CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

8.40
9.00 — Opening by Prof. Murrenhoff

Group SA	Group SG	Group SC
Simul.	**Syst.**	**Pneu.**
4SL | CR 2	4SL | CR 4/5	4SL | CR 7/8/9

10.00 — [Break]

Group SD	Group SJ	Group SF
Syst.	**Mobile**	**M&F**
4SL | CR 2	4SL | CR 4/5	4SL | CR 7/8/9

12.00 — [Lunch CR 1]

Shuttle to IFAS

Group SB	Group SH	Group SL
DFP	**Simul.**	**Comp.**
5SL | CR 2	4SL | CR 4/5	5SL | CR 7/8/9

14.00 — [Break / Exhibition]

Group SE	Group SK	Group SI
DFP	**Simul.**	**Comp./ New Apps**
5SL | CR 2	5SL | CR 4/5	3SL | CR 7/8/9

16.00 — [Break]

Scientific Poster Session

18.00 — Opening Evening at Exhibition

22.00

CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

8.40
9.00 — Opening Address
2 PL EH

Plenary Lectures
1 GL / 2 SL EH

10.00 — [Break / Exhibition]

Shuttle to IFAS

Group A	Group B	Group C
New Apps	**Pneu.**	**Simul.**
4SL | EH	3SL & 1GL | BH	4SL | CR 4/5

12.00 — [Lunch CR 1/2]

Shuttle to IFAS

Group D	Group I	Group E
Syst.	**Simul.**	**Comp.**
3SL & 1GL | EH	4SL | BH	4SL | CR 4/5

14.00 — [Break / Exhibition]

Group G	Group H	Group F
Mobile	**Syst.**	**Pneu.**
3SL & 1GL | EH	4SL | BH	4SL | CR 4/5

16.00 — [Break / Exhibition]

Exhibition & Scientific Poster Session

18.00 — Conference Banquet

22.00

CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

8.40
9.00

Group J	Group K	Group L
Simul.	**Mob. Apps**	**Comp.**
3 SL | EH	4SL | BH	4SL | CR 4/5

10.00 — [Break / Exhibition]

Shuttle to IFAS

Group M	Group N	Group O
Rnw. Energy	**Syst.**	**Comp.**
4SL | EH	4SL | BH	4SL | CR 4/5

12.00 — [Lunch CR 1/2]

Shuttle to IFAS

Group P	Group Q	Group R
Comp.	**Simul.**	**Autom.**
4SL | EH	4SL | BH	4SL | CR 4/5

14.00 — [Break / Exhibition]

Group S	Group T	Group U
Mob. Apps	**New Apps**	**F&S**
4SL | EH	4SL | BH	4SL | CR 4/5

16.00

Exhibition & Scientific Poster Session

Final Lectures / Farewell Address
2 PL + Farewell EH

18.00 — Shuttle to IFAS

19.00 — Laboratory Party

OPEN END

Aftershow Party

PL : Plenary Lecture | GL : General Lecture | SP : Specialised Lecture

EH : Europe-Hall | BH : Brussels-Hall | CR : Conference Room

DFP : Digital Fluid Power | M&F : Materials and Fluids | F&S : Fluids & Systems

Peer Reviewed | E English | G German Language

CONFERENCE

SYMPOSIUM
Monday, 9:00 am - 5:45 pm

OPENING

CR 2
9:00 - 9:20 a.m.

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

NOTES

CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

SIMULATIONS

CR 2
9:20 - 10:45 a.m.

CHAIR Prof. Petter Krus
Linköping University
Sweden

Presenter Tobias Corneli
TU Darmstadt
Germany
09:20 - 09:40
SL

Topic Development of a Hydrostatic Load Balancing System for Three-spindle Screw Pumps

In principle screw pumps are low-noise and theoretically pulsation-free positive displacement pumps. They are basically used in oil and chemical industry. Delivered liquids are e.g. jet fuel (circa 1 cSt) as well as very viscous liquids like heavy fuels (up to 100 000 cSt). For low viscosities and low rotating speeds the achievable pressure difference is limited due to the lifting force of the hydrodynamic journal bearing. The presented concept enables to increase the pressure operation limit of the screw pump.

Keywords: Screw pump, load balancing, hydrodynamic journal bearing

Presenter Stephan Wegner
RWTH Aachen University
Germany
09:40 - 10:00
SL

Topic Simulation of the tribological contact cylinder block / valve plate and influence of geometry and operating point on friction torque

In this paper a simulation program for the cylinder block / valve plate interface is presented. The aim of this program lies on producing results for different design geometries at different operating points within a reasonable time. The comparison of these results regarding hydrostatic, hydrodynamic pressure build up, solid and viscous friction helps understanding the geometric variations and can lead to an optimized interface in terms of leakage and friction. First results presented here focus on viscous and solid friction and show the main functionality of the program.

Keywords: ribological contact, cylinder block, valve plate, viscous friction, solid friction, Reynolds equation

Presenter Karl Hatmann
TU Braunschweig
Germany
10:00 - 10:20
SL

Topic A fast and universal method for deriving two-dimensional simulation parameters from complex pump geometries

Tight requirements concerning noise emission of hydrostatic pumps in various applications even affect small pumps working on low pressure levels which are already relatively quiet. Modifying these pumps in order to get a better result in flow and pressure pulsation poses a challenge because of their very complex geometries of parts. Theoretical analyses of switching characteristics or simple pump simulations require two-dimensional design parameters, which cannot be directly obtained from CAD. In order to support design optimization on these pumps, a universal method has been developed that allows an automation of the parameterization process.

Keywords: CFD, simulation, gerotor pump, flow ripple, pressure ripple

Presenter Atanas Mishev
University of Stuttgart
Germany
10:20 - 10:40
SL

Topic Development of a new gerotor pump with innovative gerotor design and investigation of its hydraulic characteristics through CFD Analysis

Oil pumps, including vane, gerotor, crescent and external gear pumps, are a critical component in many industrial applications. Generated rotor (gerotor) pumps are internal rotary positive-displacement pumps in which the outer rotor has one tooth more than the inner rotor. The inner and outer gear tooth profiles are described by epitrochoidal equidistance and circular arcs respectively. Due to their compact design, low cost, and robustness gerotor pumps are commonly used for cooling, lubrication, and filtration systems, for pumping liquids such as oil, transmission fluid, and fuel. They provide high volumetric efficiency and smooth pumping action and they work well with a wide range of fluid viscosities. In this paper a new gerotor pump with innovative gerotor design is presented and fundamentally investigated ...

Keywords: CFD, simulation, gerotor pump, flow ripple, pressure ripple

SYSTEMS

CR 4/5
9:20 - 10:45 a.m.

CHAIR Prof. Dr.-Ing. Georg Jacobs
RWTH Aachen University
Germany

Presenter Dr. Dirk Wehner 09:20 - 09:40
Hydrive Engineering GmbH SL
Germany

Topic Development of a New Pressure-Compensator-Valve for Hydrostatic-Hydrodynamic Journal Bearings

The main objective of the research project HYDROS /1/ was the development of a new hydrostatic bearing system with improved properties especially in terms of robustness, efficiency and space requirement. Beside the design of the bearing body with the bearing grooves, the choice and design of the inlet resistances for the lubricating oil supply was one of the main research focuses. A new simple inlet resistance based on the principle of a pressure compensator was invented during these investigations. The paper presents the functionality as well as the design process and discusses many advantages and its performance by experimental results.

Keywords: hydrostatic bearing, hydrodynamic bearing, inlet resistance, pressure compensator

Presenter Robert Prabel 09:40 - 10:00
University of Rostock SL
Germany

Topic Norm-Optimal Iterative Learning Position Control for a Servo-Hydraulic Cylinder

This contribution deals with the model-based control of two hydraulic cylinders that are mechanically coupled by a rigid rod and actuated each by individual servo-valves. Based on a control-oriented nonlinear mathematical model of the mechatronic system, a subsequent model simplification is performed, and two decentralised, completely controllable single-input single-output (SISO) state space representations are derived. For such motion tasks, where repetitive desired trajectories are to be tracked as accurate as possible, iterative learning control strategies have become popular. This paper presents an innovative control approach where a norm- optimal iterative learning control (NOILC) for the position of the two coupled hydraulic cylinders is combined

Keywords: Iterative learning control, nonlinear backstepping control, hydraulic cylinder, control-oriented

Presenter MD PhD Ruilin Feng 10:00 - 10:20
Zhejiang University SL
China

Topic MIMO Adaptive Robust Control of a Metal Powder Compaction Press

To deal with multivariable regulation and coordinate of multi-actuator in the sophisticated forming process of hydraulic metal powder compaction (MPC) presses, a systematic MIMO adaptive robust control (ARC) method is employed in this study. A control oriented model is constructed to describe the system dynamics concerning the nonlinearity and parameter uncertainty of the electro-hydraulic servo system. The model is divided into two subsystems corresponding to force regulation and motion control respectively. ARC control law is derived by back-stepping design based on Lyapunov function. With the resulting ARC control law plus trajectory initialization applied, the stability, tracking transient and final tracking accuracy are guaranteed.

Keywords: adaptive robust control, metal powder compaction press, electro-hydraulic servo system

Presenter Prof. Dr. Mao-Hsiung Chiang 10:20 - 10:40
National Taiwan University SL
Taiwan

Topic The Leveling Position Control and Active Anti-Vibration Control of a Four-axial Pneumatic Isolation System Using PWM-Driving Parallel Dual-On/Off Valves

This study aims to develop a leveling position control and anti-vibration control of a four-axial pneumatic isolation table system with novel PWM-driving parallel dual-on/off Valves. A novel concept using parallel dual- on/off valves with PWM control signals is implemented to realize active control and to improve the conventional pneumatic isolation table that supported by four pneumatic cushion isolators. In this study, the cushion isolators are not only passive vibration isolation devices, but also pneumatic actuators in active leveling position control and anti-vibration control. Four independent closed-loop position and velocity feedback control system are designed and implemented for the four axial isolators. In the controller design the adaptive sliding-mode controller is used to deal with the ...

