built to verify the feasibility of the control method presented. The achievements provide theoretical and practical guidance for the design of wind turbine active hydraulic yaw systems.

Keywords: Wind turbines, active yaw, differential pressure feedback, accurate control method of vane direction

Presenter Jun.-Prof. Niranjan Kumar
Indian Institute of Technology
India
09:35 - 09:55

Topic Electrical Energy Regeneration of Hydraulic-Split Power Transmission System Using Fuel Efficient Controller

This article presents an innovative technology of energy management for a conventional hydrostatic-split power transmission (CH-SPT) system used in front end loader (FEL). A fuel efficient controller and a DC generator are additionally connected in parallel with the load shaft of the drive to prevent the engine and the major hydraulic components from over-loading or under-loading conditions. Detailed simulation model of the system, so called Regenerative Hydrostatic-Split Power Transmission (RH-SPT) system is made in the MATLAB®/Simscape environment. The performance analysis and the fuel consumption of the RH-SPT drive is compared with that of the CH-SPT drive through simulation. It is observed that with increase in 10% fuel consumption, the electric power regeneration through the DC generator increases by 21% of maximum power generated in CH-SPT drive.

Keywords: Fuel consumption, Energy Management, Energy Regeneration, Regenerative Hydraulic-Split Power Transmission Drive

Presenter Linart Shabi
TU Dresden
Germany
09:55 - 10:15

Topic Investigation of Potentials of Different Cooling System Structures for Machine Tool

In the current cooling system structure of machine tools is a central fixed pump provides a constant cooling volume flow to cool all the components of the machine tool. The provided cooling volume flow does not match the temperature development of each component. This may lead to some of the components heating up while the other components are simultaneously being cooled. Due to these temperature differences, a thermo-elastic deformation of the machine structure occurs. This deformation is responsible for the displacement of the Tool Centre Point (TCP) of the machine tools. Consequently, the machine's accuracy during the production process is reduced. The main goal of this paper is to analyse the thermal behaviour of the current cooling system structure of two demonstration machines and to present a simulative study of new cooling system structures under consideration. The investigation of this research will examine the effectivity...

Keywords: machine tool, thermo-elastic deformation, cooling system, energy consumption, decentralized system

Presenter Dr. Chong Liu
RWTH Aachen University
Germany
10:15 - 10:35

Topic An energy efficiency evaluation method based on least squares combination weighted in refrigeration system

A new energy efficiency evaluation method, based on least squares combination weight (LSCW), is proposed in this paper. Furthermore, the method is based on the thorough analysis of Fuzzy Analytic Hierarchy Process (FAHP) and Information Entropy (IE). Because of the multi-parameter characteristic of the ammonia refrigeration system, some critical parameters are firstly selected with the help of detailed simulation. Subsequently, a new two-dimension matrix constructed by these parameters is designed. According to the actual working system, compared with the FAHP and IE, results show that the new method has better precision, smaller relative error and greater consistence with actual energy efficiency change.

Keywords: Energy efficiency evaluation, Two-dimension matrix, Combination weight, Relative error

NOTES

GROUP C: SYSTEMS

CHAIR Prof. Andrea Vacca
Purdue University
United States of America

CR 2
11:15 a.m.- 1:00 p.m.

Presenter Dr. Tatiana Minav 11:15 - 11:35
Aalto University
Finland

Topic Adaptive Control for direct-driven hydraulic drive

Energy efficient and environment conscious solutions are currently in high demand. This paper illustrates the potential of pump-controlled actuators such as directly driven hydraulic drives (DDH) for various zonal hydraulics applications. A novel pump-controlled actuator, powered directly by a servo motor is considered for industrial and mobile applications replacing conventional valve-controlled hydraulics. This solution is targeting improvements in energy efficiency, especially for continuous operation systems, however, due to the nature of the solution, system response has high dependency on electric motor dynamics. Therefore, adaptive controller is designed to realise benefits of the DDH. Study presents results of performance by simulation of this new concept.

Keywords: Fluid power networks, electro-hydrostatic drive, adaptive controller, zonal hydraulics

Presenter Dr. Alexander Mitov 11:35 - 11:55
Technical University of Sofia
Bulgaria

Topic Identification and synthesis of linear-quadratic regulator for digital control of electrohydraulic steering system

The paper presents an optimal reference tracking algorithm for electrohydraulic steering systems which is based on multivariable system identification, linear quadratic control and Kalman filtering for state estimation. A laboratory test-bench composed of electrohydraulic-steering unit (EHSU), steering cylinder, 32-bit microcontroller, steering wheel and joystick supports experimental work. Traditional approach for reference tracking in steering usually is based on classical control algorithms such digital PI regulator or non-digital hydromechanical feedback. In contrast the control theory suggests advanced control techniques, which can take into account multivariable nature of the process. In this way a higher closed-loop performance can be achieved.

Keywords: Multivariable identification, linear-quadratic regulator, Kalman filter, electrohydraulic steering system

Presenter Jan Siebert 11:55 - 12:15
Marco Wydra Karlsruher
Institut für Technologie (KIT)
Germany

Topic Development and Implementation of a Control and Regulation Concept for a Hydraulic Load Unit

Functionality and performance of novel hydraulic systems under real life stress can usually be examined in field tests only. In order to gather information about the behavior under stress during the development process as soon as possible, system components as well as systems get tested on test rigs. In hydraulics, applying passive loads e.g. to linear actuators can easily be done by throttling the outflow. For rotatory units, loads can either be applied with ropes and masses or other rotatory units. Especially applying active loads i.e. loads with the same orientation as the motion of the cylinder, is difficult and usually connected to a high complexity. At Karlsruhe Institute of Technology (KIT), a hydraulic load unit for hydraulic cylinders was developed to be used at various test rigs. The load units' controller design allows for the application of either active or passive loads in variable directions and intensities. The following paper introduces the load unit, its open- and closed-loop...

Keywords: hydraulic load unit, simulation of active and passive loads, open- and closed-loop control concept

Presenter Matti Linjama 12:15 - 12:35
Tampere University of
Technology
Finland

Topic Fault-Tolerant Control of a Multi-Outlet Digital Hydraulic Pump-Motor

Fault tolerance is the most important feature in safety-critical applications, including aircraft flight controls, nuclear systems, and medical devices, but it is a desirable property of any mechatronic system. In this paper, the fault tolerance of a multi-outlet digital hydraulic pump-motor is studied. This machine has actively controlled on/off valves to independently connect each piston to the tank or one of its outlets. Furthermore, the pump-motor can control an actuator directly without having directional control valves in the system; thus, the on/off control valves of the machine are the most vulnerable components of failure. A valve can either become jammed on (not able to close) or off (not able to open), whether the fault is electrical or mechanical. The effect of a defective valve is studied through simulations, and a method for fault compensation is proposed with a control algorithm adapted for each fault case. The simulations and experimental results show that the valve...

Keywords: Digital hydraulic power management system, energy efficiency, fault tolerance, motor, pump, transformer

Presenter Qi Zhong 12:35 - 12:55
Zhejiang University
China

Topic Design of control system for independent metering valve

An independent metering valve control system (IMVCS) controls the meter-in and meter-out orifices of a valve independently. This innovative structure achieves a better energy saving performance, but also requires a more complex control algorithm. A flow and pressure coupling control system is proposed to control both the flow rate of the load and the pressure in each chamber. A DSP controller with TI-RTOS real-time operating system and digital driving module is adopted for fast response and accurate control. A two level fuzzy PID control algorithm and a lookup table algorithm are applied to improve the performance of the IMVCS. Experimental results show that the created control system can effectively control an IMVCS, and realize the function of flow and pressure coupling control.

Keywords: Independent Metering, Control System, Two Level Fuzzy PID, Coupling Control

NOTES

GROUP D: DESIGN PROCESS

CR 4/5
11:15 a.m. - 1:00 p.m.

CHAIR Prof. Kazushi Sanada
Yokohama National University
Japan

Presenter Ryan Jenkins 11:15 - 11:35
Purdue University
United States of America

Topic A Semi-Empirical Lumped Parameter Model of a Pressure Compensated Vane Pump

This paper presents an experimentally validated semi-empirical lumped parameter model developed for analysing the dynamic stability and performance limitations of a pressure compensated vane pump system. The model calculates continuous displacement chamber pressure profiles for the determination of the internal forces acting on the vane pump's pivoting cam. Extensive measurements conducted on a custom test stand were used to define a nonlinearly progressive bias spring model and a transfer function model of the pump control system valves for realistic system characteristics. Analysis of the complete model reveals the performance limitations imposed by the control system valves in terms of system stability and achievable controller bandwidth are the most restrictive.

Keywords: Analysis, Control, Simulation, Pressure Compensation, Vane Pump

Presenter Tobias Speicher 11:35 - 11:55
Hochschule für Technik und Wirtschaft des Saarlandes
Germany

Topic Process-driven component adjustment in variable speed pump drives – development of a strategy to increase the overall energy efficiency

Regarding the trend of optimizing energy efficiency and meeting upcoming regulations of energy consumption there are many ways to refine existing hydraulic drive systems. To gain more knowledge about components, combinations of those components and their interaction with the overall process, a combination of measurement, simulation and calculation of energy consumption is used to build the foundation for finding optimization approaches regarding the efficiency of electro-hydraulic pump drives. This is a three-step process focusing on the following topics: increased component efficiency, matching pump drive components and adjusted process layouts. By utilizing this strategy, a manufacturer- and customer-dedicated optimization of pump drive systems can be realized.

Keywords: Variable Speed Pump Drives, Energy Efficiency, Design Strategy, Gear Pumps

Presenter Artemi Makarow 11:55 - 12:15
TU Dortmund University
Germany

Topic Holistic Approach to the System Optimization of a Proportional Valve

This contribution presents a holistic approach to the system optimization of a highly dynamic proportional valve. The model with lumped parameters which is used for the evaluation of the closed-loop performance is parameterized based on Finite-Element-Method (FEM) data. In addition to the calculation of static characteristic curves, a suitable excitation signal is applied to the transient FEM simulation. The valve dynamics of the current geometrical valve design are identified using the transient simulation results. This new approach enables a fully automated system optimization of a proportional valve. Hence, during the optimization, human expertise is not required.

Keywords: System Optimization, System Identification, Holistic Model, Highly Dynamic Proportional Valve

Presenter Andrea Lucchi 12:15 - 12:35
Dana Brevini Fluid Power S.p.A.
Italy

Topic System optimization by means of an integrated design: the Dana Brevini case.

The paper presents the Dana methodology to address the integrated design for winch systems. Beginning with the analysis of the generic expected performance of the system, the main issues and tasks are evaluated; moreover, the design workflow and the main benefits of integrated design are described with particular attention to the strong team working required to fulfil the defined target in the most efficient way. Different sub-systems are analysed: the hydraulic motor-winch coupling, with particular attention to clocking speed and its relationship with motor non-uniformity grade and specific reducing gear-ratio to improve hydraulic-mechanic coupling, the hydraulic control system with the possibility to integrate several different functions in a compact and efficient solution, the winch torque sensor and motor angular sensor, which are specifically designed to merge with the components, provide fundamental information for the defined control...

Keywords: Integrated design, hydraulic systems, efficiency, control strategy

Presenter Enrico Pasquini 12:35 - 12:55
FLUIDON GmbH
Germany

Topic Pressure Loss in Unsteady Annular Channel Flow

The paper presents a methodology for calculating the pressure loss in unsteady flows through concentric annular channels. The momentum equation in axial direction is solved in the Laplace domain to obtain the unsteady radial velocity distribution. Based on the velocity profile, the relation between the Laplace transforms of pressure loss and area-averaged flow velocity is derived. A time domain representation of this equation is provided for oscillating flows. For arbitrary temporal distributions of the flow, the inverse Laplace transform of the relation between pressure loss and flow velocity has to be derived. Since finding the inverse Laplace transform of the exact weighting function for each possible radius ratio is cumbersome, the annular channel flow is approximated by a plane channel. An error analysis shows that this approximation introduces errors less than 1 % for channel geometries down to radius ratios of 0.45. The approximated weighting function...

Keywords: concentric annular channel, frequency-dependent friction, unsteady flow, hydraulic simulation

NOTES

GROUP E: COMPONENTS

CR 7/8

11:15 a.m. - 1:00 p.m.

CHAIR Prof. Kim Stelson
University of Minnesota
United States of America

Presenter Florian Schoemacker 11:15 - 11:35
RWTH Aachen University
Germany

Topic Piston slippers for robust water hydraulic pumps

Water hydraulics are used for applications which require an environmental safety standard for the fluid. In comparison to oil, lubrication with water is a challenging aspect because of the fluid's lower viscosity. Wear and leakage in water lubricated contacts require lower pressure loads. In order to estimate the possible load carrying capacity in water hydraulics, the tribological contact between the piston slipper and swash plate in axial piston machine and respectively eccentric shaft in radial piston machines is investigated. For this purpose simulations based on the Reynolds-Equation are carried out and analysed.