Keywords: leveling position control, anti-vibration control, pneumatic servo system, pneumatic isolator,

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PNEUMATICS

CR 7/8/9
9:20 - 10:45 a.m.

CHAIR Dr.-Ing. Rüdiger Neumann
Festo AG
Germany

Presenter Florian Fritz
Uni Stuttgart
Germany
09:20 - 09:40
SL

Topic Approach of an energy assessment method for vacuum handling systems

Due to rising energy costs and the political postulation of carbon emission reduction, taking energy aspects into account during the design of handling solutions is essential. Depending on the used energy form and the system solution, the assessment has challenges as there are many dependencies within the system that do not allow the direct energetic comparison between these systems. Therefore, a structured energy assessment method is developed. An approach of investigating the specific energy consumption of a single handling process step is given. This can be used as an evaluation criterion in the decision phase as well as input for further investigation like LCC and LCA.

Keywords: vacuum handling, gripper, energy assessment, energy efficiency

Presenter Elvira Rakov
TU Dresden
Germany
10:00 - 10:20
SL

Topic Comparison of Methods for the Investigation on the Energetic Behaviour of Pneumatic Drives

In this article three methods for the investigation of the energy behaviour of pneumatic drives are presented. These methods have already been presented separately in different scientific work. In contrast to these publications this paper aims at the comparison of these methods. Moreover the methods are analysed with regard to their applicability for identifying energy saving potentials of pneumatic drive structures and to support the use of energy saving measures. The paper presents different effects that have influence on the energy consumption of pneumatic drives. The thermodynamic equations and boundary conditions of each method are discussed and compared. The methods extremely differ in relation to the required parameters and state variables. The more complex exergy analysis is able ...

Keywords: Pneumatic drives, exergy analysis, air power, compressed air consumption calculation

Presenter Johannes Storz
RWTH Aachen University
Germany
10:20 - 10:40
SL

Topic Designing a Hot Gas Bulge Test

Bulge tests are testing devices to examine material properties as flow curve and forming-limit curves of sheet metals under the same condition as they occur in most sheet metal forming processes. The increased application of hot stamping, especially in the automobile production, demands the enhancements of the existing bulge tests for higher temperatures and strain rates. Standardized bulge tests use hydraulic oil as forming medium. The forming process is commonly quasi-static and without strain rate control. A new design of a hot gas bulge test realises the requirements to measure the forming process under the condition of hot stamping up to 900 °C. An analysis of the expected material behaviour leads to possible configurations. A concept of parallel valves to control the bulge test is chosen and examined for the use in a bulge test.

Keywords: leveling position control, anti-vibration control, pneumatic servo system, pneumatic isolator,

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SYSTEMS

CR 2

11:15 - 12:35 a.m.

CHAIR Prof. Dr.-Ing. Thorsten Lang
TU Braunschweig
Germany

Presenter Michael Sprengel
Purdue University
United States of America
11:15 - 11:35
SL

Topic Investigation and Energetic Analysis of a Novel Blended Hydraulic Hybrid Power Split Transmission

Hydraulic hybrid transmissions for both on-road and off-highway vehicles is a rapidly growing field. In this paper a novel Blended Hybrid Power Split Transmission (PST) is proposed with benefits over conventional hydraulic hybrid systems. A baseline manual transmission, a series hybrid PST, and the novel blended hybrid PST were modeled and simulated in a compact SUV driving the UDDS cycle. All three transmissions were optimally controlled to remove control as a factor affecting fuel consumption and permit a fair comparison. Ultimately the novel architecture was able to decrease energy consumption by 15.9% when compared against a conventional series hybrid PST.

Keywords: blended hybrid, power split transmission, on-road vehicles, dynamic programming, optimal control

Presenter Philipp Pöttgen
TU Darmstadt
Germany
11:35 - 11:55
SL

Topic Technical Operations Research (TOR) exemplified by a Hydrostatic Power Transmission System

The possibilities of fluid power system design include different components and control strategies for the same function. Thus the final topology is usually designed by the practical experience of an engineer and afterwards verified. "Technical Operations Research" (TOR) first encourages a phase of description and then uses mathematical optimization tools, known from Operations Research, to develop and structure a technical system. In contrast to parameter optimization, the topology of the system is not fully required, but can be created within the optimization process. The main advantage of this approach is the guarantee for global optimality within the model. We present an optimal topology for a hydrostatic power transmission system.

Keywords: Optimization, topology, system, power, efficiency.

Presenter Sebastian Michel
TU Dresden
Germany
11:55 - 12:15
SL

Topic Energy-efficiency and thermo energetic behaviour of electrohydraulic compact drives

This paper focuses on the simulation of thermo energetic behaviour of electrohydraulic compact drives, in order to predict their temperature in operation. For a demonstrator a thermo-hydraulic model is developed, that includes a thermal resistance network model. The resistance network is parameterized analytically by means of known approaches from literature for basic model shapes and implemented into a system simulation model with lumped parameters. Simulation results are validated against measurements on the demonstrator, whose temperature is captured with thermo elements and a thermographic camera.

Keywords: Electrohydraulic compact drive, energy-efficiency, thermo energetic simulation

Presenter Qihuay Chen
Zhejiang University
China
12:15 - 12:35
SL

Topic The research on construction machinery potential energy regeneration

The excavator is widely used in all kinds of earthwork construction, but due to the low efficiency of hydraulic system, some energy regeneration should be put forward. The paper introduces a compound energy regeneration system that based on electric-hybrid system. Compound energy regeneration system, which shares an electrical storage component with power system, can effectively improve the energy utilization without additional expense. However the traditional energy regeneration system results in poor dynamic characteristics. A compound energy regeneration, which combine throttle-governing and regeneration devices, can guarantee the dynamic characteristics of system and realize the maximum efficiency of energy recovery. For its simple layout, it can be applied to different actuators, the paper will ...

Keywords: construction machinery, hybrid system, electric-hybrid system, energy regeneration, compound

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MOBILE

CR 4/5

11:15 - 12:35 a.m.

CHAIR Dr. ir. Peter Achten
INNAS B.V.
Netherlands

Presenter Mikael Axin
Linköping University
Sweden
11:15 - 11:35
SL

Topic A Hybrid of Pressure and Flow Control in Mobile Hydraulic Systems

This paper presents a hybrid pump controller approach for mobile hydraulic systems, influenced by both pressure and flow. The controller is tuneable to be able to set the order of importance of the pressure and flow controller, respectively. It is thus possible to realize a load sensing system, a flow control system or a mix of the two. Using a low load pressure feedback gain and a high flow control gain, a system emerges with high energy efficiency, fast system response, high stability margins and no flow matching issues. In this paper, both theoretical studies and practical implementations demonstrate the capability of a hybrid pump control approach.

Keywords: Mobile hydraulics, pressure control, flow control, energy efficiency, dynamics

Presenter Min Cheng
Institute of mechatronic control engineering
China
11:35 - 11:55
SL

Topic Efficiency Improvement for Electrohydraulic Flow Sharing Systems

Flow sharing system with load sensing is a popular technology in mobile hydraulics since it improves the operability and energy efficiency of multi-actuator systems. In this paper, a flow sharing system with electrohydraulic flow matching control was experimentally discussed on a test bench with a mini excavator. Besides, a novel valve control method is proposed to further improve energy efficiency under overall working conditions. The valve openings can be adaptively regulated according to the working point by utilizing working pressure feedback. The pressure losses of the valves can be reduced while the actuator velocity performance can be ensured. The feasibility of the proposed controller has been validated by simulation results.

Keywords: Energy saving, Flow matching, Flow sharing, Load sensing

Presenter Guido Francesco Ritelli
Purdue University
United States of America
11:55 - 12:15
SL

Topic Experimental-Auto-Tuning Method for Active Vibration Damping Controller. The Case Study of a Hydraulic Crane

The paper describes an experimental-based technique to determine the control parameters of a control strategy aimed to reduce oscillations in hydraulic machines. In electro-hydraulic machines, it is common practice to tune the controller through analytical and/or trial and error procedures. Very often these approaches are time consuming and inaccurate. The research takes as reference the control of the mechanical arms of a mid-size hydraulic crane. To highlight the potentials of the proposed technique, the crane was initially configured with a particular settings of the counterbalance valves which promotes the oscillatory tendency of the machine. The results shows how it was possible to obtain an acceptable dynamic behaviour through an automated tuning process.

Keywords: On-line control, Control auto-tuning, hydraulic cranes, oscillation damping

Presenter Naseem Daher
Purdue University
United States of America
12:15 - 12:35
SL

Topic New Steering Concept for Wheel Loaders

Boosting the efficiency, productivity, safety, and intelligence of mobile machines is of utmost importance to original equipment manufacturers, system suppliers, and end consumers given the accelerated demand on fossil fuels, increased environmental awareness, and impetus for mitigating hazardous operation. This work deals with a novel steering technology that addresses the above needs for articulated mobile machines, wheel loaders in particular. In a steering-only cycle, the new technology results in 14.5% fuel savings, 22.6% productivity gain, and 43.5% fuel efficiency increase as measured on a prototype test vehicle. From an active safety standpoint, the new technology offers the potential for devising yaw stability control via active steering by employing a virtual yaw rate sensor, which reduces ...

Keywords: construction machinery, hybrid system, electric-hybrid system, energy regeneration, compound

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MATERIALS & FLUIDS

CR 7/8/9
11:15 - 12:35 a.m.