Keywords: Water Hydraulics, radial piston pump, piston slipper, hydrostatic compensation, hydrodynamic load carrying capacity

Presenter James Marschand 11:35 - 11:55
Purdue University
United States of America

Topic Comparison of a Variable Displacement 3-Piston Inline Digital Pump using Electrically and Mechanically Actuated Poppet Valves

Digital pumps using high speed on/off valves to control fluid entering and leaving the piston cylinder displacement chamber can increase efficiency by eliminating the leakage and friction associated with the port plate. Leakage scales with the displacement because the displacement chamber is only pressurized during a portion of the piston stroke. This work investigates the modeling, prototyping, and testing of two prototype digital pumps. The first prototype actuated on/off valves using electrical solenoids; the second configuration used mechanical cams. The mechanical actuation improved the repeatability and accuracy of the valves, matching or exceeding the performance of the electrically actuated prototype while eliminating all transducers and electronics. The mechanically actuated pump operated at 86% efficiency (full displacement) and 58% efficiency (25% displacement).

Keywords: Digital Hydraulics, Inline Piston Pump, Efficiency, Digital Pump/Motor

Presenter Prof. Robert Castilla 11:55 - 12:15
Universitat Politècnica de Catalunya
Spain

Topic Fluid Dynamic Effects of Interteeth and Sideway Clearances on a Mini Gerotor Pump using Dynamic Meshing Decomposition

A new-born design and construction of a mini gerotor metering pump with trochoidal-teeth is presented. The technical innovation in this new-born design is to study the fluid dynamic effects of interteeth and lateral clearances by using OpenFOAM toolbox, an open source CFD software. This work is based on two critical aspects, the deforming of the mesh following the solid gears rotation, a complex interaction between mesh and gear profile surface that has to maintain a moderate quality of the mesh, and the simulation by means of a new boundary condition of the interteeth contact, reproducing actual contact points between the rotors. The possibility of contact point simulation by means of a proper mesh motion model is also suggested.

Keywords: Gerotor pump, Computational Fluid Dynamics, Dynamic Mesh, Leakage

Presenter Ying Li 12:15 - 12:35
Zhejiang University
China

Topic Experimental study on churning losses reduction for axial piston pumps

The proportion of churning losses increases significantly with the increasing speed, thus churning losses reduction has a significant influence on the efficiency improvement in axial piston pumps. In this paper, a test pump with nano-coating is proposed, and analyzed in details. The analysis shows that the surface energy and friction coefficient on the outside surface of cylinder block are reduced due to the decrease of surface roughness and wettability on the nano-film. Experimental results indicate that energy losses of the proposed nano-coated test pump are reduced by 12~37%. Some of the conclusions in this paper may provide a suitable novel guidance for improving the friction-reducing abilities in axial piston pumps.

Keywords: Churning losses, cylinder block, nano-coating, axial piston pumps

Presenter Prof. Bulent Sarlioglu 12:35 - 12:55
University of Wisconsin-Madison
United States of America

Topic Investigation of the Aerodynamics Characteristics of the Integrated Motor-Compressor

The objective of this work is to design and investigate the aerodynamic performance of a novel integrated motor-compressor. The integrated motor-compressor integrates the axial-flow compression into the electromagnetic function by designing the airfoil-shaped rotor of the electric machine to provide compression. Hence, the integrated motor-compressor is both an axial-flow compressor and an electric machine. It is capable of providing axial flow compression and electromagnetic torque at the same time. In this work, the aerodynamic design of the proposed machine is done and evaluated by both analytical method and computational fluid dynamics (CFD). The effect of attack angle to the blade lift and drag forces are investigated. The effect of solidity to the axial-flow compressor performance is also evaluated. The electromagnetic performance of the proposed machine is investigated by motor sizing equations and finite element analysis (FEA).

Keywords: Aerodynamics, axial-flow compressor, electric motor, FEA, CFD

NOTES

GROUP F: MOBILE APPLICATIONS

CR 2
02:00 - 03:45 p.m.

CHAIR Prof. Christian Stammen
XCMG European Research Center GmbH
Germany

Presenter Dr. Tatiana Minav 02:00 - 02:20
Aalto University
Finland

Topic Control strategy for a direct driven hydraulics system in the case of a mining loader

As a response to the strict government emissions regulations, hybridisation of non-road mobile machinery is required. In this paper, behaviour and efficiency of a hybrid mining loader is studied. The full prototype with implemented DDH (Direct Driven Hydraulics) units had been built; however, its performance was unsatisfactory – a large undershoot and steady-state error of 34 % persisted. Therefore, a new control strategy was suggested to overcome the issues. Performance of the system was enhanced by applying a fuzzy PID controller. As a result, reference tracking was significantly improved compared to the conventional PID control case and steady-state error of 1 % was achieved, while the overall efficiency was kept high in the range of above 50%.

Keywords: fuzzy control, direct driven hydraulics, mining loader, efficiency

Presenter Prof. Andrea Vacca 02:20 - 02:40
Purdue University
United States of America

Topic Combining Control and Monitoring in Mobile Machines: the Case of an Hydraulic Crane

The widespread use of electro-hydraulic (EH) technology of the last decades has led to important improvements in the control features, safety and performance of hydraulic machines. However, limited work exploited the use the EH control features for condition monitoring. This paper proposes a neural network based diagnostic algorithm, that takes advantage of the parameters of a controller developed for the case of an independent metering hydraulic system. The reference application is a truck loading crane available at the authors' research center. The results show how the proposed methodology is effective to detect faults (the faults considered pertain to the pump, the metering valves and the cylinder), with a limited number of sensors.

Keywords: Control, Diagnostic, Independent Metering, Hydraulic Cranes, Mobile Hydraulics

Presenter Dr. Ruqi Ding 02:40 - 03:00
East China Jiaotong University
China

Topic Fault-tolerance Operation for Independent Metering Control Valve

This paper focuses on the faulty issues of the independent metering valve (IMV) in mobile applications. First, typical faults are studied in a 2t excavator to analyze their negative influences. The model of the abnormal system is estimated according to the results of fault detection and diagnosis. Accordingly, a fault-tolerance controller is designed to reconfigure normal controller by the coordinate control of other parallel available valves. With the presented fault operation, the dynamic characteristic under reconfigured modes can strictly match with that of faulty system. Simulations are conducted in the excavator to verify the fault-tolerance controller.

Keywords: Independent metering valve (IMV), fault detection and diagnosis, fault tolerance control (FTC), excavator, safety...

Presenter Kerstin Ritters 03:00 - 03:20
TU Braunschweig
Germany

Topic Efficiency studies on double pump supply units

In this paper three concepts of double pump supply units are presented and compared to a conventional variable displacement pump as reference. These supply units consist of two off-the-shelf pumps in a parallel arrangement and they are meant to perform like a continuously variable source of flow rate. In order to evaluate possible energy savings of the supply units, their efficiency characteristics are firstly computed in a steady-state simulation but also examined on a test bench. By means of a semi-synthetic load profile for an exemplary application, the annual savings of the systems are calculated in comparison to the reference pump. Moreover, a rating system for the system's complexity is shown and applied to the three concepts in order to judge the tradeoff between efficiency and complexity. The studies show that the more complex concepts provide higher saving potentials than simpler systems, but the interdependence may come unpredictably in some cases.

Keywords: double pump, efficiency, auxiliary pump, boost

Presenter Dr. Lei Ge 03:20 - 03:40
Taiyuan University of Technology
China

Topic High Energy Efficiency Driving of the Hydraulic Excavator Boom with an Asymmetric Pump

Hydraulic excavator is widely used in the construction field, due to their small size to power ratio and big actuation forces. However, due to large throttling loss and gravitational potential wasting, its energy efficiency is very low, which is even lower than 10%. This paper aims to improve the energy efficiency of the hydraulic excavator by reducing throttling loss and regenerating potential energy directly based on a novel pump controlled system. The system under consideration utilizes a newly designed asymmetric pump which has three ports, the two are connected to the hydraulic cylinder, the other is connected to an accumulator. Thus, this system can regenerate the potential energy directly and can match the unequal flow rates of the single rod cylinder basically. Furthermore, working performances of the excavator boom system with the asymmetric pump and independent metering circuit are studied comparatively. Results show that, compared with an independent metering...

Keywords: Hydraulic excavator, high energy efficiency, asymmetric pump controlled, energy recovery

NOTES

GROUP G: TRIBOLOGY & FLUIDS

CR 4/5

02:00 - 03:45 p.m.

CHAIR Prof. Peter F. Pelz
TU Darmstadt
Germany

Presenter Tobias Mielke 02:00 - 02:20
RWTH Aachen University
Germany

Topic Entrainment of free water into a hydraulic system through the rod sealing

Water in oil-based hydraulic systems is a source for many machinery failures. It accounts for up to 20% of the life expectancy failures and even before that, it impacts the expected performance negatively /1/. Water can enter a hydraulic system in various ways. In this article, the entry through the dynamic seal of the rod is investigated. After a brief description of the damage mechanisms of water in a hydraulic system, the theory of the entrainment is explained. The test bench is then described to study the effect. Finally, entrainment results for two test fluids (oil and water) are presented and compared to the theory.

Keywords: Rod Sealing, Water, Contamination, Reynolds Equation

Presenter Joep Nijssen 02:20 - 02:40
Delft University of Technology
Netherlands

Topic Development of an interface between a plunger and an eccentric running track for a low-speed seawater pump

The DOT concept for offshore wind energy is a seawater hydraulic network where turbines are directly coupled to a centralized hydro-power platform. The essential missing component is a low-speed hydraulic pump that uses seawater as its hydraulic medium. This low speed hydraulic pump is currently being designed and tested by DOT, where novel machine components have been developed. This paper describes the development of an interface between an oval running track which is used as eccentricity to actuate a hydraulic piston. Several approaches have been performed as well as prototyping and validation steps. These steps as well as the design approach are presented in this work.

Keywords: Fluid power networks, positive displacement pump, Eccentricity, crank shaft replacement

Presenter Alexander Terwort 02:40 - 03:00
TU Darmstadt
Germany

Topic Bubble nucleation in hydraulic systems

Free gas in a hydraulic system is usually accompanied by negative aspects. Currently available models usually underestimate degassing at liquid-gas interfaces that are exposed to fluid flows, which is the most relevant degassing mechanism in hydraulic systems. Therefore, a new approach for physical modelling of bubble formation at liquid-gas interfaces is presented. Based on recent findings on diffusion-driven nucleation a simple model to calculate the mass fraction of gas being set free in a hydraulic fluid is derived. This approach is experimentally validated and could be implemented in available calculation tools.

Keywords: Cavitation, oil hydraulics, degassing, diffusion-driven nucleation

Presenter Lars Brinkschulte 03:00 - 03:20
Karlsruhe Institute of Technology
Germany

Topic An approach to wear simulation of hydrostatic drives to improve the availability of mobile machines

Wear in swashplate type axial piston pumps mainly occurs in three tribological contact pairs. These are swashplate-slipper, piston-cylinder and cylinderblock-valveplate. This article focuses on a simulation model, based on the approach of Archard and Fleischer, to predict the wear in the piston-cylinder contact. Besides general geometric data, the exact piston and cylinder contours and the wear-induced material removal over time are taken into account. A special focus in the simulation is on the investigation of the dependency of the viscosity of the hydraulic fluid on the wear. First results from test runs demonstrate a good correspondence between the simulation and measured wear on a test bench.

Keywords: swashplate type axial piston pump, piston-cylinder contact, fluid film, wear simulation, influence of viscosity, experiment

Presenter Yuan Chen 03:20 - 03:40
Zhejiang University
China

Topic Investigation of Laser surface texturing for Integrated PV (pressure×velocity)-value-decreased Retainer in an EHA Pump

An integrated retainer which wraps the slippers and rotates with them is assembled in an Electro-hydrostatic actuator (EHA) pump, to eliminate the high linear velocity at slipper bottoms and to diminish the PV (pressure×velocity) value of the contact area. The impacts of laser surface texturing on the performances of the high-speed rotating retainer are investigated by conducting the CFD simulation of the flow inside several micro-dimples and the experiments on an EHA pump prototype. Wear marks are observed and the dimples with an area ratio of 16.4% are found to improve the volumetric and mechanical efficiencies of the prototype by up to 7.4% at the speeds of 6000~10000 rpm.

Keywords: Electro-hydrostatic actuator pumps, laser surface texturing, integrated retainer, CFD simulation, sliding wear

NOTES

GROUP H: PNEUMATICS

CR 7/8

02:00 - 03:45 p.m.

CHAIR Dr. Olivier Reinertz
RWTH Aachen University
Germany

Presenter Stephan Merkelbach 02:00 - 02:20
RWTH Aachen University
Germany

Topic Development of a rotary pneumatic transformer

Pneumatic drives are widely used in industrial applications. As the energy demand of production systems becomes more and more important, nowadays, many users favour a reduction of the general supply pressure to save energy. Nevertheless, some applications afford compact and powerful drives. To serve these demands, an energy efficient local pressure boosting is necessary. Today, linear pressure boosters based on double-piston cylinders are used to fulfil this task. The paper proposes a novel concept based on pneumatic radial piston motors. The new concept features a radial piston compressor, which is driven by a radial piston motor. The paper shows simulation data as well as a validation by experimental investigations of a working model of the new booster. Different configurations of the booster are examined for a range of driving pressures and pressure ratios. The experimental results are compared to a standard pneumatic booster...