CHAIR Dr.-Ing. Gerhard Schuster
Argo-Hytos
Germany

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

Topic Toward Better Energy Regeneration and Efficiency through Hydraulic Fluid Selection in an Electro-Hydraulic Forklift

The goal of this study is to improve the potential of energy recovery to electric energy in an electro-hydraulic forklift system. A previous study showed that achieved ratio of up to 40% for energy savings can be achieved. The tested drive consists of a DTC controlled electric servo motor directly connected to a reversible hydraulic pump. According to this study, the energy efficiency and the energy recovery from the electro-hydraulic forklift system can be increased by 5 to 18 %-units by choosing appropriate hydraulic oil. New ideas and directions of further research were obtained during the study.

Keywords: Electric drive, energy efficiency, forklift, Lithium-titanate battery, potential energy recovery ...

Presenter Stefan Heitzig
RWTH Aachen University
Germany
11:35 - 11:55
SL

Topic Measurement and Simulation of Friction Forces in Piston/Bushing-Contacts operating with Tailor-Made Biofuels

Within the cluster of excellence "Tailor-Made Fuels from Biomass" at RWTH Aachen University new biofuels are developed and investigated. To ensure a safe and reliable functioning of the new fuels in combination with state of the art fuel injection equipment, every fuel has to fulfil minimum requirements regarding lubricity. Hence, one focus of the cluster lies on the tribology of the fuel candidates. Compared to diesel fuel the so far investigated biofuels differ strongly in their tribological characteristics. To investigate the impact of the fuel candidates on the tribological contacts in standard common-rail pumps a piston-test-rig was set up. The rig allows the measurement of friction forces in a piston/bushing-contact under realistic operating conditions. In the test rig all components of the relevant fuel lubricated ...

Keywords: Friction, Common-Rail-Pump, Simulation, Biofuel

Presenter Dr. Franc Majdič
University of Ljubljana
Slovenia
11:55 - 12:15
SL

Topic Piston-Type Accumulator for Water Power-Control Hydraulics

Environmental protection regulations are becoming increasingly strict, so the storage and regeneration of energy are of great importance. In this paper a newly developed, 4-litre, water-hydraulic accumulator of working pressure up to 390 bars is presented. A prototype was manufactured and certificated by the European pressure directive PED 97/23/EC. The results, based on the measurements of the characteristic properties of the hydraulic dynamics and thermodynamic changes of the gas (nitrogen) in the hydraulic accumulator using two different liquids (hydraulic oil and water), are presented and compared for three different pre-set pressures of nitrogen (30, 60 and 90 bar) and four different thermodynamic processes. A significant difference in the tested hydraulic accumulator efficiency was found, ...

Keywords: Water, mineral hydraulic oil, piston-type hydraulic accumulator, thermodynamic process, efficiency

Presenter Paul W. Michael
Milwaukee School of Engineering
United States of America
12:15 - 12:35
SL

Topic An Investigation of Hydraulic Motor Efficiency and Boundary Lubrication Additive Effects

This paper investigates boundary film formation, friction, and surface topography in benchtop tribometers and hydraulic motors. Fluids investigated varied in antiwear additive, friction modifier, and base oil composition. The mechanical efficiencies of geroler, axial piston, bent axis, and radial piston motors were measured under low-speed conditions. The friction modifier increased motor efficiency. EDX analysis of motor surfaces after testing revealed the presence of tribochemical films from the hydraulic fluid additives. In benchtop tribometer testing, the friction modifier reduced friction but exhibited higher wear. This could be related to surface competition of the friction modifier and antiwear chemistries. Insights towards the development of fluids that enhance motor efficiency are presented.

Keywords: Boundary Lubrication, Friction Modifying Additives, Hydraulic Motor Efficiency

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DIGITAL FLUID POWER

CR 2

01:45 - 03:30 p.m.

CHAIR Prof. Dr.-Ing. Rudolf Scheidl
TU Linz
Austria

Presenter Tapio Lantela
Aalto University
Finland
01:45 - 02:05
SL

Topic Analysis of the performance of fast acting miniature solenoid actuator for digital valves

Digital hydraulic valve systems consist of several on/off valves connected in parallel. These valves require a small, fast acting and energy efficient actuator. This article studies the performance of five soft magnetic materials for the magnetic circuit of a solenoid actuator, as well as the effect of the number of coil turns and the size of the coil on the response time and the energy consumption of the actuator. The studied actuator is utilised as the pilot actuator of a miniature valve. The performance is evaluated with finite element simulations and experimental tests. A response time of less than 0.5 ms is achieved with a 0.4 mm armature movement.

Keywords: Digital hydraulics, electromagnetic actuator, finite element method

Presenter Daniel Skelton
Purdue University
United States of America
02:05 - 02:25
SL

Topic Design of High Performance Actuation System for Valves

This paper introduces an innovative high performance actuation system for hydraulic valves based on the coupling of energy storage components. The Energy Coupling Actuator (ECA) allows the moving component of a valve (poppet, spool etc.) to be momentarily coupled and decoupled with an already moving mass to produce linear motion. This paper also presents the design and testing of a prototype ECA which uses a MR fluid coupler to validate a coupled-physics model that was developed early in the design phase. The experimental testing was conducted so as to validate the concept of using a momentum coupling mechanism to achieve high speed valves for digital hydraulic applications.

Keywords: Digital, high speed, valve, magneto rheological fluid

Presenter Miika Paloniitty
Tampere University of Technology
Finland
02:25 - 02:45
SL

Topic Concept of Digital Microhydraulic Valve System Utilising Lamination Technology

Digital hydraulic valve systems have been studied much during the last decade. Most theoretical advantages of the digital hydraulic valve systems have been verified with test systems. Experimental research has been concentrated on valve systems where the flow rates of the valves are adjusted according to the powers of two. An alternative approach is to use a wide array of one size miniaturised on/off-valves. Previous research indicates that this approach has a great number of benefits. These benefits, however, have not been verified with experimental results so far. The reason is the lack of a suitable miniature valve which is a sufficiently low cost and usable in this kind of valve system. To fill this demand, a research project has been carried out at the Tampere University of Technology. The research has ...

Keywords: Pulse number modulation, laminated manifold, digital hydraulics, control principle

Presenter Tobias Dreher
TU Dresden
Germany
02:45 - 03:05
SL

Topic Systematic analysis of the performance potential of solenoids used in pneumatic switching valves

The electromagnetic actuators of switching valves have a distinct mechatronic character with nonlinear properties and therefore, further development addresses demanding challenges to their manufacturers. In this research project, a multi-domain simulation model is used for the calculation and the systematic analyses of the influences of all relevant design parameters on the valve performance. All elements of the network simulation model are determined by a geometry model, which is an abstracted parametric description based on the design data of the valves. This abstraction also enables the transferability of the results to hydraulic applications. The multi-domain network model is coupled to an optimisation tool, which is suitable to efficiently carry out extensive parameter studies. As a result, the ...

Keywords: switching valves, magnetic actuators, parameter studies, performance potentials

Presenter Miikka Ketonen
Tampere University of Technology
Finland
03:05 - 03:25
SL

Topic Retrofitting digital hydraulics – An analytical study

Reason for the slow adaptation of new greener technologies is often the need for large modifications in products or systems. Different kind of regenerative pump-motor transformers might give an optimal solution for the energy efficiency of upcoming hydraulic systems, but the authors' viewpoint is that it will take decades before the technology is going to be widely adopted. On the other hand especially the industrial hydraulic systems have long lifetimes and the large scale of the system often makes it unprofitable to fully rebuild the system for improved energy efficiency. In order to improve the existing industrial and mobile hydraulic systems in a shorter time range, retrofittable digital hydraulic valve concepts are presented to replace the old proportional and servo valves. In this paper, the advantages of the three different digital valve ...

Keywords: Digital hydraulics, Retrofitting, Digital Valve System, Pressurized return line, Regenerative pressure line

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SIMULATION AND VALIDATION

CR 4/5
01:45 - 03:30 p.m.

CHAIR Prof. Yeh-Sun Hong
Korean Aerospace University
Korea

Presenter Dr. Mohamed Elgamil
Cairo University
Egypt
01:45 - 02:05
SL e

Topic Dynamic Performance of Servovalves with Closed Center Type Pilot Stage

In this paper some aspects of the performance of a new class of hydraulic servovalves incorporating pilot shafts inserted inside the valve main spools are investigated. The pilot control orifices are shaped so that the main spool displacement follows the pilot shaft input angular displacement without need of spool position feedback sensor. These valves have large pilot pressure sensitivity, high speed of response, capability of replacing three or more stages with only two stage valves and provide a good chance to improve the system total efficiency. These valves also consume only on demand pilot oil flow rate and hence their efficiency is high. With this kind of pilot valves, simple two land spools that provide flow force compensation could be used. The valve mathematical model is derived and solved numerically for

Keywords: servovalve, pilot stage, closed center, dynamic response, stability, self-feedback, flow force

Presenter Dr. David van Bebber
Ford Forschungszentrum Aachen
Germany
02:05 - 02:25
SL e

Topic Computer Experiment - From Design of Experiment to System Optimization

Increasing complexity of hydraulic and other related technologies in combination with the demand of reduced development times and costs, results in tasks that cannot be solved with classical development approaches. Numerous system parameters and conflicting optimization criteria leads to extensive testing and simulation. Computer Aided Engineering (CAE) can help to solve the increased demands in early development phases, while allowing the engineer to consider even more parameters in the investigation and optimization process. Traditional statistical methodologies, which were developed for physical experiments, known as Design of Experiment (DoE) are helpful, however unable to utilize all special characteristics of computer simulations such as the absence of measurement noise. Thus in

Keywords: Computer Experiment, Design of Experiment, Meta-Models, Multi-Objective Optimization

Presenter Prof. Dr. Victor Juliano De Negri
Federal University of Santa Catarina, Brazil
02:25 - 02:45
SL e

Topic Analysis of the influence of geometric parameters on the characteristic curves of directional control valves

This paper discusses the influence of the internal geometry on the steady-state characteristic curves of directional spool valves. Standards such as IEC 60308 and ISO 10770 series establish steady-state and dynamic characteristics that must be achieved by directional valves under specific operating conditions. Aiming to support the analysis and design of directional on/off and continuous control valves, a model based on the principles of fluid mechanics has being studied which allows the analysis of the influence of internal geometry on the behavior of flow rates and pressures. In this paper theoretical and experimental results of an overspeed sensor are presented taking into account the standard requirements. Some characteristics such as hysteresis, pressures at the working ports, and internal leakage ...

Keywords: Directional control valves, internal geometry, characteristic curves, manufacture tolerances

Presenter Johannes Willkomm
Bosch Rexroth AG
Germany
02:45 - 03:05
SL e

Topic Model Predictive Control of Speed-Variable Variable-Displacement Pumps to Optimize Energy Efficiency

In recent years, a trend towards speed-variable pump drives has become apparent. By using an axial piston pump with variable displacement, motor speed and volume flow can be decoupled. The resulting degree of freedom can be used to increase the energy efficiency of hydraulic processes. This paper introduces a novel model predictive control concept which ensures minimum energy consumption for any given hydraulic process. By means of a dynamic loss model energy savings of up to 30% can be achieved in comparison to known approaches. In particular, the performance of the new model predictive concept for highly dynamic processes will be proved, in which common control strategies have become inefficient.

Keywords: Model predictive control, energy efficiency, speed-variable pump, electro-hydraulic drive

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COMPONENTS

CR 7/8/9
01:45 - 03:45 p.m.

CHAIR Dr.-Ing. Christoph Boes
Moog
Germany

Presenter Yang Li
Beihang University
China
01:45 - 02:05
SL

Topic Design and Analysis of a Novel Direct Drive Pump Based on Collaborative Rectification

In this paper, a modular direct drive pump system based on novel rectification construction is proposed. The fundamental subsystem is the direct drive pump cell (DDPC). A DDPC consists of a piston and a spool valve, and the rod and the spool are integrated and driven together. The functional pump system is constructed through conduits connections between two or more DDPCs. The valid construction principles are logically modelled and summarized in the form of theorem. The kinematic output flow rate model of a typical double-DDPC pump module is established. The discussions indicate the fluid displacement of the novel pump system is flexible and easy to control.

Keywords: direct drive; collaborative rectification; construction principles; displacement control

Presenter Andrew Schenk
Purdue University
United States of America
02:05 - 02:25
SL

Topic A transient fluid structure interaction model for lubrication between the slipper and swashplate in axial piston machines

Axial piston hydraulic machines rely on adequate lubrication between numerous sliding interfaces for long term, efficient operation. Previously, design of these interfaces has been accomplished using significant prototyping, a costly and time consuming process. A sophisticated numerical model has been developed, focused on one sliding interface between the slipper and swashplate, which aims to predict lubrication performance of different designs under multiple pump operating conditions. Due to rapidly varying pressures, the transient model considers a thermo-elastohydrodynamic lubrication problem by analyzing both the fluid and solid domains in a novel numerical coupling scheme. Simulation results for a slipper design are presented, comparing the impact of differing operating conditions as well as ...

Keywords: Axial piston pump, slipper, fluid structure interaction, transient deformation

Presenter Barbara Jennewein
University of Kaiserslautern
Germany
02:25 - 02:45
SL

Topic Effects of dynamic loads on the wear of rotary shaft seals

Radial lip seals made of elastomer are used to prevent lubricant leakage in machineries. So far, the wear behaviour under the effect of radial vibrations and static eccentricity of the shaft, which always occur in practice, has never been studied experimentally. This paper presents experimental results of the lip seals wear under static and dynamic loads with varying frequency and amplitude. As a result, the seals with an ideal centred shaft and housing exhibit the best wear behaviour. The amount of wear is significantly increased by static eccentricities or shaft oscillations.

Keywords: wear, rotary shaft seal, dynamic loads, eccentricity, elastomer

Presenter Prof. Andrea Vacca
Purdue University
United States of America
02:45 - 03:05
SL

Topic An Experimental Investigation of the Lateral Lubricating Gaps in External Gear Machines with Axially Balanced Lateral Bushes

Axially balanced lateral bushes are components found in External Gear Machines (EGM) used for high pressure applications and are essentialforefficient operationofsuch machines. The present workis focusedon a detailed experimental investigation aimed at measuring the lateral gap lubricant film thickness using capacitive displacement sensors. The experimental measurements were performed on a prototype EGM, where the capacitivesensorswereinstalledonthepumpbody. Inadditiontothefilmthickness measurements conducted using the capacitive sensors - detailed measurements of the EGM body were conducted using a coordinate measuring machine. In addition, thermo-elastic deformation analysis of the pump body under pressure and

Keywords: External Gear Machine, Film Thickness Measurements, Capacitive Sensors

Presenter Prof. Jing Li
Tongji University
China
03:05 - 03:25
SL

Topic Investigation on the Thermodynamic Characteristics of a Hydraulic Piston Accumulator

Hydraulic accumulators are widely used in systems to restrain pressure pulsation and absorb transient impact, or as flow rate supplement. This article presents a thermo-mechanical-coupling model of a hydraulic piston accumulator based on theories of energy conservation and heat transfer. Compare to traditional hydraulic accumulator models treating nitrogen as ideal gas in isothermal or adiabatic, real-time heat exchange between nitrogen and ambient, then the items caused by dynamic temperature of nitrogen are considered in the pressure reflection in the coupling model. Working conditions are discussed to investigate the thermodynamic performance of a piston accumulator using in a hydraulic brake subsystem of X-type aircraft by simulating and testing.

Keywords: Hydraulic piston accumulator, Thermo-mechanical-coupling model, Thermodynamic characteristic,

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DIGITAL FLUID POWER

CR 2

04:00 - 05:40 p.m.

CHAIR Prof. Dr.-Ing. Seppo Tikkanen
TU Tampere
Finland

Presenter Christoph Gradl 04:00 - 04:20
Johannes Kepler University
Austria
SL

Topic A pulse-frequency controlled hydraulic drive for the elastic deformation of a structure

Various control strategies in digital hydraulics have been studied and published in the last years. Pulse Frequency Control (PFC) which – opposite to PWM – uses the pulse repeating frequency and not the pulse width as control input, is a fairly new control concept in digital hydraulics. PFC may be to be preferred if the hydraulic switching device can realize a very particular pulse in a favourable way, e.g. concerning energetic efficiency, simplicity and cost of components, or ease of component or control standardization. This paper deals with the application of PFC to the control of a hydraulic drive. It is assumed that a digital flow unit (e.g. digital pump) can realize only one particular flow pulse which can be repeated any time but not before the previous pulse is finished. As a consequence, the relative ...

Keywords: PFC, pulse frequency control, digital hydraulic, Bernoulli-Euler beam

Presenter Mikko Heikkilä 04:20 - 04:40
Tampere University of Technology
Finland
SL

Topic Digital Hydraulic Power Management System with Five Independent Outlets – Simulation Study of Displacement Controlled Excavator Crane

Earlier simulations as well as measurements have shown the potential of the Digital Hydraulic Power Management System (DHPMS). The machine can function as a pump, a motor and a transformer, and due to multiple independent outlets, actuators with arbitrary pressure levels can be efficiently served. In addition, pre- compression and pressure release phases can be optimized for every point of the operation, thanks to the actively controlled on/off valves of the pumping pistons. Hence, the energy stored into compressed fluid is possible to utilize optimally. In this study, a DHPMS with five outlets is modelled and a controller is created to directly control two actuators; a lift cylinder and tilt cylinder of a small excavator crane. An accumulator is attached to the fifth outlet and the accumulator ...

Keywords: Digital hydraulic hybrid, Digital Hydraulic Power Management System, Displacement control, Energy

Presenter Christian Stauch 04:40 - 05:00
ZeMA Zentrum für Mechatronik und Automatisierungstechnik GmbH, Germany
SL

Topic Flatness Based Control for a Digital Hydraulic System

This contribution is concerned with flatness based control design for a class of digital hydraulic drives based on an independent metering approach. As an example, a fixed-displacement motor driving an inductive load with variable load torque is considered. The motor is controlled by means of switching valves in full bridge arrangement allowing for four quadrant operation. Additionally, hydro-pneumatic accumulators are connected to each port for pulsation smoothing. For the resulting nonlinear multiple input multiple output problem, a flatness based tracking controller involving a cavitation avoidance strategy is presented. The control method proposed is applicable to both major digital hydraulic principles: the fast switching approach (pulse width modulation) and the parallel connection ...

Keywords: digital fluid power, independent metering, flatness based control, load observer

Presenter Andreas Plöckinger 05:00 - 05:20
Linz Center of Mechatronics GmbH
Austria
SL

Topic Digital Hydraulics for An Industrial Micro-Positioning System

At the 13th Mechatronics Forum International Conference in 2013 a novel Micro- Positioning System for a multispindle milling machine was presented. The purpose of this system is to compensate relative positioning errors of simultaneously operating spindles of multi spindle mill centres. In the first system a fast proportional control valve was used to fulfil the needs on reaction time and accuracy. This paper reports about a digital hydraulic control concept for the micro-positioning drive replacing the proportional valve of the first system. The use of fast digital valves in combination with a standard industrial motion controller allows an increase of the accuracy compared to proportional valve control. The absolute position accuracy of that digital system depends much more on the precision of the position sensor ...