Keywords: Pneumatics, Energy Efficiency, Pressure Booster

Presenter David Straub 02:20 - 02:40
Stuttgart University
Germany

Topic Experimental and Theoretical Investigation of Lightweight Pumps and Fluid Reservoirs for Electrically Driven Vacuum Systems in Automated Handling Processes

It is known that the performance of a hydraulic system can be increased significantly by a combination of a pump and a reservoir. As the electrical vacuum generation's ability to compete compared to classical ejectors is limited in this article the combination of pumps and reservoirs is applied to the vacuum technology used in automated handling processes. Evacuation times and energy consumption of the electrical vacuum pumps are measured. Two possible use case scenarios are the basis for investigations how a fluid reservoir influences evacuation time and energy consumption. The results are then compared to a pneumatic ejector.

Keywords: automation, vacuum handling, vacuum pump, fluid reservoir

Presenter Annabell Effner 02:40 - 03:00
TU Dresden
Germany

Topic Fast Switching Pneumatic Valves Driven by Magnetic Shape Memory Materials

The increasing requirements on fast switching pneumatic valves, especially regarding the installation size, durability and high dynamics, demand for innovative systems. Magnetic shape memory (MSM) alloys are smart materials that can be activated by magnetic field to produce force and motion. Due to their high work-output and dynamics they are a promising alternative technology for a new generation of fast valves. This paper presents an investigation on the design process of a fast switching pneumatic valve based on MSM alloys. In particular, two valve concepts are described: a lever valve concept based on the magnetic elongation and mechanical resetting of the MSM element by a spring, and a seat valve consisting of an air-cored coil with a MSM element which opens the valve during its compression. The first valve concept is characterised by a lower dynamic behaviour compared to the second valve concept, but also by smaller power input required for...

Keywords: magnetic shape memory, pneumatic valve, fast switching, optimization actuator, reluctance network

Presenter Dr. Miha Pipan 03:00 - 03:20
Faculty of Mechanical Engineering Ljubljana
Slovenia

Topic Closed-loop control algorithm for fast switching pneumatic valves

In this paper, a control algorithm for PWM based control of fast switching pneumatic solenoid valves is studied on the basis of the measured fluid flow characteristics. The dynamic nonlinear behaviour of fast switching valves is analysed using state-of-the-art mass flow sensors. The minimum PWM pulse width and nonlinear flow characteristics depending on PWM pulse width and pressure difference are observed. On the basis of the experiment data a new intelligent control algorithm based on the customized bilinear interpolation method is developed and tested on pneumatic muscle.

Keywords: Fast pneumatic switching valves, PWM modulation, flow characteristics, algorithm

Presenter Filipp Kratschun 03:20 - 03:40
RWTH Aachen University
Germany

Topic Transient simulation of a pneumatic sharp edged L-shape fitting

The increase of system dynamic within the area of pneumatics requires sophisticated numerical methods to determine the systems' performance. Cycle durations in the range of just a few milliseconds and below require the implementation of transient gas dynamic solvers to predict the systems behavior accurately and to save computational time. Yet, such solvers lack of accuracy for sharp edged elbows. This paper presents a hybrid approach using a one dimensional and a two dimensional finite volume Riemann-Solver. The results are compared to analytical acoustics theory and to a CFD approach using a turbulence model.

Keywords: System Simulation, Pneumatics, Numerical Solver, Gasdynamics

NOTES

GROUP I: NEW & SPECIAL APPLICATIONS

CR 2

04:15 - 06:00 p.m.

CHAIR Prof. Kalevi Huhtala
Tampere University of Technology
Germany

Presenter Dr. Vito Tič
University of Maribor
Slovenia
04:15 - 04:35

Topic Low compressibility of ionic liquids and its effects on pulsation within hydraulic system

The paper presents possible use of Ionic Liquids as a lubricant suitable for use as a hydraulic fluid. After a short presentation of ionic liquids and their interesting properties, the paper focuses on very low compressibility (resp. very high Bulk modulus) of ILs compared to the common hydraulic mineral oils and investigates the effects of their high bulk modulus on pressure pulsation and flow ripple of hydraulic pump. Two most adequate ionic liquids for hydraulic application with highest bulk modulus where chosen and a special test rig was built using bent axis 7-piston pump powered by a servo motor. Results show change of resonance frequencies of entire hydraulic system due to higher bulk modulus and higher density of the ionic liquids. On the other hand, there is no significant change in pump pressure pulsation in non-resonance frequency range below 2500 rpm.

Keywords: hydraulic fluid, Ionic liquid, pump pulsation, flow ripple

Presenter Marcel Rückert
RWTH Aachen University
Germany
04:35 - 04:55

Topic High Pressure Falling Cylinder Viscometer-Error Analysis and Improvement Proposal

With pressure levels rising for applications such as compression-ignition engines and numerical design approaches are used to optimise fluid power components, rheological properties of the fluid in the according operation points gain interest. The measurement of viscosity under high-pressure has been subject to research for many years. However, to this day, it still bears uncertainty. This paper presents typical errors for high-pressure measurements and strategies to minimise uncertainty. With a focus on material combinations, geometric parameters and the measurement principle, the errors are explained, and an improvement proposal is given based on the findings.

Keywords: Viscosity, Viscometer, High-pressure, Rheology, Measurement

Presenter Nils Preuß
TU Darmstadt
Germany
04:55 - 05:15

Topic Accumulators with sorbent material – an innovative approach towards size and weight reduction

Utilizing accumulators in hydraulic systems with the purpose of energy storage, temporal changes in state of the storage medium must be considered during design and prospectively also monitored during operation. High efficiency aside, the reduction of weight and size is of high interest, especially in mobile applications. Regarding these objectives, accumulators with sorbent material are an innovative and promising development. The herein introduced generic physical model enables the consideration of sorption processes in the description of such accumulators. The results are discussed by means of time response analysis and compared to the behaviour of conventional accumulators. Potential use cases are investigated and the model application to a practical duty cycle is shown.

Keywords: accumulator, size reduction, sorbent material

Presenter Andreja Poljšak
Faculty of Mechanical Engineering Ljubljana
Slovenia
05:15 - 05:35

Topic Polymer composites materials for water hydraulic seat on/off valves

High pressures and harsh working conditions in hydraulic systems has made us sceptical about suitability of plastics for its components. Nevertheless in some cases it can become a sufficient substitute for expensive steels. In water hydraulic components, where demanding surface contacts are slowing its development, polymers can be a solution. Focus of our research is on implementing polymers into a moving contact in high speed water hydraulic on/off valve where high friction and wear occur. In this article we are presenting friction coefficient and wear rate of some engineering polymers immersed in water for different time periods. PEEK and POM showed comparable results regardless their price difference.

Keywords: water hydraulics, friction coefficient, wear rate, polymers, composites

Presenter Dr. Niels Diepeveen
DOT
Netherlands
05:35 - 05:55

Topic Field tests of the DOT500 prototype hydraulic wind turbine

To reduce turbine mass, maintenance requirements, complexity, and thus the Levelized Cost of Energy (LCOE) for offshore wind, the Delft Offshore Turbine (DOT) concept combines individual hydraulic drive train wind turbines with a centralized generator system. In 2015 DOT built and tested a large-scale prototype, by retrofitting a 600kW wind turbine with a hydraulic drive train using commercial off-the-shelf components. The goal was to showcase a proof of concept from a technological and controllability point-of-view. This paper presents the results of building and testing the DOT500. Its drive train has an oil-hydraulic stage and a water-hydraulic stage. The method of rotor torque control with spear valves is novel and proves to be a substitute for conventional implementations.

Keywords: offshore wind, fluid power transmission, water hydraulics

NOTES

GROUP J: TRIBOLOGY & FLUIDS

CR 4/5
04:15 - 06:00 p.m.

CHAIR Prof. Peter Anders
Hochschule Furtwangen
Germany

Presenter Dominik Krahl 04:15 - 04:35
TU Dresden
Germany

Topic Burning Hydraulics – Experimental Investigations of the Micro-Diesel Effect and Gas Discharge within Models of a Valve and a Pump

This paper deals with light-emitting phenomena in hydraulic components, which are closely linked to cavitation. Both the micro-diesel effect and the gas discharge have been optically investigated within plane models of a valve and a pump section, respectively. The gas discharge is caused by an electrostatic charge of the oil or of the component. One result of the investigations is an overview of the areas of occurrence and the minimum necessary operating conditions of the phenomena. The form of appearance of both phenomena is also shown. Furthermore, the impact of electrically insulating materials is presented. In addition some measurements of the temperatures in close proximity to the phenomena are presented.

Keywords: Micro-Diesel Effect, Cavitation, Valves & Pumps, Electrostatic Discharge

Presenter Paul Michael 04:35 - 04:55
Milwaukee School of Engineering
United States of America

Topic An Investigation of the Effects of Fluid Composition on Aeration, Efficiency, and Sound Generation in an Axial Piston Pump

In this investigation, hydraulic fluids of varying base oil and additive composition were evaluated in a dynamometer fitted with a reservoir that incorporated an aerator at the inlet, and a mass flow meter at the outlet. The effects of aeration on piston pump efficiency and air borne noise generation were evaluated. Hydraulic oils that entrained a greater volume of air demonstrated lower volumetric efficiencies and higher sound levels. The fluids differed in volumetric efficiency by as much as 8% and perceived sound level by as much as 50%. Based upon 2,500+ hours of testing in a high-intensity loader application, the performance benefits of the low aeration fluid were persistent.

Keywords: Fluid properties, air release, density method, sound analysis

Presenter Julian Angerhausen 04:55 - 05:15
RWTH Aachen University
Germany

Topic Influence of transient effects on the behaviour of translational hydraulic seals

In common practice a hydraulic cylinder undergoes permanent acceleration and deceleration. In general this transient behaviour is neglected in the simulation of hydraulic seals, especially regarding the fluid film where stationary conditions are assumed. In order to gain a detailed understanding of the dynamic sealing process, a finite element based, elastohydrodynamic simulation model for hydraulic seals has been developed, including transient effects /1/. In this paper the influence of these transient effects on the behaviour of a hydraulic seal is investigated. The influence is studied under different system conditions in order to examine to which extend the consideration of transient effects in a simulation of hydraulic seals is inevitable.

Keywords: Hydraulic Seals, Transient Behaviour, Friction, FE-Simulation, Breakaway Force

Presenter Tobias Corneli 05:15 - 05:35
TU Darmstadt
Germany

Topic Reduction of bearing load capacity due to measured wall slip

The presented work investigates the temperature dependence of the Navier slip boundary condition and the related reduction of load capacity of a bearing. In part (i), the Navier slip boundary condition is discussed and a modified Reynolds equation, including slip, is derived. Based on this modified Reynolds equation, the pressure distribution and the load capacity of a slider bearing are obtained. Part (ii) presents the Darmstadt Slip Length Tribometer, utilized for measuring the slip length of technical rough surfaces. Part (iii) shows the temperature dependent results of the slip length measurements and the effect on the load capacity of the slider bearing in comparison to the standard no slip boundary condition.

Keywords: Fundamentals, Journal Bearing, Sealing Technology, Slider bearing

Presenter Lizhi Shang 05:35 - 05:55
Purdue University
United States of America

Topic Advanced Heat transfer model for piston/cylinder interface

The piston/cylinder interface in axial piston machines requires both sealing and bearing functions. The fluid and structure coupled physical phenomena including the temperature distribution of the piston and cylinder block controls the gap fluid behavior, therefore, the dual functions of the piston/cylinder interface. Instead of addressing the heat transfer problem of the piston and the cylinder block separately as the former model, the proposed advanced heat transfer model solves the temperature distribution of both solid bodies together using the fluid domain heat transfer characteristic to assemble the two solid parts. Comparing to the former unconnected heat transfer model, the integrated model is found more robust and accurate especially at challenging operating conditions.

Keywords: Piston/cylinder interface; fluid structure and thermal interaction modelling, heat transfer

NOTES

CONFERENCE

COLLOQUIUM
Tuesday 09.00 a.m. - 05.45 p.m.

CONFERENCE PROGRAMME TUESDAY, 20TH OF MARCH

OPENING & WELCOME ADDRESS

EUROPE HALL
9:00 - 9:30 a.m.

1st Speaker — 09:00 - 09:30

Univ.-Prof. Dr.-Ing. H. Murrenhoff
Head of IFAS
RWTH Aachen University
Germany

2nd Speaker

Christian H. Kienzle
Chairman of the Board of the Fluid Power Association within VDMA, Frankfurt/M., Germany
CEO of ARGO-HYTOS GMBH, Kraichtal

PLENARY LECTURES

EUROPE HALL
9:30 - 10:30 a.m.

CHAIR — 09:30 - 10:00

Univ.-Prof. Dr.-Ing. H. Murrenhoff
RWTH Aachen University
Germany

1st Speaker

Prof. Dr. Peter Post
Vice President Applied Research
Festo AG & Co. KG
Esslingen, Germany

Topic Digitization in pneumatics for increasing automation efficiency

Recent developments in automation technology including pneumatics have to be evaluated in the context of many discussions around Industry 4.0. Therefore, four main fields of activities need to be covered when talking about Industry 4.0: Horizontal integration, vertical integration, lifecycle management/engineering and people. In all this fields modern pneumatic developments are offering solutions, which will be addressed in the presentation.