Keywords: digital hydraulics, micro positioning, machine tools

Presenter Markus Flor 05:20 - 05:40
Bosch Rexroth AG
Germany
SL

Topic Generating application benefits by using an intelligent combination of digital hydraulics throttle control and variable-speed displacement unit drives

Speed-variable pump systems (svp) can significantly improve the efficiency of a hydraulic system. Anyhow, such systems have weak spots with regard to certain duty points. 1bit digital hydraulics systems on the other hand have been proven to be very precise and energy efficient but unsatisfactory at high volume flows. This paper presents a combination approach of svp and 1bit digital hydraulics in order to compensate for the individual weaknesses of each approach. The combination circuit, the modes of operation and the expected advantages are illustrated. The experimental research carried out is being described and the results with regard to control quality, performance and energy efficiency are being presented and evaluated.

Keywords: Digital hydraulics, ballistic mode, combination approach, variable-speed displacement unit

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SIMULATION

CR 4/5
04:00 - 05:40 p.m.

CHAIR Prof. Eric Bideaux
INSA de Lyon
France

Presenter Satoru Ohashi
IHI Corporation
Japan
04:00 - 04:20
SL

Topic The simple measurement method of the viscoelastic character in a viscoelastic pipe

Viscoelastic characteristic is known as an important consideration when we calculate the pressure propagation or frequency response in a viscoelastic pipe like a high-pressure rubber hose which is often used in various hydraulic systems. However, in order to determine the viscoelastic properties for a hose, a complicated measurement and procedure using an exclusive use measurement bench is required. In this paper, a simple method for determining the viscoelastic properties of a hose is described, and the measurement results of viscoelastic characteristic in several different kinds of hoses are shown.

Keywords: viscoelastic characteristic, viscoelastic pipe, hose, simulation, bulk modulus

Presenter Dr. Gudrun Mikota
Johannes Kepler University
Austria
04:20 - 04:40
SL

Topic A multi-degrees-of-freedom model for hydraulic pipeline systems

A multi-degrees-of-freedom approximation is set up for a pipeline network that connects a pump with two hydraulic cylinders. Pressure pulsations resulting from the pump's flow rate pulsations are simulated in all system nodes. An eigenvalue analysis reveals the natural frequencies and pressure mode shapes of the network. High pressure pulsation levels are explained by the fact that the network operates near a lightly damped resonance. By adding auxiliary pipelines at two pressure mode shape antinodes, the relevant natural frequency is lowered, resulting in an effective reduction of pressure pulsation. A comparison of transcendental and approximated transfer functions demonstrates both accuracy and restrictions of the method.

Keywords: Simulation, hydraulic networks, natural frequencies, mode shapes, system tuning

Presenter Dr. Marat Gimadiev
Samara State Aerospace University
Russia
04:40 - 05:00
SL

Topic Simulation and Experimental Results of Unsteady Flow in Pipe System of Processing Plant

The important problem arising at operation of technological installations at the enterprises of energy, chemical, oil-processing and food industries is ensuring their reliability in conditions of high dynamic loadings of pipelines. The unsteady hydrodynamic processes occurring in pipeline highways at fast opening and closing of valves often lead to loss of sealing of pipelines' joints, breakage of fittings and can become the reason of emergencies. Such processes are especially dangerous to the pipelines made of polymeric materials being widely applied today, for example, in power plants. About 90 tanks-filters of chemical water purification with a capacity of 30 m3 with hundred meters of the pipeline 150mm diameter in which unsteady flow is occurred are operated in by- product recovery departments of large combined heat and ...

Keywords: unsteady flow, plastic pipe, flow-structure interaction, valve, reaction force

Presenter Vasil Slavov
University of Stuttgart
Germany
05:00 - 05:20
SL

Topic Simulation of the dynamic behaviour of hydraulic hoses

The simulative investigation in the structural dynamics and acoustics has become essential during the recent years and nowadays has turned into inseparable part of the development process. In order to investigate the vibrational and dynamic behaviour of hydraulic hoses and complete hydraulic system a finite element model was built and validated. The first part of this paper describes the validation procedure of the hydraulic hose finite element model. The FE-Model was validated applying the results of the conducted modal analysis, which were compared with the simulative modal properties by solving an optimization problem. Numerous parameter studies were carried out under different boundary conditions in order to investigate the hose dynamic behaviour Furthermore this model was implemented in an existing ...

Keywords: hydraulic hose, vibration, simulation

Presenter Tobias Speicher
Hochschule für Technik und Wirtschaft des Saarlandes
Germany
05:20 - 05:40
SL

Topic New system optimization opportunities by simulation based line tuning

An optimized line system increasingly influences the competitiveness of hydraulic systems because of steadily rising standards for provided comfort, such as low noise and little vibration emissions, and efficiency besides the basic requirement of a stable system behavior. To meet these demands, system developers are often forced to elaborate active countermeasures in the form of complex control strategies, especially for systems that show a high degree of pressure and flow pulsation, e.g. digital hydraulics. But there are also possibilities of passive influence, for example by adapting the line system. The problem here, however, is the high experimental effort that is required by these adjustments. In this paper we discuss, by using the example of a hydraulic hose, how this experimental effort can be significantly reduced by using new ...

Keywords: time domain simulation, hose line model, pulsation and noise reduction, system optimization

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COMPONENTS

CR 7/8/9
04:00 - 05:40 p.m.

CHAIR Dr.-Ing. Sebastian Mundry
Caterpillar Mining
Germany

Presenter MD PhD Massimiliano Ruggeri
IMAMOTER
Italy
04:00 - 04:20
SL

Topic A novel fault tolerant high precision roto-traslating spool valve

A Roto-Translating valve of the spool type is described, focusing both on design and control characteristics. The new patented design is realized assembling a spool to a sleeve, the two parts are moved by two independent actuators and are placed to into the valve body. The valve can realize both basic logic functions (AND, OR), both advanced control techniques, moreover in term of safety it offers a fail operational characteristic, in reason of an operational redundancy and functional diversity. A remarkable enhancement of speed and precision is achieved by the use of two concurrent actuators, moreover the flexibility allow to get rid of the need of a specific spool design for each different application.

Keywords: Proportional Valve, roto-translating valve, fault tolerant, functional safety, torque motor, rotary coil

Presenter Dr. Zengmeng Zhang
Dalian Maritime University, China
04:20 - 04:40
SL

Topic Research on High-Strength Water Hydraulic Artificial Muscle for Underwater Manipulator

The water hydraulic artificial muscle pertains to the application in underwater manipulators widely used in ocean development, with high force-to-weight ratio, fast response, good bio-imitability. However, it is necessary to improve the strength of the water hydraulic artificial muscle to fit the requirements of underwater environments and the work pressure of water hydraulic components. This paper describes the geometric construction and processing technique of high-strength artificial muscles. Meanwhile, a test system is designed and built to experimentally analyse drive characteristics. The theoretical relationship among the amount of contraction, pressure and output drawing force of the water hydraulic artificial muscle is tested and verified.

Keywords: Water hydraulics, high-strength artificial muscle, drive characteristic, underwater manipulator

Presenter Stefan Hein
TU Bergakademie Freiberg
Germany
04:40 - 05:00
SL

Topic Contribution to the innovation of the measuring dynamics in the oil hydraulics

The contribution introduces a new dynamic measurement system for the hydraulic volume flow. Opposite electric drive systems a decisive competitive disadvantage is removed with that. There the dynamic already belongs stand type to this from electrical power and tension to masses. On the other hand, up till now only the pressure can be measured without problems dynamically in the oilhydraulics. It is shown at the example of a wind power station how advantageously the simultaneous dynamic measuring of both status quantities is used at electric drive systems . In analogy for these successes the new dynamic volume current measurement could reveal new interesting horizons to the oilhydraulics in future.

Keywords: dynamic volume current measurement, dynamic measurement system, signal monitoring,

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CONFERENCE

COLLOQUIUM
Tuesday 8.40 am - 5.30 pm

OPENING & WELCOME ADDRESS

EUROPE HALL
8:40 - 10:00 a.m.

1st Speaker	Univ.-Prof. Dr.-Ing Ernst Schmachtenberg Rector RWTH Aachen University Germany	08:40 - 09:05
2nd Speaker	Univ.-Prof. Dr.-Ing. H. Murrenhoff Head of IFAS RWTH Aachen University Germany	
3rd Speaker	Christian H. Kienzle CEO Fluid Power Association of German Engineering Federation (VDMA) Germany	

Presenter	Prof. Dr.-Ing. Wolfgang Steiger Volkswagen Group Germany	09:05 - 09:30 PL e
Topic	The Path to A Post Fossil Fuel Era	

The earth's energy demand is constantly increasing. Separating the economic development from the energy demand does not seem possible. At the same time, the effort to exploit useful energy sources, especially fossil fuels and renewable sources, is growing. As a result, the price basis of a certain energy source is not solely determined by its quantity, but also by the effort required to produce and distribute it. This leads to certain basic guidelines…

Presenter	Dr. Karim Mokaddem PSA Peugeot Citroen France	09:30 - 09:55 PL e
Topic	Hybrid air: A disruptive technology and an entrepreneurial innovation model within PSA Peugeot Citroen	

Increasingly ambitious standards are being set worldwide to reduce emissions of greenhouse gasses and pollutants (NOx and particulates), with targets of 95 g of CO2 per km in Europe and 117 g per km in China by 2020. Full-Hybrid vehicles will be a necessary part of the equation to meet the 2020 CAFE targets. Hybrid Air is a new type of full-hybrid powertrain that combines a petrol engine and compressed air for energy storage instead of a battery, offering an alternative to electric hybrid solutions…

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PLENARY LECTURES

EUROPE-HALL
10:00 - 11:00 a.m.