2nd Speaker — 10:00 - 10:30

Dr. Steffen Haack
Senior Vice President Industrial Hydraulics
Bosch Rexroth AG
Lohr, Germany

Topic Industrial Hydraulics- are we really on track concerning Industry 4.0?

Industry 4.0, a term that we encounter almost every day. What are the effects of networking of machines and entire factories as well as the ongoing digitalization on machine and plant design today and in the future? Based on some theoretical considerations, the entire engineering process is examined from the first product idea to the installed solution. The requirements of Industry 4.0 are major challenges for manufacturers and users, but they also offer huge potential. What about Hydraulics, are we really on track? The first steps with electro-hydraulic solutions have been taken, but there is still a lot of work and effort needed not least in order to close the gap to electrical solutions.

NOTES

GROUP 1: DIGITALIZATION, CONNECTIVITY & COMMUNICATION

CHAIR Dr. Marcus Fischer
ARGO-HYTOS GmbH
Germany

EUROPE HALL
11:00 a.m. - 12:30 p.m.

Presenter Raphael Alt 11:00 - 11:20
RWTH Aachen University
Germany

Topic A survey of „Industrie 4.0“ in the field of Fluid Power – challenges and opportunities by the example of field device integration

This contribution gives a brief introduction to general aspects of “Industrie 4.0”. Besides basic strategies to improve the added value and flexibility of a production, challenges of the transformation, which have to be overcome by the companies, are shown. The commissioning of production machines gains more significance in a dynamic production of a smart factory, so that in consequence the automation of the commissioning would bring significant advantages. Current fluid power systems are not excluded, since most steps of the commissioning are still done manually by the technician. By analysing the integration of a linear electro-hydraulic actuator into a production machine, limitations and problems of current systems are identified and related to the field of fluid power. The analysis of possible solutions is leading to methods and modern information and communication technology, introduced by the “Industrie 4.0”.

Keywords: Cyber-physical system, intelligent field device, plug and produce, plug and play, commissioning, Industrie 4.0...

Presenter Tapio Torikka 11:20 - 11:40
Bosch Rexroth AG
Germany

Topic Predictive Maintenance Service Powered by Machine Learning and Big Data

We present a service for Predictive Maintenance in which existing machine data from control units or data from retrofitted sensors can be acquired from industrial machines by various gateway solutions. These gateways preprocess the data onsite and transmit it securely to a cloud-based Big Data system without impacting the production process of the industrial machine. Additional servers run Machine Learning algorithms to analyze the incoming data and generate data-based models representing the machine behavior. Results from existing applications show that significant benefits can be created for our customers and that Machine Learningalgorithms demonstrate superhuman performance in detecting anomalous machine behavior.

Keywords: big data, digitalization, connectivity, machine learning, predictive maintenance

Presenter Oliver Breuer 11:40 - 12:00
FLUIDON GmbH
Germany

Topic From Big Data to Smart Data

Industrial Internet of Things (IIoT) and Industry 4.0 are very popular buzz words today. The „me too“ factor is pretty high and attracted companies are faced with an overwhelming market of data management solutions. But despite the large amount of data that can be collected from industrial facilities, the real benefit is behind colourful graphics and charts. To get there, the data provided by the connected components of an IIoT capable system has to be analysed and put into context. So, the question is not what can be done with all the collected data but how to generate useful information.

Keywords: Digital Twin, Simulation, IIoT, Model-based Systems Engineering

Presenter Prof. Peter F. Pelz 12:00 - 12:20
TU Darmstadt
Germany

Topic Towards digitalization of hydraulic systems using soft sensor networks

Today buzzwords like “smart machine” and “intelligent component” dominate the discussion about digitalization in the fluid power domain. However, the engineering fundamentals behind the words “smart” and “intelligent” often remain unclear. A common and target-oriented discussion needs transparent approaches including the applied technical system understanding. Therefore, this paper presents new concepts of soft sensor networks which allow the aggregation of information about fluid systems from heterogeneous sources. Soft sensors presented in this paper are physical models of system components that ensure transparency. Soft sensors and soft sensor networks are applied on exemplary hydraulic systems on three different levels: (i) the sensor level, (ii) the component level and (iii) the system level.

Keywords: soft sensor network, digitalization, condition monitoring, predictive maintenance

NOTES

GROUP 2: COMPONENTS

BRUSSELS HALL
11:00 - 12:30 a.m.

CHAIR Prof. Monika Ivantysynova
Purdue University
United States of America

Presenter Galina Haidarschin — 11:00 - 11:20
Danfoss Power Solutions GmbH & Co. OHG
Germany

Topic Benchmarking of potential substituents for leaded bronze in axial sliding bearings for mobile hydraulic applications

This study comprises testing of RoHS-compliant axial sliding bearing materials, including bronzes, brasses, thermally sprayed coatings and PVD coatings, in a pin-on-disc tribometer and bench testing in an axial piston pump. The aim was to compare and benchmark these materials against commonly utilized leaded bronze with respect to durability and tribological mechanisms and to derive principles for axial sliding bearing material suitability in hydrostatic components. By evaluating the test results, some fundamental understanding was gained about characteristics which materials must exhibit to achieve sufficient tribological performance and durability in hydrostatic components including, but not limited to resistance against friction-induced material transformation and sufficient ductility to withstand pressure-induced part deflection.

Keywords: Axial piston pumps and motors, axial sliding bearing materials, RoHS-compliance, tribology

Presenter Roman Ivantysyn — 11:20 - 11:40
TU Dresden, IFD
Germany

Topic Investigation of the Thermal Behavior in the Lubricating Gap of an Axial Piston Pump with Respect to Lifetime

Axial piston pumps are universal displacement machines that are used in a vast variety of applications. Their high pressure resistance and ease of operation make them very popular, especially in mobile applications and aerospace. The lifetime of axial piston pumps is depending on the design of the rotating kit, the application and its overall robustness to external loads. The fluid film between the moving parts is responsible for bearing the loads and sealing the displacement chambers. Its design is the most complicated part for a pump designer. All pumps to this date have been designed in a trial and error process, which is not only costly, but doesn't yield an optimum in terms of efficiency and robustness. This paper aims to investigate the influence the fluid film has on the lifetime of the pump. From the three main lubricating interfaces of an axial piston pump, two - cylinder block / valve plate and slipper / swash plate - were analysed in terms of temperature for...

Keywords: Axial Piston Machines, Lifetime, Lubricating Gap Design, Temperature Field

Presenter Dr. Peter Achten — 11:40 - 12:00
INNAS BV
Netherlands

Topic Reducing the wall thickness of the cups and pistons in floating cup pumps and motors

The rotational speed of slipper type, axial piston pumps and motors is limited. One of the most important reasons for this limitation is the barrel tipping torque, which is (amongst others) affected by the centrifugal forces of the pistons. The force of the barrel spring is needed to overcome the tipping of the barrel, and thus preventing the malfunction of the pump or motor. The hydrostatic pressure can create an additional hydrostatic force, pushing the barrel to the port plate, and thereby preventing the barrel to tip. But, at low operating pressures, the hydrostatic force is insufficient, and the tipping torque can only be counteracted by the central barrel spring. Due to the limited strength of this spring, the barrel will tip above a certain operating speed. At that point, the face seal of the barrel will no longer make a full contact with the port plate, and the pump or motor cannot any longer be operated, due to excessive leakage and wear. Floating cup (FC) pumps ...

Keywords: Floating cup, FEM-analysis, barrel tipping torque

Presenter — 12:00 - 12:20
Emmanuel Viennet
Fribourg University of Applied Sciences
Switzerland

Anton Gaile
Liebherr-Aerospace Lindenberg GmbH
Germany

Topic Noise and vibration reduction for an aerospace secondary controlled hydraulic motor

During flight, passenger comfort is affected by noise emissions from various aircraft systems. Apart from jet engines one of the main sources of noise within the fuselage is the power control unit (PCU) for high-lift actuation. In preparation for take-off and landing this hydraulic motor is responsible for the extension and retraction of the slats and flaps. Along with the increase in operating pressure from 206bar (3,000psi) to 345bar (5,000psi) noise and vibration induced by fluid power systems became more striking. Consequently the aim of the BMWI founded research project "Move On" was to reduce the emissions of Liebherr's power control unit. The results of these research activities are presented within this paper. It is shown how the noise emissions could be reduced in a secondary controlled hydraulic motor by means of a valve-plate and structure optimization. In addition the results of a noise measurement campaign, conducted by Airbus on an A350, are presented.

Keywords: Noise, vibration, hydraulic motor, fluid power systems, axial piston motor, valve-plate optimization

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GROUP 3: INDUSTRIAL APPLICATIONS

EUROPE HALL
1:30 - 3:00 p.m.

CHAIR Robert Rahmfeld
Danfoss Power Solutions GmbH & Co. OHG
Germany

Presenter Dr. Bastian Beckmann 1:30 - 1:50
Bosch Rexroth AG
Germany

Topic myCro – Downsizing of hydraulic power units by revolutionizing the design

Industrial technology is confronted with the constant demands for a reduction in investment and operating costs. Especially hydraulic power units as a core element for supply of flow and pressure for hydraulic actuation systems have a big influence by minimization of the required oil quantity used as well as by optimizing the targeted fluid condition. In addition to the reduction in the required size and weight, the cost of steel fabrications can also be significantly reduced by a smaller tank and the oil quantity during initial filling and maintenance can be reduced. With the innovative engineering-package "myCro" presented here, these advantages can be exploited by the customer.

Keywords: Downsizing, Hydraulic power unit, Degassing, Oil conditioning

Presenter Marcus Helmke 1:50 - 2:10
TRsystems GmbH
Germany

Topic Computer-assisted modeling and automatic controller adjustment based on an innovative non-parametric identification method

Model-based control and regulation concepts will become increasingly important due to their specific advantages, for example in respect of performance, stability, consideration of nonlinearities etc., for hydraulic drives in particular. The fundamental prerequisite for their application is sufficiently precise knowledge of the system's response characteristic. The prerequisite for their acceptance, however, is the availability of computer-supported tools, methods and algorithms, which enable a case-specific identification and controller design. This article presents a concept for achieving these goals on the basis of an innovative nonparametric identification method, which has proved to be extremely efficient in initial applications.

Keywords: hydraulic presses, characteristic diagram, operating point, model based control, self-learning control

Presenter Wilhelm Hagemeister 2:10 - 2:30
Ingenieurgemeinschaft IgH
Germany

Topic Dynamic High-Torque Test Stand with Hydrostatic Drive

This paper presents a Dynamic High-Torque Test Stand with hydrostatic drive technology. The topics discussed within the scope of this paper are the mechanical design and the hydraulic characteristics as well as, detailed solutions implemented in this test rig using innovative technology. The evaluation methods used to determine the test specimen properties are also described in more detail.

Keywords: elastomer coupling, test rig, hydrostatic drive, torque sensor, correlation method, ellipse identification

Presenter Ekhard Siemer 2:30 - 2:50
SMS group GmbH
Germany

Topic Electro-Hydrostatic Drive Concept for the Ring Rolling Process

Rising electricity costs are forcing machine builders and plant operators to find solutions for how energyintensive machines can be operated and produce more efficiently. Large potentials lie in the drive technology used. The example of the electro-hydrostatic drive concept for the ring rolling process demonstrates how a higher productivity with minimized power consumption and at the same time simplified and cost-effective installation brings competitive advantages. Together with Moog GmbH, SMS group GmbH has developed a new generation of ring rolling machine, the RAW ecompact, with a modern electro-hydrostatic drive concept.

Keywords: Power on demand, speed-controlled electro-hydrostatic drive, radial piston pump, ring rolling

NOTES

GROUP 4: MOBILE APPLICATIONS

BRUSSELS HALL
01:30 - 03:00 p.m.

CHAIR Prof. Marcus Geimer
Karlsruher Institut für Technologie (KIT)
Germany

Presenter Dr. Milos Vukovic — 01:30 - 01:50
Linde Hydraulics GmbH & Co. KG
Germany

Topic Systematic Data Analysis for Optimal System Design

As part of the trend towards greater digitalization the number of sensors installed in mobile machinery is increasing each year. OEMs are consequently now capable of collecting large amounts of component measurement data, which they unfortunately do not have time to analyze or are not capable of interpreting. This is quite a pity, because when used in the right way such information can be used to develop a much better understanding of the machine and to develop new systems with lower fuel consumption and improved performance. The following paper introduces an approach used at Linde Hydraulics to analyse and assess large amounts of data with the goal of systematically identifying potential and designing new and improved hydraulic Systems.

Keywords: Mobile hydraulics, excavators, data analysis, system optimization

Presenter Marani Pietro — 01:50 - 02:10
CNR - IMAMOTER
Italy

Topic Experimental Evaluation of the New Meter Out Sensing Architecture

This paper presents the experimental assessment of the very first prototype of Meter Out Sensing System architecture. The system, based on the proportional control of meter out valves, is a novel hydraulic architecture in the field of Mobile Machines. The objective of the hydraulic control is obtained firstly by a negative control of the supply system, adjusting the pressure drop on the meter out to a given value, secondly by a three way compensator able to regenerate the flow. The energy saving is then obtained because of lower throttle losses on meter in connection and the regeneration feature that is enabled hydraulically under specific operating condition.