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

Presenter Dr. Win Rampen
Artemis Intelligent Power Limited
United Kingdom
10:00 - 10:20
GL

Topic The Development of Digital Displacement Hydraulics for Renewable Energy Drivetrains (or Necessity is the Mother of Invention!)

In 1974 in the wake of the first global energy crisis the UK began to look at large scale renewable energy sources. Professor Stephen Salter invented a wave energy device now remembered as the Salter Duck at the University of Edinburgh. Digital Displacement® hydraulics came about as a response to the exceptionally difficult problem of converting the slow, irregular, high force motion of ocean waves, to a constant speed rotation to drive a synchronous generator. The rethink of hydraulic power transmission, based on conventional pumping mechanisms and integrated active valves with microprocessor control, has resulted in very controllable fluid-power drivetrains with efficiencies matching, or even exceeding, those of electrical machines. The presentation will cover the early development of the technology and continue to the present where Artemis, now as a subsidiary of Mitsubishi, is assisting in the development of the 7MW SeaAngel offshore ...

Presenter Philip McCluskey
Caterpillar
United States of America
10:20 - 10:40
SL

Topic Caterpillar Hydraulic Hybrid Excavator – Customers, Diversity Drives Innovation

The fuel-saving Cat® 336E H Hybrid was launched in 2013 as the industry\'s first hydraulic hybrid excavator. With over 300 patents filed, the innovative hydraulic hybrid technology is a significant departure from the typical hybrid approach. To accomplish such a feat required an acute, intense focus on the customer and a diverse, global team empowered to drive an innovative solution. Learn the story behind the development of this game-changing product from Caterpillar.

Presenter Dr. Frank Bauer
Hydac
Germany
10:40 - 11:00
SL

Topic Increasing the efficiency of hydraulic accumulators by enforcing isothermal behaviour

The current trend of improving the efficiency of mobile machines indicates that hydraulic hybrids are playing an important role in order to realize a proper system solution. First machines like excavators, material handlers, harbour cranes and so on are already presenting very competitive solutions based on robust hydraulic accumulator technology. Beside the well known robust design which is very easy to handle, maintain and service the low investment costs for the additional components lead to a very attractive solution with ROIs between one and two years. For some applications (depending on the load cycle) the efficiency and the energy capacity of the hydraulic accumulator itself becomes very important. In this case small improvements concerning the accumulators are determining whether the hybrid approach is successful or not ...

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Institute for Fluid Power Drives and Controls

NEW APPLICATIONS

CHAIR Dr.-Ing. Herbert Pfab
Liebherr
Austria

EUROPE HALL
11:30 - 13:00 a.m.

Presenter Thomas Schiepp 11:30 - 11:50
ETO MAGNETIC GmbH SL e
Germany

Topic Magnetic Shape Memory Actuators for Fluidic Applications

Magnetic Shape Memory (MSM) actuators represent a new type of smart electromagnetic actuators where the MSM material elongates and contracts in a magnetic field. The MSM material has the ability to change its size or shape very fast and many million times repeatedly. Based on internally designed and produced Magnetic Shape Memory materials, the ETO GROUP has developed its new MAGNETOSHAPE® technology that offers mono-, bi-, and multistable actuator solutions that have potential to serve various fluidic applications, from pneumatics to hydraulics, stationary or mobile. In this paper, we present an overview of the current state of the MAGNETOSHAPE® technology and its future impact on fluidic applications.

Keywords: magnetic shape memory, electromagnetic actuator

Presenter Thomas Jockenhöfer 11:50 - 12:10
Hauhinco Maschinenfabrik SL e
G. Hausherr, Jochums GmbH
& Co. KG - Germany

Topic Waterhydraulic brings 50.000 ton press giant back to life

Alcoa, a global leader in Aluminum products manufacturing, celebrated the rebirth of its huge closed die forging press. This press reflects for the company, but especially for the Cleveland Works OH, one of the most important and profitable machines. Also the American Government has big interest in this press, as it forges parts for very prestigious customers of the armaments and aerospace industries. After a fatal failure in the mechanical press structure in 2009, it was decided to make a complete modernization of this important press. That had to include the change from the crankshaft controlled valves to a new modern waterhydraulic system.

Keywords:

Presenter Dr. Peter Tappe 12:30 - 12:50
Magnet-Schultz GmbH SL e
Germany

Topic COILRAM – Pulsed Force Generation for Extreme Valve Challenges

The functional mechanism of classic solenoids for hydraulic and pneumatic applications works on the basis of the force effect between interfaces of magnetically soft materials. If these interfaces are realized by means of an air gap between a fixed core as well as a movable armature and if this air gap is arranged possibly within one coil, effective actuation forces for middle air gaps are achieved. The kind of force generation described here has industrially prevailed for small and middle air gaps in hydraulic and pneumatic applications. Particularly by the impact on the characteristics via geometry variation of core and armature the operating principle is perfect for constant actuation tasks in proportional valves ...

Keywords: Solenoid, dynamic, pulse

Presenter Daniel Barfuß 12:10 - 12:30
TU Dresden SL e
Germany

Topic Lightweight hydraulic components in novel multi-material-design for mobile applications

The increasing demand for transportation systems and construction machines with higher energy-efficiency enforces the development and realisation of hybrid drive trains for recovering kinetic energy. Electric hybrids have been mostly used in automotive industry until now. Hydraulic hybrids form an advantageous alternative to electric hybrids, offering higher power density and lower raw material costs due to the limited sources of noble earths. However, the weight of hydraulic components currently used in stationary or working hydraulic systems is much too high for a reasonable application in cars. Thus, a bladder accumulator and a manifold-block in innovative lightweight design have been developed and realized at the institute of lightweight design and polymer technology of the TU Dresden.

Keywords: Lightweight design, Carbon fibre reinforced plastic, Bladder accumulator, Manifold block, ...

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Many Thanks for Sponsoring IFKeeper

PNEUMATICS

BRUSSELS-HALL
11:30 - 13:00 a.m.

CHAIR Dr.-Ing. Peter Staffe
Bosch Rexroth
Germany

Presenter Prof. Dr. Peter Post
Festo AG & Co. KG
Germany
11:30 - 11:50
GL e

Topic Smart Pneumatics for Intelligent Manufacturing

The wide spread applications of pneumatics in all kind of industries are significantly based on the intrinsic advantages of pneumatic components, namely their compactness, robustness, flexibility together with ease of use and cost advantages. Modern pneumatics development is governed by general principles of sustainability, which includes resource efficiency and energy efficiency, by mechatronic system integration, by modular integrated components and miniaturised functions, by communication technologies, distributed intelligence and interface management. The tremendous success of pneumatics is the result of an unbroken innovatory impulse, driven by pneumatic industry and corresponding research institutes together with high end applications in production industry.

Keywords:

Presenter Dr. Wolfgang Gauchel
Festo AG & Co. KG
Germany
11:50 - 12:10
SL e

Topic Using thermodynamic changes of condition for describing system behaviour of air compressor stations

The basis for energy efficient pneumatic applications in the drive and handling technology field is the choice and dimensioning of components such as pneumatic cylinders and tubing. Proven by various research projects, there is a need for a holistic approach, i.e. not only describing the drive systems itself but also accounting for the upstream elements such as the compressed air generation. With the increasing processing power of computers, the engineering process is accompanied nowadays by intelligent software tools. By historic development, there is a huge gap between the way engineering tools from compressor manufacturers and pneumatic experts are set-up, mainly in terms of mathematical description. The presented paper intends to simplify the understanding of experts in pneumatics to the mathematical description of ...

Keywords: Pneumatics, compressor stations, efficient system design, energy savings, sustainability

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Presenter Christian von Grabe
RWTH Aachen University
Germany
12:10 - 12:30
SL e

Topic Efficiency Improvements by Air Recuperation through the Use of Ejectors and its Application

Meter-out controlled actuators are widely used in pneumatic systems, because they provide an easy and cost effective solution to adjust the velocity of the actuator. Discharging the compressed air into the environment, as usually done in typical pneumatic systems, is energetically unfavourable. A new concept allows operating pneumatic systems with meter-out controlled actuators in a virtually closed loop circuit. Thereby a complex circuitry is avoided and a flexible system layout with all its benefits is preserved. The conventional exhaust air throttle is replaced by an ejector and a pressure controlled switching valve. This allows to recuperate the exhaust air into a low pressure accumulator to raise the pressure level before the compressor without changing the drives performance.

Keywords: energy recuperation, ejector, compressed air system, meter-out control

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Presenter Theodor Paulus
Bosch Rexroth AG
Germany
12:30 - 12:50
SL e

Topic Vorsteuerventiltechnik für kompakte pneumatische Ventilsysteme

Not submitted in time

Keywords:

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SIMULATION & VALIDATION

CR 4/5
11:30 - 13:00 a.m.

CHAIR Dr.-Ing. Dirk Klug
Schuler SMG
Germany

Presenter Christoph Krimpmann
TU Dortmund
Germany
11:30 - 11:50
SL

Topic Intuitive Objective Definition for the automated Optimization of Hydraulic Valves

The increasing use of microcontroller based and network enabled components in hydraulic systems forms the base for an efficient automated or semi-automated optimization of digitally adjustable parameters. While there is a multitude of powerful optimizers, there is still a lack of usability, limiting their application in industry. This paper proposes an intuitive way of defining objectives and constraints. This is accomplished by using interfaces similar to graphics editors rather than programming. The results are demonstrated by optimising a hydraulic valve controller in a Hardware-in-the-Loop scenario and compared to other state of the art methods.