Keywords: Regeneration, Meter Out Control, Energy Saving, Proportional Hydraulic Controls

Presenter Lorenzo Serrao — 02:10 - 02:30
Dana
Italy

Topic Adaptive Park Brake Technology to Improve Stability of Wheeled Excavators

Rocking is often observed in wheeled excavators while digging, which impacts driver comfort and precision. To minimize rocking, wheeled excavators need special axles with brakes at the wheel-end. The paper presents a new solution to use low cost in-board brakes achieving the same or better stability compared to wheel brakes. This is achieved by disconnecting one axle and braking it, while torque is actively applied on the other axle with a hydrostatic traction motor, to preload the driveline and keep the vehicle more stable. The system hydraulic circuit and the corresponding control algorithms are presented, as well as experimental results that prove the concept feasibility.

Keywords: Fluid power systems, mechatronics, excavator, driveline, control

Presenter Dr. Martin Inderelst — 02:30 - 02:50
XCMG ERC
Germany

Topic Quantification of Energy Saving Measures in a 21t Excavator Hydraulic System – A Holistic Investigation?

The paper is about to show a comprehensive evaluation of energy efficiency in the field of excavating machinery. The results detected with 21t excavator platforms over years deal as a basis to determine the major energy efficiency influencers in and outside the machine. Cycles are given for a state of the art hydraulic system in Asian markets. The measurement data collected and results provided finally lead into an ABC-analysis to show the urgent need for new approaches to really save energy in future construction processes.

Keywords: Hydraulic systems, energy efficiency, loss analysis, ABC-analysis, excavators

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GROUP 5: ENERGY MANAGEMENT

CHAIR Dr. Peter Achten
INNAS BV
Netherlands

EUROPE HALL
03:30 - 05:00 p.m.

Presenter Sebastiaan Mulders 03:30 - 03:50
TU Delft
Netherlands

Topic Control design and validation for the hydraulic DOT500 wind turbine

Offshore wind turbines are getting larger in terms of size and power output, resulting in lower rotation speed and higher torque at the rotor. As hydraulic transmissions are generally employed in high load systems, the case for compact hydraulic drive trains is becoming ever stronger. The hydraulic Delft Offshore Turbine (DOT) concept replaces drive train components with a single sea water pump, and pressurizes sea water to a central multi-megawatt electricity generation platform. This paper presents the first steps in realizing the DOT concept, and prototype tests are conducted with a single full-scale wind turbine with a hydraulic configuration. A hydraulic torque control strategy is developed and in-field test results are presented.

Keywords: Control Strategies, Fluid power networks, Control Design, New Approaches and Methods, Feasibility

Presenter Prof. Kim Stelson 03:50 - 04:10
University of Minnesota
United States of America

Topic Characterization and Calibration of a Power Regenerative Hydrostatic Wind Turbine Test Bed using an Advanced Control Valve

A hydrostatic transmission is commonly used in off road construction equipment for its high power density. It can also be used in wind turbines for more reliable and cost effective transmission than a conventional gearbox. A power regenerative test platform has been built at the University of Minnesota to understand the performance of a hydrostatic transmission in a wind turbine. In this paper the use of an advanced control valve to characterize the components of the test bed has been demonstrated. The electrohydraulic valve has precise control on pressure and flow and gives more flexibility to the testbed.

Keywords: hydrostatic transmission, wind turbine, efficiency, calibration

Presenter Dr. Mirjana Ristic 04:10 - 04:30
Bosch Rexroth AG
Germany

Topic Electrification of hydraulics opens new ways for intelligent energy-optimized systems

Based on different motivations and driving forces for the electrification of hydraulics, this paper introduces and explains the solutions and basic principles used for increasing the energy efficiency by electrification. The following chapters explore these solutions and principles in depth. The key success factors for the electrification of hydraulics are intelligent energy management and appropriate energy storage type and size. Particular attention is paid to the energy storage systems giving an overview of their optimal application fields. The „Smart Energy Mode" energy management solution for industrial applications is then introduced. Afterwards, the Smart Energy System Design is explained by way of an industrial and a mobile example. The paper concludes with a remark concerning the current needs of automatic linking of different model-based tools. This ensures the holistic approach required in this context.

Keywords: Energy management, electrification, variable-speed pump drives, simulation, sizing, energy buffer

Presenter Tobias Pietrzyk 04:30 - 04:50
RWTH Aachen University
Germany

Topic Design study of a high speed power unit for electro hydraulic actuators (EHA) in mobile applications

One way to increase the compactness and power density of electro hydraulic power units is to increase the rotational speed level. Hence, a high-speed electrical drive and a high-speed gear pump are connected. Particularly, high-speed internal gear pumps are not state of the art and increasing rotational speed entails a lot of challenges for the hydraulic system. This paper analyses the influence of different pump parameters for the speed limit of internal gear pumps. Furthermore, a preliminary dimensioning of drive concepts is used to identify the best concept in terms of power density.

Keywords: High-speed power unit, EHA, high-speed pump, internal gear pump

NOTES

GROUP 6: COMPONENTS

BRUSSELS HALL
03:30 - 05:00 p.m.

CHAIR Prof. Jürgen Weber
TU Dresden
Germany

Presenter Peter Tappe — 03:30 - 03:50
Magnet-Schultz GmbH
Germany

Topic High-dynamic Proportional Solenoid on the basis of Established Production Technologies

Proportional solenoids generate a proportional force effect from an electrical input signal. The force is created between the movable armature and the magnetizable counter-piece. Due to this known physical effect and inherent to the functional principle, the magnetic force can actuate in one direction only. The return movement is made by a spring. Based on this principle the realization of well controllable hydraulic and pneumatic valves is possible. The novel solenoid design developed at MSM enables a bi-directional force effect. For this, particularly the armature is considerably modified and fitted with permanent magnets. In addition to the influence of the force direction, the pre-magnetisation of materials causes a considerable improvement of dynamics.

Keywords: solenoid, high dynamic, proportional valve, hydraulic

Presenter Dr. Jörg Schneider — 03:50 - 04:10
Thomas Magnete GmbH
Germany

Topic Proportional pressure reducing valves with intrinsic fail safe function

During the last two decades the aspect of functional safety has constantly gained more importance for all manufactures of mobile hydraulic machines or manufactures of subsystems used therein. Initiated by the IEC 61508 /1/ first issued in 1998 many divisions have deduced their own standards concerning functional safety with the goal to build control structures that are leading to fewer occurrence of dangerous situations during normal machine operation as well as in the case of a failing subsystem. Looking into the failure modes assigned to a Proportional Pressure Reducing Valve (PPRV) within the ISO standard 13849 /2/ it was possible to integrate an intrinsic safety function into various types of pressure reducing valves. In the case of a stuck valve spool this fail safe function opens a second flow path from the control port to tank (Figure 1) resulting in a limited output pressure (Figure 2). For applications where this limited control pressure is in accordance with...

Keywords: functional safety, pilot valve, PPRV, fail safe function, pressure control valves

Presenter Christian Stauch — 04:10 - 04:30
HYDAC Fluidtechnik GmbH
Germany

Topic Proportional Leak-Free Pressure Control Valve

Pressure control valves combine both a reducing and a relieving function. Such valves typically are spool type valves which principally suffer from leakage flow. Additionally, in case of an electrical failure, usual proportional pressure reducing and relieving valves fully open either the supply port connection or the tank port connection. In some applications like clamping functions in machine tools, this is a clear disadvantage. For fail safe operation in machine tools, it is desired to hold the set pressure in case of failure. The article introduces a new kind of proportional pressure reducing and relieving valve, which is leak-free due to seat valve technology. Furthermore, the valve is able to keep the set pressure in case of power-off and is therefore well-qualified for clamping applications.

Keywords: control valve, independent metering, leak-free pressure control

Presenter Dr. Roman Weidemann — 04:30 - 04:50
WEBER-HYDRAULIK GmbH
Germany

Topic Smart hydraulic cylinder with force measurement system

The trend of intelligent components can be observed in various fields. Intelligent component means components with highly integrated sensors and control technology. This enables the system manufacturer to design more complex equipment, and nevertheless decrease in the required integration effort. As a customer-oriented supplier and development partner WEBER-HYDRAULIK concern itself with the development of highly integrated, reliable and reasonably priced sensors for hydraulic cylinders. While an optical position transducer is developed for mass production, this article focuses on the development activities of an in-cylinder integrated force measurement. Parallel to the further development of the application-specific force measurement system for supporting cylinders, a universally applicable concept for contactless force measurement was investigated.

Keywords: smart components, contactless force measurement, integrated sensors, hydraulic cylinders

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PLENARY LECTURE

EUROPE HALL
5:15 - 5:45 a.m.

CHAIR	Univ.-Prof. Dr.-Ing. H. Murrenhoff RWTH Aachen University Germany
Speaker	Aaron Saunders Vice President Engineering Boston Dynamics Waltham, United States of America
Topic	Building the World's Most Dynamic Humanoid Robot

A key to high performance mobile robotics is maximizing strength to weight. Powerful, low inertia limbs with high bandwidth actuation enable robots to take on elements of dynamic balance that make them move more like people and animals. Atlas, weighing in at 80 kg and standing 1.5m tall, is the latest in a line of advanced battery powered humanoid robots being developed at Boston Dynamics to push progress in these key areas. This talk will cover recent developments on the Atlas program along with lessons learned and some of the obstacles we face in building advanced robots. We will show how the combination of Direct Metal Manufacturing (DMM), or 3D printing, and advances in human scale hydraulic actuation have let us create a compact robot with high strength-to-weight ratio. These designs along with advances in whole-body balance, give Atlas the ability to manipulate objects in its environment, travel on rough terrain, and perform dynamic tasks approaching what an average person can do.

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CONFERENCE

COLLOQUIUM
Wednesday 09:00 a.m. - 06:30 p.m.

GROUP 7: SYSTEMS

CHAIR Prof. Andrew Plummer
University of Bath
United Kingdom

EUROPE HALL
09:00 - 10:30 a.m.

Presenter Nathan Keller 09:00 - 09:20
Purdue University
United States

Topic Thermal Management of Open and Closed Circuit Hydraulic Hybrids – A Comparison Study

This paper presents a comparison study of the required thermal management of the open and closed circuit hydraulic hybrid system. The hydraulic and thermal system behaviour of the open and closed circuit systems were successfully modelled using a lumped parameter approach. The temperature of both open and closed circuit systems have been compared using different cooling conditions based on the UDDS driving cycle. The simulation results show that the open circuit systems have the potential to require smaller heat exchangers as compared to closed circuit systems. In addition, the open circuit system consumes less power from the prime mover and incorporates a smaller charge pump.

Keywords: Hydraulic Hybrids, Open and Closed Circuit Systems, System and Thermal Modelling

Presenter Igor Kuhlhoff 09:20 - 09:40
Bosch Engineering GmbH
Germany

Topic Application of Weibull reliability model for functional safety of electro-hydraulic systems

Functional safety standards define safety levels based metrics calculated from reliability of a safety function components. However, calculated metrics rely on assumptions suitable for electronic components, and do not reflect correctly reliability of hydraulic components. Such components are better described by a Weibull distribution, but due failure rate not being constant on time, it is more complex to determine metrics and are not considered in functional safety standards. This paper offers a method of how to consider such reliability models, and study the behaviour of a safety function by consideration of Weibull distribution on hydraulic valves.

Keywords: Functional safety, Electro-hydraulic systems, Reliability, Weibull

Presenter Gregor Paulmann 09:40 - 10:00
Geneviève Mkadara
Airbus Helicopters Deutschland GmbH / Germany
S.A.S. / France

Topic Condition monitoring of hydraulic pumps – lessons learnt

An overview to the performed analysis and lessons-learnt from flight control & hydraulic designers' perspective on a condition monitoring (CM) concept for helicopters (H/C) hydraulic pump is given. A selection of already performed studies on condition monitoring applications for hydraulic pumps is discussed and the main obstacles in the CM implementation process for H/C hydraulic pumps are drawn from it as lessons-learnt. It is considered unavoidable to enter the CM concept by a data collecting and processing phase. Thanks to the CM hybrid algorithm continuous maturity improvement by data feeding, the obtained in-service data will be then directly used to identify the failure in real-time. In parallel, the data trend evolution analysis should allow to decide if it can be used also as a predictive element into the CM system for the dedicated failure mode.

Keywords: Helicopters, axial piston pumps, condition monitoring, lessons learnt

Presenter Tobias Radermacher 10:00 - 10:20
TU Dresden
Germany

Topic Development and Test of a Hydraulically Actuated Prototype Trailing Edge Flap for a Wind Turbine

Maximum and fatigue loads determine the dimensioning of rotor blades for wind turbines. Due to the large inertia of blades with weights above 35 tons, the reduction of loads via dynamic pitching of blades has a limited effect. Known from aviation, the trailing edge flaps (TEF) have been subject of recent research in wind energy, however there is no commercial solution for a practical implementation till now. The paper presents the development of a novel solution for trailing edge flaps. Experiments carried out at a test section of a 44 m rotor blade are evaluated.

Keywords: Wind Energy; Hydraulic Trailing Edge Flap, Rotor Blade, Lightning protection

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GROUP 8: TRIBOLOGY & FLUIDS

BRUSSELS HALL
09:00 - 10:30 a.m.

CHAIR Prof. Katharina Schmitz
RWTH Aachen University
Germany

Presenter Igor Mass — 09:00 - 09:20
Hochschule Niederrhein
Germany

Topic Pressure distribution of greases in hydrostatic bearings under static conditions

In order to improve power efficiency in hydrostatic bearings a research project was found to minimize the leakage in this type of bearing. One concept for this solution is to use greases as lubricant. The non-Newtonian behaviour of greases which is determined by a characteristic yield stress builds the point of interest. The scope of this paper was to examine if self-sealing is reachable in a thrust bearing and can be predicted by simulation. Therefore an experimental setup and a numerical calculation model were developed. The results confirm the hypothesis and define possible operation conditions for this approach in the field of hydrostatic bearings.

Keywords: non-Newtonian fluid, tribology, Bingham Fluid, lubrication, hydrostatic bearing, power efficiency

Presenter Prof. Yutaka Tanaka — 09:20 - 09:40
Hosei University
Japan

Topic Estimating the Air Volume Fraction in Hydraulic Oil by Measuring the Effective Bulk Modulus

This study demonstrates the utility of estimating the volume fraction of air in hydraulic oil by measuring the effective bulk modulus of the oil. In this paper, we propose a method for measuring and calculating the effective bulk modulus and volume fraction of air in oil and report experiments that show the validity of the method by comparing with the results measured by another method. Our results clarify that the volume fraction of air in oil can be determined by measuring the effective bulk modulus of the oil.

Keywords: Air volume fraction, Effective bulk modulus, Fluid density, Hydraulic system

Presenter Markus Schulz — 09:40 - 10:00
University of Stuttgart
Germany

Topic Influence of different shaft surface finishes on the tribological and functional behaviour of radial shaft seals

The shaft counterface of a radial shaft seals is usually plunge ground. With the aim to reduce costs and production times, many companies try to use new and alternative manufacturing processes for that task. For example, belt grinding and superfinishing methods are frequently considered and used. Result of these often-unreflecting changes of the manufacturing methods, is often leakage and increased wear of the sealing components as well as other related problems. Because, there is only little information about the functional behaviour of this types of surface finishes in terms of sealing applications, an experimental investigation has been carried out. This paper presents the results of these experiments.

Keywords: Radial Shaft Seals, Surface Topography, Failure Analysis, Shaft Manufacturing Methods

Presenter Dr. Mandy Wilke — 10:00 - 10:20
Trelleborg Sealing Solutions
Germany

Topic Optimization of Existing Hydraulic Sealing Systems Due to Improved Lubrication

The performance requirements of multiple sealing systems for reciprocating movements are continuously increasing with friction, wear and service time being key performance criteria. The new concept, presented in this paper, is about adjusting lubrication conditions of all single sealing elements within a sealing system so the load on each element can be reduced and the performance in terms of friction-wear-lifetime can be optimized. This paper describes the dilemma in terms of optimizing the performance of the primary and secondary seal andbrings up a new seal concept, where the risk of leakage of lubricant is balanced to ensuring performance of the primary seal and the extended life of the secondary seal.

Keywords: Energy efficiency, lifetime improvement, hydraulic sealing system with improved lubrication, alternative coating...

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GROUP 9: COMPONENTS

CR 4/5

09:00 - 10:30 a.m.

CHAIR Dr.-Ing. Albert-W. Schultz
Magnet-Schultz GmbH & Co. KG
Germany

Presenter Dr. Marko Simic 09:00 - 09:20
Faculty of Mechanical Engineering Ljubljana
Slovenia

Topic CFD optimization of hydraulic high-response switching valve

In this paper the optimization of the spool and housing geometry in a small hydraulic switching valve to enable the reduction of the axial flow forces to a minimum value is described. Non-optimized valve geometry is usually the main cause for many problems related to response time, actuation force and energy consumption. To overcome these limitations we have done a thorough numerical and experimental analysis focused on fluid flow forces. The results show that the axial flow forces can be reduced significantly just by modifying the geometry of the valve spool and housing. Thus the valve dynamic characteristics can be significantly improved.

Keywords: seat valve, computational fluid dynamics, flow forces, geometry optimization

Presenter Marc Leinweber 09:20 - 09:40
Thomas Magnete GmbH
Germany

Topic Innovative transmission solenoids and -valves through standardization in the product development- and manufacturing process

In automatic and dual clutch transmissions, electromagnetic solenoids and valves are required, which have high requirements for the magnetic force profile and in particular on the magnetic force hysteresis. While there are rising numbers of gears and shifting operations in the transmission, these parameters help to increase the efficiency of the whole transmission and consequently lead to a reduction of fuel consumption and emissions. The aim of the development was to increase the power density of such solenoids, by further minimization of the magnetic force hysteresis and by setting an economic benchmark. Furthermore, the goal was to develop a flexible standardization of these components, which enables an easy adaption to various customer requirements while offering a cost efficient production on a multi-product line.

Keywords: solenoids and valves for transmission

Presenter Dr. Futoshi Yoshida 09:40 - 10:00
KYB Corporation
Japan

Topic Study on Dynamic Characteristics of Water Hydraulic Proportional Control Valve in Nonlinear Region

Water hydraulic proportional control valves are a novel fluid control device using water as the working fluid. They are very hygienic and eco-compatible, permit high-output control, and have applications in many industries. Previously, the authors expressed its characteristics as a third-order transfer function including a compensation circuit (with spool displacement as a control parameter), solenoid, and pilot valve, and examined the effects of design parameters on frequency characteristics, step response, and system stability. Here, its characteristics are examined in the non-linear region by introducing the non-linearity of the control apertures and damping orifice. The results demonstrate the feasibility of applying a linear model in this region.

Keywords: Water hydraulics, Proportional control valve, Dynamic characteristics, Nonlinear region

Presenter Paolo Leutenegger 10:00 - 10:20
Liebherr-Elektronik GmbH
Germany

Topic LiView®: a disruptive sensor technology for intelligent hydraulic components

LiView® is an innovative stroke transducer for hydraulic cylinders, that is based on the electrical measurement of the cylinder structure in order to gain information on the piston absolute position and speed. In our paper we present the main characteristics of the LiView® product, the achieved results in the last two years of development and we discuss the performance of the system as measured throughout the many test campaigns run both at cylinder and machine level in the first target customer applications. Moreover, the implications deriving by the use of this technology on hydraulic systems are discussed, showing its disruptive potential for future machines.

Keywords: Cylinder stroke measurements, disruptive technology, cylinder state measurement, real-time state, high-speed...

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GROUP 10: DIGITALIZATION, CONNECTIVITY & COMMUNICATION

CHAIR Prof. Rudolf Scheidl
Johannes Kepler University Linz
Austria

EUROPE HALL
11:00 - 12:30 a.m.

Presenter Dr. Maxim Andreev 11:00 - 11:20
ESI ITI GmbH
Germany

Topic Pipeline simulation by the method of characteristics for calculating the pressure pulsation of a high-pressure water plunger pump

The article describes ways to adapt the method of characteristics to solving the problem of pressure pulsation calculation of a high-pressure plunger water pump considering a complex pipeline network using a CAE software "SimulationX". The objective of this adaptation is to increase the stability of the numerical solution and reduce the calculation time. To verify the accuracy of the simulation, the pressure pulsations were compared with pulsations in various parts of a real complex pipeline. As a result, a compromise between accuracy and speed of calculations was achieved, which improves the process of pump development.

Keywords: Fluid power networks, digitalization, connectivity, communication

Presenter Vincent Rémillard 11:20 - 11:40
Famic Technologies Inc.
Canada

Topic Simulating an Electrohydraulic Self-Levelling Loader by Means of CAN Bus Connected Devices

The necessity for greener, flexible and more efficient equipment has led OEMs and manufacturers to create intelligent fluid power systems. The complexity of the design of these integrated solutions, involving many fields of expertise, provides significant challenges. Control Specialists and system designers have their own knowledge domains so there is an increasing need to use an integrated simulation platform so they can work together. Hybrid modelling methods of mechatronics software, integrating equation- or model-based modelling and datamapping from test results– known as Machine Knowledge Management – have many benefits. By combining these fields of expertise using co-simulation between software and hardware, control specialists and application experts will be properly integrated in the design and analysis process.

Keywords: CAN bus, Fluid Power, Electronic controls, Simulation, Mechatronics

Presenter Prof. Kazushi Sanada 11:40 - 12:00
Yokohama National University
Japan

Topic Condition for Real-time Measurement of Power of Unsteady Fluid Flow in a Pipe by Kalman Filter

In this paper, a real-time measurement system of power of incompressible unsteady laminar flow in a pipe using a Kalman filter is studied and condition for successfully performing the real-time measurement is discussed focused on the number of element of a pipeline model used for the Kalman filter. The optimized finite element model of pipeline dynamics is used as a plant model of the Kalman filter. The number of element for finite approximation may influence on accuracy of the approximation. Large enough number of element to approximate pipeline dynamics may increase real-time computational task of the Kalman filter. In this paper, the optimized finite element model integrated with the Kalman filter is briefly introduced. The Kalman filter with the optimized finite element model is installed in a real-time computing system. Turnaround time of the Kalman filter is measured for various numbers of element. The turnaround time is a key factor to...

Keywords: Indirect measurement, Kalman filter, Pipeline dynamics, Incompressible fluid flow, Real-time system

Presenter Norman Brix 12:00 - 12:20
Bosch Rexroth AG
Germany

Topic Torque Control for Mobile Machines

The movement of a vehicle is determined by the torque acting at the wheel. With the speed-controlled engine in mobile machines, the torque characteristics at the wheel are determined by the transmission. Traditionally, this is realized with the inherent mechanic-hydraulic torque behaviour of the components, like a torque converter or an axial piston pump. The disadvantage of this approach is the missing flexibility, resulting in trade-offs like low fuel efficiency or high effort for the realization of control functions. In contrast, the ongoing electronification of mobile machines is the enabler for a new, much more flexible technological approach for hydrostatic drive trains: Torque Control.

Keywords: Hydrostatic Transmission, Vehicle Control, Power Management, Efficiency, Torque Control

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GROUP 11: PNEUMATICS

BRUSSELS HALL
11:00 - 12:30 a.m.

CHAIR Dr. Peter Saffe
Aventics GmbH
Germany

Presenter Maximilian Waerder
RWTH Aachen University
Germany
11:00 - 11:20

Topic Psychoacoustic analysis of pneumatic switching valve noise

Pneumatic components and systems are usually considered to be rather unpleasant according to their acoustic appearance especially in the area of industrial large-scale production plants. Within these applications the major part of the noise emission coincides with the outlet ports of valves where the working medium is depressurized. However, former research and development have yield constructive measures and components as mufflers reducing the absolute magnitude of the measurable sound level to a tolerable range. Regulations and legal requirements might thus be satisfied, yet the subjective perception of the sound still tends to be labeled as uncomfortable or even unbearable. These aspects are not considered within the typical metrics of the sound pressure or power level. In order to achieve objective comparisons and an absolute classification of the sound perception psychoacoustic analysis might be adduced. In this study, the correlation...

Keywords: Pneumatics, Noise, Acoustics, Psychoacoustics, Valve design

Presenter David Rager
Festo AG & Co. KG
Germany
11:20 - 11:40

Topic New programmable valve terminal enables flexible and energy-efficient pneumatics for Industry 4.0

This paper presents the Festo Motion Terminal, a new programmable valve terminal, and its technical concept. On this basis, a new type of pneumatic motion control is developed. Two main features – electronic controllable motion and energy-efficiency – are addressed that enhance pneumatic drives from sole mechanic components towards a mechatronic system. The control is an adaptive open-loop control which uses an estimated position and velocity signal of the piston. Cost-efficient integrated components and software-based functionality make this concept economic as well as flexible – essential attributes for Industry 4.0.

Keywords: pneumatic drive, valve terminal, energy efficiency, position estimation, digitalization

Presenter Fedor Nazarov
TU Dresden
Germany
11:40 - 12:00

Topic A Novel Approach for Pneumatic Pressure Booster

Pneumatic pressure boosters are widely applied in handling systems to increase the network pressure. Although they may enable a considerable energy saving for the entire pneumatic system, there is still a large potential for performance improvement. However, the boosting technologies in other domains, as the electrical DC-to-DC converters, present high efficiency. In the given study transferability of electrical DC-to-DC converters into pneumatics was investigated and the potentials of new circuits were researched. Based on the lumped parameters simulation results the most prospective concepts were identified using the three criteria: maximal pressure gain, exergy efficiency, and mass flow rate. The prototypes were implemented on a test rig to verify the simulation results and to compare them with each other.

Keywords: Pressure booster, Pneumatics, Efficiency

Presenter Prof. Joao Falcão Carneiro
University of Porto
Portugal
12:00 - 12:20

Topic Experimental characteristics of a linear peristaltic actuator

Pneumatic systems are widespread whenever linear motion between two endpoints is required. However, mainly due to friction forces, motion control is difficult. This paper explores a different solution, based on a linear peristaltic principle, to overcome this problem. The pneumatic actuator proposed has several potential advantages over conventional ones: long strokes require little added cost, curved motion profiles are possible and friction force at low velocities presents better characteristics than the ones of conventional actuators. This paper presents a preliminary study of elementary experimental characteristics of the proposed solution. It is shown that no stick slip occurs at low velocities, whilst maintaining force capabilities similar to those of conventional actuators.