Keywords: Hydraulic Valves, Optimization, User-Interaction, Hardware-in-the-Loop, Evolutionary Algorithms

Presenter Kento Kumagai
Hitachi Construction Machinery Co., Ltd
Japan
11:50 - 12:10
SL

Topic Renewed Study of Vibration Phenomenon in Poppet Type Valve

Poppet type valve is one of the most popular components in hydraulics, it is also known as a trouble maker because it induces some unpredictable vibration in hydraulic system. In this research, thanks to the advanced visualization technology and digital simulation technology, we make a re-study of the old unpredictable vibration problem phenomenon. Results show that stability of a poppet valve is essentially depend on the components and parameters which composed the system, but the stable or unstable state is influenced by the cavitation state at the downstream of the valve. Since stability has not a clear mathematical relation with the quantity of the cavitation, and the cavitation has complicated relation with various factors, the vibration may come out suddenly beyond prediction.

Keywords: Poppet valve, vibration, compressibility, cavitation, visualization, digital simulation

Presenter Dr. QingHui Yuan
Eaton Hydraulic Group
United States of America
12:10 - 12:30
SL

Topic Flow Forces Investigation through Computational Fluid Dynamics and Experimental Study

Flow forces play a critical role in determining hydraulic valves' performance. In the past few decades, a significant amount of research has been conducted to address this issue analytically, numerically, and experimentally. In this paper, we provide an industry perspective on all three elements. The analytical prediction has been used widely in hydraulic product design and has proven helpful as a design guide line. However, its limitation is getting increasingly obvious as valve design bears more complexity that stretches beyond the analytical equation's capability. The experimental validation is the most accurate method since it directly measures the actual flow force value given a design. Yet, it is impractical to validate all designs via hardware prototyping. The materials and engineering cost of cutting metal for any ...

Keywords: Proportional Valve, Directional Valve, Flow force, Computational Fluid Dynamics (CFD)

Presenter Olivier Reinertz
RWTH Aachen University
Germany
12:30 - 12:50
SL

Topic Simulative optimisation of a novel commutation valve for servopneumatic rotational drives

The paper deals on the development of a novel magnetically actuated commutation valve for servopneumatic rotational drives which combines commutation and control functionality. In addition, it possesses minimised drag torque and a miniaturised building space allowing the build-up of highly miniaturised rotational drives. The required optimisation of the pneumatic, mechanical and electromagnetic system is carried out by numerical simulations. The paper focuses on magnetic simulations as well as the interaction with other domains and especially the valves mechanics. Finally, simulations are validated by prototype measurements showing the expected behaviour while being influenced by inevitable manufacturing tolerances.

Keywords: Commutation valve, electromagnetic FEM

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SYSTEMS

EUROPE-HALL
02:00 - 03:30 p.m.

CHAIR Dr. Peter Synek
VDMA
Germany

Presenter Dr. Peter Achten
Innas B.V.
Netherlands
02:00 - 02:20
GL

Topic Innovation in The Fluid Power Industry

In the coming decade, cost reduction and energy efficiency will be the dominating success factors for any industry. Currently, the hydraulic industry is not fit to meet these demands: hydraulic systems and components are simply too expensive and too inefficient. It is important to mention that there are no fundamental reasons for the poor performance and high manufacturing, production, and engineering cost. Without doubt, hydraulics can be efficient and low-cost. However, the niche market in which the hydraulic industry operates simply does not have an alternative for the hydraulic cylinder. Without feeling the heat of competition, the hydraulic industry has not had enough incentive to invest in new products and technologies. But changes are apparent. Relatively high labour cost already threatens the production ...

Keywords:

Presenter Dr. Kristof Schlemmer
Hydac System GmbH
Germany
02:20 - 02:40
SL

Topic Autonomous Electro-hydraulic Safety Actuators Using Hydro-pneumatic Springs

Critical processes, such as thermal power generation or chemical production processes, require maximum safety and uncompromised availability at the same time. Hence, operational control of the process medium and safety function are mostly provided by the same device or a number of such devices. Commonly, the steam or process valve is operated by an electro-hydraulic linear actuator powered by a shared, centralised power supply unit and backed up by a disc spring stack for energy storage. In this paper, an alternative actuator prototype is presented, employing an approach that is novel to this field of application. Firstly, the actuator uses hydro-pneumatic accumulators for storing energy. Secondly, it is designed to be autonomous through integration of all power supply and ancillary functions into a compact, ...

Keywords: Steam control valve, Functional Safety, turbine trip, accumulator, reliability

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Presenter Dr. Klaus Roosen
Parker Hannifin GmbH
Germany
02:40 - 03:00
SL

Topic Energetic optimisation of variable speed pump systems towards European Ecodesign directive

In this paper, the design of energy optimised hydraulic pump systems is described. Based on the legislative regulations given by the European Commission and the technology of conventional hydraulic power supply concepts different new solutions with high impact on energy savings are developed by use of speed variable electric motors. New approaches such as suitable single and hybrid pump concepts as well as different electric motor concepts are taken under consideration. The optimised total system design is fund on calculation based on detailed component data by use of the "Parker-DriveCreator" software.

Keywords: Modern fluid power, energy savings, speed variable pump, ecodesign, efficiency

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Presenter Dr. Christoph Boes
Moog Holding GmbH & Co KG
Germany
03:00 - 03:20
SL

Topic Electro hydrostatic Actuators for industrial Applications

The use of hydraulic actuation system has been challenged during the last years by a strong demand of a reduction of the energy consumption in combination with the well-known advantages of hydraulic systems. This paper shows a proposal to full fill these requirements based on an electro hydrostatic actuator. This principle has been used in aircraft flight actuation systems since more than 15 years. The described actuator concept shows an approach for balanced, unbalanced and plunger cylinders by use of only one pump in combination with a speed variable servo motor. The presented solution combines the advantages of hydraulic systems and electro mechanic solutions, which means power by wire and power only on demand.

Keywords: Modern fluid power, Energy consumption, Power by wire, Hydraulic systems, Pumps

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HYDAC

SIMULATION & VALIDATION

BRUSSELS-HALL
02:00 - 03:30 p.m.

CHAIR Dr.-Ing. Robert Rahmfeld
Danfoss Power Solutions
Germany

Presenter Dr. Christian Raksch
Bosch Rexroth AG
Germany
02:00 - 02:20
SL

Topic Determination of reliability parameters of hydraulic components for safety applications in industrial and mobile machines

The standards for functional safety (e.g. IEC 61508, ISO 13849 and IEC 62061) opened up a new era in the design of machinery, in which the safety of the control system is evaluated according to its reliability. In order to prove the safety of their machines, designers now need different parameters, e.g. MTTFd or B10d. Based on a ISO/IEC survey from 2012, the availability of those parameters is the main problem in applying functional safety standards. But what exactly do these parameters mean? How can these parameters be determined for different control technologies? This paper offers an overview of the main methods for the determination of the reliability parameters for functional safety in terms of hydraulic components.

Keywords: safety, reliability, MTTFd, ISO 13849, Weibull

Presenter Katharina Schrank
RWTH Aachen University
Germany
02:20 - 02:40
SL

Topic A New Approach to Model a Multi-phase Hydraulic Capacity and its Experimental Validation

In this paper a new model is presented that allows the calculation of the pressure build-up and decrease in a multi-phase capacity with the overall goal to increase lumped parameter simulations accuracy. Therefore the model considers different compositions of the fluid at the start of simulation. Phase changing effects like the solution and release of air are taken into account. To validate the model, measurements are performed allowing a precise recording of the pressure build-up and reduction in a rigid test chamber. The tests are performed by varying the volume of the test chamber up to a pressure of 80 bars as well as far below atmospheric pressure.

Keywords: pressure build-up, simulation, multi-phase capacity, dissolved air, entrained air

Presenter Johannes Untch
TU Braunschweig
Germany
02:40 - 03:00
SL

Topic Approach for the investigation and evaluation of hydraulic tank designs regarding air in oil behaviour

Due to the undesired effects of free air in oil good air separation properties of hydraulic tanks are required. In a research project at the Institute of Mobile Machines and Commercial Vehicles methods for the simulation based evaluation of air in oil behaviour in hydraulic tanks of mobile machines will be developed. After mentioning fundamentals of air in oil the possibilities of simulative evaluation are outlined and the test bench is described. The test bench allows the evaluation of air in oil behaviour of different tanks in construction machinery scale. Volumetric flows, oil quality and tempering can be controlled according to corresponding duty cycles.

Keywords: Air in oil, hydraulic tank, Computational Fluid Dynamics (CFD)

Presenter Oliver Koch
TU Dresden
Germany
03:00 - 03:20
SL

Topic Real-time models for hardware-in-the-loop simulation of hydraulic drive and control systems

The growing amount of electronics in mobile hydraulic systems increases the need for a better quality and efficiency of the system development process. The application of HiL test racks supports effective testing of control devices, which enables handling the complexity of such systems. This generates a demand for real-time models, which represents an engineering challenge for itself. This paper illustrates the proceeding to generate a real-time simulation model using the example of an excavator. Starting point is a validated, non-real-time capable model. The use of analysis tools integrated into the simulation environment identifies critical elements. Based on the results the simulation model is adapted due to appropriate measurements. Finally, the achievable accuracy of the real-time simulation ...

Keywords: Real-time system simulation, Hardware-in-the-Loop, Eigenvalue analysis, Modern fluid power, ...

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COMPONENTS

CR 4/5
02:00 - 03:30 p.m.

CHAIR Dr.-Ing. Frank Bauer
Hydac
Germany

Presenter Prof. Dr. Wieslaw Fiebig
Wroclaw University of Technology
Poland
02:00 - 02:20
SL e

Topic A vane pump integrated with an electric motor

In this paper an innovative design solution of a vane pump integrated with an electric motor is presented. An integrated motor-pump assembly with a supply converter and control system has been developed and electromechanical and hydraulic processes in the motor pump group are analyzed. A simulation model of the motor pump group has been developed in order to investigate its functionality, electromechanical and hydraulic parameters and dynamics of the system.