Keywords: Servopneumatic systems, pneumatic actuators, conventional motion control

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GROUP 12: COMPONENTS

CR 4/5
11:00 - 12:30 a.m.

CHAIR Dr. Gerd Scheffel
Parker Hannifin GmbH
Germany

Presenter Peter Kloft 11:00 - 11:20
HYDAC Technology GmbH
Germany

Topic Edge welded metal bellows accumulators

Edge welded metal bellows accumulators are the cutting edge of hydro-pneumatic accumulators. Compared with other designs such as diaphragm-, bladder- or piston accumulators the gas chamber is usually hermetically sealed and the metallic barrier between gas and fluid side shows no permeation. This design is maintenance free and keeps its performance for the whole service live. They have extraordinary media compatibility and an extremely wide operational temperature range. HYDACs newest design is mounted on a jet engine. It withstands very high external loads such as vibrations, shocks and fire. One special feature is an indicator which allows checking the integrity of the metal bellows without having a sealed component.

Keywords: hydraulic accumulator, metal bellows, indicator

Presenter Dr. Olivier Reinertz 11:40 - 12:00
RWTH Aachen University
Germany

Topic A comparative study on dither signals and their parameterisation

Driving signals of electromechanical control valves require a well dosed dynamic excitation to reduce hysteresis and to optimise dynamics. Nevertheless, a knowledge based signal definition and parameterisation is rarely possible. The paper attempts to close this knowledge gap by analysing the valve's dynamics with commonly used signals and control schemes. Hence, parameter estimation rules for adapting given parameters for one signal form to another are deduced. Finally, experimental validation of the findings is carried out by comparison of the dynamics of a customary valve driven by the different control signals. The paper concludes with recommendations for dither signal parameterisation.

Keywords: Pulse Width Modulation, Dither, Electro Hydraulics, Control Valve

Presenter Sangbeom Woo 11:20 - 11:40
Purdue University
United States of America

Topic A model based approach for the evaluation of noise emissions in external gear pumps

This paper contributes to the topic of modelling noise generation and propagation in hydraulic pumps, particularly focusing on the external gear pumps. By using proper methodologies for the fluid, structure, and air domains, the model proposed in this study can predict the resultant noise emissions coming from the interactions between these three domains. Two cases of numerical simulations were performed, considering a different complexity for reproducing the pump mounting conditions. For validation purposes, noise measurements were taken in a semi-anechoic chamber on a commercial unit. The effects of the mounting situation on the overall emitted noise as well as the level of the agreements between simulation and experiments are discussed.

Keywords: External gear pumps, Vibro-acoustic modelling, Fluid-borne noise, Structure-borne noise, Air-borne noise

Presenter Prof. Takao Nishiumi 12:00 - 12:20
National Defense
Academy of Japan
Japan

Topic Development of a novel Helmholtz hydraulic silencer for attenuating the pressure ripple from a fixed displacement pump with variable rotational speed

Pressure pulsations are caused by the flow ripples from a positive displacement hydraulic pump. They are transmitted throughout fluid power equipment and cause unwanted excitations of the mechanical parts. In many practical applications, a Helmholtz type hydraulic silencer may be used to attenuate such pulsations. It is the preferred solution on account of its simple structure and high attenuation performance. However the distinctive drawback of this silencer is that it is effective only within a narrow range of the attenuating frequency. Therefore, the silencer is only suitable for use in hydraulic systems, running at constant pump rotational speeds. The purpose of this research is to develop a novel silencer for hydraulic systems that have a fixed displacement pump driven at variable rotational speeds. First, a mechanism for adjusting the resonant frequency has been proposed. This works by changing the volume of the silencer. Secondly, a prototype...

Keywords: Helmholtz type hydraulic silencer, pressure ripple, displacement pump, variable rotational speed, transmission loss

NOTES

GROUP 13: DESIGN PROCESS

EUROPE HALL
01:30 - 03:00 p.m.

CHAIR Prof. Siegfried Helduser
TU Dresden
Germany

Presenter Dr. Jürgen Berbuer 01:30 - 01:50
Entwicklungsbüro für Fluidtechnik
Germany

Topic Efficiency by design: Piston pumps and motors with predefined tribological systems enable prediction and optimization of losses and efficiency

Predefined tribological systems enable the designer of hydrostatic pumps and motors to leave the domain of mixed friction contacts and obtain a new way of design. The locations of force conduction and gap sealings evolve from incalculable subsystems into machine elements with predictable and computable properties. The method is displayed and validated by the example of the RAC (radial piston machine) development and leads to a novel concept for an axial piston pump and motor that promises a favourable efficiency chart and excellent start-stop-properties (patent pending).

Keywords: Hydrostatic pump and motor, friction, tribology, energy losses, efficiency, hydrostatic bearing

Presenter Rüdiger Kampfmann 01:50 - 02:10
Bosch Rexroth AG
Germany

Topic State-of-the-art and future methods for model-based engineering in practical applications

Continuously increasing demands for more powerful and more efficient hydraulic machines lead to a rising complexity of these systems. Using model-based development methods is one approach to face this challenge. This implies, that the entire development process, from the definition of requirements through to the design, commissioning and operation of the system is supported by physical models. In this paper, an overview about the enhancements arising from model-based engineering methods is presented. Therefore, first methods focusing on the design/commissioning phase, which are already used within industrial applications are presented. Afterwards, currently developed techniques aiming on the operation phase of a system, which are enabled through the upcoming digitalization, are considered.

Keywords: Connected hydraulics, system simulation, model-based engineering, smart services, parameter estimation

Presenter Andreas Dietrich 02:10 - 02:30
Thomas Magnete GmbH
Germany

Topic Computer Aided Development and Optimization of Electrohydraulic Pump Actuators for Mobile Applications

This article describes the analysis and selection of an electrohydraulic pump actuator by means of simulations in order to optimize operation for any given hydraulic system. The focus is on developing a multidisciplinary method of analysis. This involves interlinking various submodels such as the electric motor model, pump model and cost model with a system model. With the help of this method, a large number of designs can be analyzed automatically for the purpose of assessing the behaviour of the overall system. This delivers a preferred design variant tailored to the customer's requirements.

Keywords: Multidisciplinary analysis method, electrohydraulic pump actuator, product development process, cost models

Presenter Dr. Georg Schoppel 02:30 - 02:50
Bosch Rexroth AG
Germany

Topic Virtual Engineering in Hydraulic Valve Design

This paper elaborates on the use of virtual engineering methods such as Computational Fluid Dynamics (CFD), Finite Element Method (FEM) and system simulation to significantly improve the performance of hydraulic valves. The different simulation methods are used in conjunction to tackle the typical conflicts of goals in hydraulic engineering (e.g. pressure resistance vs. pressure drop). The approach is illustrated and the results are shown in two hydraulic valve engineering projects.

Keywords: Virtual Engineering, Simulation, Hydraulic Valves, Optimization

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GROUP 14: PNEUMATICS

BRUSSELS HALL
01:30 - 03:00 p.m.

CHAIR Prof. Peter Post
Festo AG & Co. KG
Germany

Presenter Dr. Wolfgang Gauchel
Festo AG & Co. KG
Germany
01:30 - 01:50

Topic Automated Commissioning of Pneumatic Systems

A significant part of the costs of a pneumatic motion in a machine is caused by commissioning. Today every cylinder chamber needs to be connected by tube to the exactly right port of the valve terminal. In this paper a new concept for commissioning pneumatic systems is presented, where the tubes can be plugged in any arbitrary port of the valve terminal. So the commissioning can be fastened – and money can be saved. The concept bases on the Festo Motion Terminal, a new valve terminal whose valve slices can exercise different valve functions. The functionality change is made only by software. This versatility can be used for the automated commissioning.

Keywords: Commissioning, Digitalisation, Business Model

Presenter Philipp Hedrich
TU Darmstadt
Germany
01:50 - 02:10

Topic Active Pneumatic Suspension for Future Autonomous Vehicles: Design, Prove of Concept and Hardware-in-the-Loop Simulations

In this article, we present a new concept of an active air spring, which can apply pressure and tension forcesindependently of its deflection. The active strut mitigates body oscillations and improves the driving comfortmaking it attractive for autonomous driving to avoid motion sickness. The model of the active air spring systemand the controller design are described. Furthermore, the suitability of the actuator concept for use in an activechassis is shown. Finally, we show results of hardware-in-the-loop simulations.

Keywords: active suspension, active air spring, hydraulic actuator, controller design, hardware-in-the-loop

Presenter Harald Kuolt
J. Schmalz GmbH
Germany
02:10 - 02:30

Topic Vacuum generation for handling technology: mobile, autonomous and energy efficient

In automated production systems handling is a key technology. Especially for gripping and clamping of workpieces, vacuum automation plays an essential role in all industry segments. Core part of a vacuum gripping system is the vacuum generation. Pneumatically driven vacuum generators are widespread in the handling technology. Due to the technological development there are also new tasks and challenges, because in future applications there is a trend that compressed air will hardly be available. In this paper it is presented, how electrically driven vacuum generators can increase the energy efficiency of mobile handling systems and also in addition to that can influence new forms of work, like human-robot collaboration.

Keywords: Vacuum Handling, Automation, Human-Robot Collaboration, Energy Efficiency

Presenter Shuai Ren
Beihang University
China
02:30 - 02:50

Topic A pressure-time adaptive algorithm of a new simulated cough device based on pneumatic system

Nowadays, assisted cough devices are widely used in airway mucus clearance for patients who cannot cough autonomously. However, these devices use an open loop system where the inspiration pressure and time cannot be adapted to each other, which may cause over or under-inflation. In this paper, a new simulated cough device based on pneumatic system is presented. Moreover, a pressure-time adaptive algorithm is proposed to settle the mismatching problem of inspiration pressure and time. Both simulation and experimental studies are conducted to estimate the applicability of this algorithm for different compliance in a simulated lung. This paper provides a constructive suggestion for the development of airway clearance technologies.

Keywords: assisted cough device, mucus clearance, adaptive algorithm, simulation, experiment

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GROUP 15: COMPONENTS

CR 4/5

CHAIR Dr. Frank Bauer
HYDAC Technology GmbH
Germany

01:30 - 03:00 p.m.

Presenter Thomas Kramer 01:30 - 01:50
TU Dresden
Germany

Topic Intelligent Condition Monitoring of Bi-stable Process Valves

Bi-stable latching valves are an energy-efficient alternative to mono-stable switching valves especially in applications of process technology requiring low switching frequencies. However, the bi-stability of such valves may be disadvantageous, since external forces can change the valve state randomly without being noticed by the controller. Condition monitoring by using position estimation method enables a valve state determination and thus, safe cost- and energy-efficient bi-stable valves as alternative to mono-stable switching valves. The paper shows an implementation of a periodic determination of the valve's state into a cost-efficient electronics for commercial use. Differential inductance method serves as position estimation method, which requires only a voltage and current measurement. Different methods for its calculation are performed and investigated in a realistic environment by using a fluid operated valve.

Keywords: bi-stable valve, polymer bonded magnetic material, self-sensing position determination, condition monitoring

Presenter Christophe Habegger 01:50 - 02:10
SONCEBOZ SA
Switzerland

Topic New generation of intelligent electromechanical valve actuation

Modern hydraulic systems of mobile machines are requiring components with new control structures, in order to be compatible with the modern networks of the future. The new generation of electro-mechanic valve actuation technology of Sonceboz is presented in this paper. Compared to the previous actuator, the performance has increased significantly. Moreover, the new control concept enables a wide range of connectivity and on-board diagnostic features. The result is a high innovative valve actuation system with online diagnostic functions that can operate in a network with decentralized intelligence. Therefore, supporting hydraulic valve manufactures to meet the challenges for the highly connected systems of tomorrow.

Keywords: Mobile hydraulics, valve actuation, connectivity, OBD, decentralized intelligence

Presenter Wolfgang Bock 02:10 - 02:30
Fuchs Schmierstoffe GmbH
Germany

Topic Hydraulic Fluids - Solutions of Complex Requirements

The presentation will introduce special hydraulic fluids, with which fluid technology solutions for complex requirements, especially exceptional stresses, boundary lubrication, can be offered. Newly developed hydraulic fluids for high-pressure operations are presented, which will meet the increased requirements of redesigned pump tests and test field trials. In this case the respective material combination and the additivation which is adjusted to the pressure and temperature level, plays a decisive role. Moreover special hydraulic fluids, latest application-specifically adjusted development trends and a short overview of the main base oil and additive trends are mentioned.

Keywords: Hydraulic oils, hydraulic fluids, high pressure pump tests, base oils, EP/AW additives

Presenter Roland Fietz 02:30 - 02:50
Freudenberg Selaing Technologies GmbH
Germany

Topic Online Calculation of Guide Rings for Hydraulic Cylinders

Hydraulic cylinders are some of the hydraulic components which convert the energy into force and / or movement at the end of the hydraulic circuit. Side loads can occur, which must be absorbed by guide elements. A simplified FEM-based calculation method and test methods of plastic guide rings are described, depending on various parameters (material, deflection, angular misalignment, geometrical conditions, etc.). For the product developers, material-specific prognosis of the guide elements behaviour are possible, regarding stresses, strains and load-bearing capacity of the guide elements, considering the specific dimensions and general conditions, due to a company-internal, parameterized FEM tool. In consequence of an optimized design, the number or the width of the guide elements in a cylinder can possibly be reduced, the resulting advantage could be a shorter length of the cylinder components and corresponding cost reduction.

Keywords: Hydraulic cylinder, bearing ring, guide ring, wear band, FEM Material Modeling

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Many Thanks for Sponsoring IFAS Labyrinth

GROUP 16: SYSTEMS

EUROPE HALL
03:30 - 5:00 p.m.

CHAIR Dr. Christoph Boes
Moog GmbH
Germany

Presenter Bert Brahmer **03:30 - 03:50**
Voith Turbo H+L hydraulic GmbH&Co.KG
Germany

Topic On Adaptive Electro Hydrostatic Actuators

Whenever decision makers want to follow the trend towards "all-electric" machines, but still need to maintain the major advantages of hydraulic drives, electro hydrostatic actuators (EHA) have become the technology of choice for industrial applications. In an EHA, a variable speed electric motor drives a displacement pump which is directly coupled to the actuator, namely a cylinder. After proofing the functionality of this concept in many commercial applications, current developments are targeting features and levels of efficiency that will even outperform the electro mechanical state of the art. Adaptive electro hydrostatic actuators will finally be the benchmark in terms of compactness, ease of use and energy efficiency for many application classes. This paper presents two different implementations for variable pitch EHAs and a mobile device for EHA fluid management and service.

Keywords: EHA, Adaptive Electro Hydrostatic Actuator, Hybrid Drive, Sizing Trap, Downsizing

Presenter Dr. Heiko Baum **03:50 - 04:10**
FLUIDON GmbH
Germany

Topic Disordered flow to the reservoir – measures to improve the situation

To reduce cycle times, hydraulic drives become consciously more dynamic, what consequently leads to higher fluid exchange rates. On the part of the pressure supply no effort is too big for the design engineers. The return pipe to the tank is, however, often still calculated with rough formulas. This can lead to damages to the plant by cavitation, water hammers and diesel effects and is no longer up-to-date. On investigating water hammer events in tank-pipes it becomes obvious that an examination with simple rough calculations is not leading to the desired results. Too many factors must be considered at the calculation of water hammer. Fortunately, nowadays the numeric simulation can calculate the pressure gradient and the pressure am-plitude of a water hammer in very good approximation. Thus, by means of simulation a basic understanding of the problem in the tank pipe can be achieved. In this contribution the boundary conditions which lead to the emergence...

Keywords: water hammer, cavitation, column separation, tank pipe, simulation

Presenter Dr. Edgar Weishaupt **04:10 - 04:30**
HYDAC Systems & Services GmbH
Germany

Topic 2oo3plus – A New Design of Electro-hydraulic Safety Controls for Critical Applications

This paper presents an alternative design approach of electrohydraulic safety manifolds for use in quick-closing actuators. Setting off from the common 2oo3 voting architecture, a separation of flow paths produces a new solution employing six solenoid-operated 2/2-way poppet valves with electrical coupling. The technical discussion exhibits various advantages, such as improved reliability, both from a systematic and from a probabilistic point of view. It is shown that the new 2oo3plus system beats common other structures with regard to the safety metrics according to IEC 61508.

Keywords: IEC 61508, SIL, 2-out-of-3 voting, Functional Safety, valve actuator, turbine trip

Presenter Dr. David van Bebber **04:30 - 04:50**
Ford Research And Innovation Center Aachen
Germany

Topic System Resonance Frequency Analysis With Distributed Parameter Cylinder Models

During the working stroke of hydraulic cylinder drives unexpected and unwanted resonances in attached pipes are often unavoidable. A main reason is the continuous change of the system's natural frequency because of variable piston and cylinder positions. An analytical investigation of variable resonance situations is difficult since geometric boundary conditions like e.g. diameters and lengths of pipes/cylinders as well as nonlinear effects like e.g. the fluid's compressibility or a viscous-elastic tube expansion must be considered. Typically, concentrated parameter models are used for cylinder drive simulations, though such models are not capable to represent the exact influence of variable cylinder chamber volumes on the resonance situation. This publication presents a new approach that realizes a variable cylinder chamber volume or length in combination with a advanced distributed parameter approach. With theoretical fundamental investigations as well ...

Keywords: simulation, pressure wave, hydraulic cylinder, pipe, resonance

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GROUP 17: MOBILE APPLICATIONS

BRUSSELS HALL
03:30 - 5:00 p.m.

CHAIR Prof. Ludger Frerichs
TU Braunschweig
Germany

Presenter Seiji Hijikata — 03:30 - 03:50
RWTH Aachen University
Germany

Topic A Hydraulic Hybrid Architecture combining an Open Center with a Constant Pressure System for Excavators

Although energy efficiency of an Open Center System (OC-System), used widely for excavators, has been improved from the perspective of hydraulic efficiency, total efficiency including the engine has not been taken into account sufficiently. Meanwhile, a Constant Pressure System (CP-System) enabling the engine to be driven optimally is developed but is not accepted in the industry due to complexity of components. Thus in this research, a hybrid system combining an OC-System with a CP-System is proposed enhancing total efficiency. This system is designed for simulation based on the basic theory and the analysis of measurement data. The simulation shows it consumes 30 % less fuel than the conventional OC-System

Keywords: Hydraulic Hybrid, Open Center, Constant Pressure, Energy Efficiency

Presenter Ulrich Lenzgeiger — 03:50 - 04:10
Bosch Rexroth AG
Germany

Topic Electronic Load Sensing for Tractors

Hydraulic load-sensing systems have become state-of-the-art technology for tractors. They combine high energy efficiency with ease of use and functionality. However, current systems are suitable for comprehensive machinery management only to a limited degree, particularly if there is a wide variety of different implements. With electronic load-sensing (e-LS) machine manufacturers are able to individually, actively and dynamically optimize the hydraulic system in response to various requirements relating to the implement and work process. Improved productivity and efficiency increase the economic benefit of the machine and new functions allow automated and monitored workflows for a simplified machine operation.

Keywords: Tractor hydraulics, Load Sensing, electronics, connectivity, automation

Presenter Daniel Dix — 04:10 - 04:30
XCMG ERC
Germany

Topic From driver feedback to valve spool

In the last decades, simulation tools and virtual prototypes were vastly promoted to speed up development processes. But for complex systems, the modelling and model validation effort is very high, and always some modelling inaccuracies have to remain due to account for effective cost and computational effort for the simulations and validation tests. To contribute to the discussion from another point of view, this paper will present a new approach to speed up development by extreme reduction of hardware iteration time to test changes of main valve spool geometry according to operator feedback.

Keywords: control edges, valves, design process, design tool, CAM

Presenter Thales Agostini Ribeiro Batista — 04:30 - 04:50
Universidade Federal de Santa Catarina
Brazil

Topic Boosting Efficiency of an Excavator by Zonal Hydraulics

Hybridization is frequently applied in order to increase the energy efficiency of off-road and construction machinery. One such novel energy saving method was proposed for working hydraulics, based on an established zonal concept for airplanes. The introduced method supplied the power on demand to the actuators, utilizing direct-driven hydraulics in machinery. However, component selection plays a significant role in order to achieve high efficiency. Therefore, the primary goal is to evaluate the energy efficiency of selected components for the front hoe of the micro excavator under the digging and levelling cycles. The efficiency of the zonal hydraulic pre-selected components was evaluated utilising a developed Matlab/Simulink model and energy efficiency maps.

Keywords: Excavator, Zonal Hydraulics, Energy Efficiency, Efficiency Map, Sizing, Direct Driven Hydraulics

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ANNIVERSARY LECTURES

EUROPE HALL
5:15 - 6:30 a.m.

1st Speaker	Univ.-Prof. Dr.-Ing. Ernst Schmachtenberg Rector RWTH Aachen University Germany	05:15 - 05:25
2nd Speaker	Dr. Shimpei Miyakawa Chairman of ADS Technical Committee Japan Fluid Power Association Tokyo, Japan	05:25 - 05:40
Topic	Bond of 3+ Decades of an AvH Awardee at RWTH Researching Water Hydraulics	

This is an introduction of the 33-year-long technology development and market launch for ADS (Aqua Drive System: New Water Hydraulics), which uses tap water (additive free) as working fluid. The technology development started from the stay of the author at RWTH Aachen University at IHP/IFAS on November 1984 and continued till July 2017, leading to the present success. ADS is to be positioned as a fourth driving technology that comes after oil hydraulics, pneumatics, and electrical drives. Nowadays safety and security are relevant technologies that add novel values (oil-free, effective use of water resources) to new markets of ADS such as healthcare/medicine, foods, semiconductors, packaging, and beverage.

3rd/4th Speakers	Univ.-Prof. Dr.-Ing H. Murrenhoff / Univ.-Prof. Dr.-Ing. K. Schmitz Head of IFAS RWTH Aachen University Germany	05:40 - 06:30
Topic	50 Years of Fluid Power Research at RWTH Aachen University - Highlights and Future Challenges	

The lectures of the parting director Prof. Hubertus Murrenhoff and the future director Prof. Katharina Schmitz complete the series of plenary lectures. Prof. Murrenhoff looks back on 50 years of interdisciplinary research. Prof. Schmitz outlines the future direction of the institute and its intended research activities. The contributions also include the Best Paper Award from the Global Fluid Power Society (GFPS) for the conference's best scientific contribution.

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SCIENTIFIC POSTER SESSION

Monday	01:00 p.m. - 10:00 p.m.
Tuesday	10:30 a.m. - 07:00 p.m.
Wednesday	09:00 a.m. - 06:30 p.m.

GROUP PA : COMPONENTS

Standard Sealing Systems for Hydraulic Cylinders
Gonzalo Barillas I Freudenberg Selaing Technologies GmbH I Germany
Martin Goerres I Freudenberg Selaing Technologies GmbH I Germany

The improvement of the total efficiency of the gerotor orbital hydraulic motor
Ervin Strmcnik I Faculty of Mechanical Engineering Ljubljana I Slovenia

An active-control digital hydraulic damper: Design, Modeling and simulation
Dr. Chenglong Wang I Shandong University of Science and Technology, China

A control approach for fast voice coil actuators for servo valve applications in mobile and industrial hydraulics
Dr. Lucian Nascutiu I Technical University of Cluj-Napoca I Romania

GROUP PB : DESIGN PROCESS

The optimization design algorithm of hydraulic components under multiple operating conditions
Jiaming Wang I State Key Laboratory of Fluid Power and Mechatronic Systems I China

GROUP PC : INDUSTRIAL APPLICATIONS

Development of an integrated monitoring and filtration system for assuring performance of hydraulic mould oscillation systems used in continuous casting machines at flat steel plants
Dr. Taher Salah El-Din I EZDK I Egypt

Experimental Investigation of a Directly Driven Hydraulic Unit in an Industrial Application
Dr. Tatiana Minav I Aalto University I Finland

Reliability Evaluation of Hydraulic Pump Based on Performance Degradation
Prof. Lijie Zhang I Yanshan University I China

GROUP PD : MOBILE APPLICATIONS

Energy Loss Analysis of an Electro-Hydraulic Excavator
Dr. Tatiana Minav I Aalto University I Finland

SCIENTIFIC POSTER SESSION FOYER | Upper Floor

GROUP PE : NEW & SPECIAL APPLICATIONS

Wireless Control of an Electro-Hydraulic Robotic Manipulator
Prof. Zeljko Situm I University of Zagreb I Croatia

A new type of hydraulic swing drive with integrated motion sensor for narrow spaces
Wei Cai I Yanshan University I China

Hydraulic Multi-axial Leveling Control for Turbine Access System of Offshore Wind Farms
Prof. Mao-Hsiung Chiang I National Taiwan University I Taiwan

GROUP PF : PNEUMATICS

Application of Pneumatic Muscle Actuator to Pulse Diagnosis System of Chinese Therapy
Prof. Jyh-Chyang Renn I National Yunlin University of Science and Technology I Taiwan

Fault Diagnosis of Pneumatic Actuator Based on Virtual Prototype Fault Simulation
Prof. Wanlu Jiang I Yanshan University I China

On Stability of the Two Stage Piloted Gas Pressure Control Unit
Prof. Viktor Sverbilov I Samara National Research University I Russian Federation

GROUP PG : SYSTEMS

Principle and Application in FAST of Parallel Reliability Test BenchProf.
Wei Cai I Yanshan University I China

GROUP PH : TRIBOLOGY & FLUIDS

Oil film characteristics and failure mechanism analysis of one kind of mechanical seal under the effect of fluid-structure-thermal coupling
Yueheng Song I Beihang University I China

Innovative Structural Design and Coupled Vibration Analysis of the Bionic Hydraulic Pipeline
Jun.-Prof. Lingxiao Quan I Yanshan University I China

Experimental Researches to Measure the Total Resistance Forces That Appear at tht Switching Process of Directional Control Valves
Dr. Corneliu Cristescu I Hydraulics and Pneumatics Research Institute INOE 2000-IHP I Romania

Surface tension of fuels – Analysis of measurement methods and applicability on high-pressure surroundings
Marcel Rückert I RWTH Aachen University I Germany