Keywords: vane pumps, electric motors, control systems, integrated motor pump group, fluid power drives

Presenter Dirk Schulze Schencking
RWTH Aachen University
Germany
02:20 - 02:40
SL e

Topic Systematic influence of hydrostatic displacement unit efficiency in operating range

In modern state of the art units the physical limits of the overall efficiency are almost reached. Due to this fact this contribution focuses on the systematic influence of efficiency of hydrostatic units in specific operating points. Based on the radial piston unit with axial cone valve plates (RAC), which provides the possibility of an isolated modification of losses, the adaption of the efficiency to a specific operating range is demonstrated.

Keywords: overall efficiency, piston slipper, valve plates, RAC, losses

Presenter Dr. Liselott Ericson
Linköping University
Sweden
02:40 - 03:00
SL e

Topic Swash Plate Oscillations due to Piston Forces in Variable In-line Pumps

This study investigates the oscillations of swash plates caused by piston forces acting on the swash plate. Earlier investigations of variable axial piston pumps assume a fixed swash plate angle, i.e. the swash plate is fixed at different displacement angles. Under normal operating conditions, the swash plate is controlled by a hydraulic actuator which affects the swash plate. The presented models are able to separate different losses caused by the swash plate oscillations and the controller. The results show oscillations on the swash plate which affect both efficiency and flow pulsation and hence the noise level.

Keywords: Fluid power pump/motor, efficiency, noise, flow pulsations

Presenter Dr. Masashi Sasaki
Mitsubishi Heavy Industries, Ltd.
Japan
03:00 - 03:20
SL e

Topic Large Capacity Hydrostatic Transmission with Variable Displacement

In the wide range products such as wind turbine generator, engine generator, railway vehicle, ship and so on, the demands for large capacity hydrostatic transmission with high efficiency are increasing as a substitute of conventional drive train system such as gearbox for the purpose of improvement and differentiation of such products. For satisfying such demands, large capacity hydrostatic transmission with variable displacement was developed with applying the Digital Displacement ® technology /1/ of Artemis Intelligent Power, Ltd. The hydrostatic transmission introduced in this paper is comprised of original hydraulic pump and motors. As a result, the authors confirmed that it is possible to manufacture and provide the new hydrostatic transmission with large capacity over 7MW.

Keywords: Hydrostatic transmission, Large capacity, Variable displacement

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MOBILE

EUROPE-HALL
04:00 - 05:30 p.m.

CHAIR Prof. D.r Monika Ivantysynova
Perdue University
United States of America

Presenter Prof. Dr. Hubertus Murrenhoff 04:00 - 04:20
RWTH Aachen University GL
Germany

Topic An Overview of Energy Saving Architectures for Mobile Applications

In modern mobile machines, the working implements and drivetrains often use fluid power drives due to their superior power density and robustness. The state of the art in today's machines is still load sensing as these circuits offer excellent performance at reasonable cost. Maintaining the dominance of fluid power in this sector will largely rely on whether or not new more efficient circuits and technologies can be developed. To do so, design engineers must be aware of all possible circuit configurations available to them. This paper takes a systematic approach and begins by introducing a framework to classify all current system architectures and to aid in the development of new architectures. It includes impressed flow and pressure circuits as well as analog ue and digital solutions with recuperation and regeneration ...

Keywords: Hydrostatic drives, mobile hydraulics, drive circuits, drive architectures, recuperation, regeneration

Presenter Milos Vukovic 04:20 - 04:40
RWTH Aachen University SL
Germany

Topic STEAM – a holistic approach to designing excavator systems

To design the next generation of highly efficient mobile hydraulic machinery it is necessary to take the next step, that is to consider such machines as whole systems interacting with their environment. Instead of concentrating on only the hydraulic system, the machine should be designed by taking into account the interaction of all the subsystems, including the environment. This is a challenge because such machines are used for a large variety of different tasks and a standard operating cycle to judge efficiency has yet to be defined. Despite this fact, by analysing a number of typical duty cycles a few conclusions or design rules can be formulated. The new mobile hydraulic system, called STEAM, is designed using these rules and considers an excavator as a whole system. This paper presents the necessary theoretical concepts and the ...

Keywords: Energy efficiency, mobile hydraulics, excavators, internal combustion engine

Presenter Markus Schneider 04:40 - 05:00
TU Dresden SL
Germany

Topic Green Wheel Loader – Development of an energy efficient drive and control system

Today's mobile machines still offer vast potentials regarding energy efficiency which can be exploited by increasing the efficiency of drive train subsystems and optimising their interaction. Within the research project "TEAM", the most promising drive train technology currently available is incorporated into a wheel loader in order to demonstrate the fuel savings possible through highly efficient subsystems and adapted operating strategies. This contribution gives an overview over the machine's drive train structure and the developed operating strategy and shows fuel saving estimations obtained by system simulation. Furthermore, main issues of software engineering and testing using an HiL Simulator will be discussed as well as results of subsystem bench tests.

Keywords: Energy Efficient Drive Trains, Operating Strategy, Software Development and Testing, TEAM

Presenter Dr. Christian Stammen 05:00 - 05:20
XCMG European Research Center GmbH SL
Germany

Topic Secondary Energy-saving Measures in Mobile Hydraulics

In every aspect of engineering, the improvement of energy efficiency is promoted. In mobile hydraulics, the most visible efforts of industrial development or academic research are concentrating on either reduced losses for main functions (pump control vs. valve control for cylinders, hydrostatic drive trains with mechanical gearbox, closed-center load-sensing systems vs. open-center main control valves, ...), energy recuperation (most relevant for lower dynamics, e.g. on cranes [Liebherr IFK 2012] or the efficiency improvements in certain main components such as pumps.

Keywords:

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ECKART®
HYDRAULIK · PNEUMATIK

SYSTEMS

BRUSSELS-HALL
04:00 - 05:30 p.m.

CHAIR Dr.-Ing. K. Roosen
Parker Hannifin
Germany

Presenter Bert Brahmer — 04:00 - 04:20
Voith Turbo H + L Hydraulic GmbH & Co. KG
Germany
SL e

Topic Drives for Punching and Forming Machines: How Hydraulics compare to Current Electromechanical Systems

For decades, hydraulic drives have been the technology of choice for punching, nibbling and forming. Over the last years, though, servo mechanical drives have been trying to step into this application domain. What is motivating machine OEMs and end users to pursue this trend? Evaluating the primary claim of servo mechanics - energy efficiency - reveals that in many application conditions, hydraulics can well compete. Further analysing the particular application requirements reveals the relevance of intrinsic benefits of hydraulics: direct linear actuation, excellent dynamics and ruggedness. Still, for hydraulics, there remains the challenge to make systems more simple and easy to use.

Keywords: Servo Mechanic, Servo Hydraulic, Punching, Nibbling, Energy Efficiency

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Presenter Juliane Weber — 04:20 - 04:40
TU Dresden
Germany
SL e

Topic Thermo-Energetic Analysis of the Fluidic Cooling Systems in Tooling Machines

In the manufacturing of a wide variety of components of mechanical engineering, plant and vehicle construction machining processes occupy a central position. The increasing demands on productivity, production accuracy, and energy efficiency are essential to be considered. Inaccuracies caused by thermo-elastic deformations are the main dominant problem for the achievable precision. Fluid power systems are a key element for controlling and managing the thermo-elastic behaviour of tooling machines. Particularly in terms of accuracy under conditions of energy-efficient manufacturing they must be included in the design studies of machine tools from the beginning. The purpose of this paper is to present first results of the experimental analysis of a machining centre ...

Keywords: Tooling Machine, Heat Transfer, Cooling circuit, Energy Efficiency, Experimental Investigations

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Presenter Ulrich Walter — 04:40 - 05:00
W.E.St. Elektronik GmbH
Germany
SL e

Topic Assistance system to support the start-up procedure of electro hydraulic drives

The commissioning of hydraulic controlled axes is often a time-consuming and therefore cost-intensive activity, as particularly a system of this kind covers a number of technologies, and therefore it is not always clear who should be responsible for this technology. Although there is much talk of intelligent hydraulic axes, at the same time, the complexity is increased so much that only an expert can understand it. An intelligent hydraulic system should be more; it must make it easier for the user to work with and to commission, and also facilitate the optimisation process in the same way as an assistance system in a car.

Keywords: Intelligent axis, self adaptation, start-up assistance, positioning control

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Presenter Prof. Dr. Željko Šitum — 05:00 - 05:20
University of Zagreb
Croatia
SL e

Topic Secondary Energy-saving Measures in Mobile Hydraulics

This paper focuses on the design and robust nonlinear controller synthesis based on the backstepping approach for force real-time control of a 50-kN hydraulic press. The main feature of the test system is its open hardware structure and easy programmability using different control devices and appropriate control strategies. A nonlinear dynamic model of the hydraulic system interacting with environment has been developed. The press contains a servo-solenoid pressure-control valve for regulating the pressure in the cylinder chamber. The press is equipped with a pressure transducer installed in the cylinder chamber for indirectly measuring the pressing force as well as with a load cell inserted below the piston rod and environment for directly measuring the applied force. On the press is also possible to measure the position of the ...

Keywords: Hydraulic press, nonlinear control, force control, backstepping

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PNEUMATICS

CR 4/5
04:00 - 05:30 p.m.

CHAIR Dr.-Ing., MBA Albert R. Schultz
Magnet Schultz
Germany

Presenter Matthias Doll
Festo AG & Co. KG
Germany
04:00 - 04:20
SL

Topic How big is the efficiency of pneumatic drives? An experiment provides clarity!

For efficiency evaluations pneumatic and electric drive systems are often compared on basis of their efficiency factors. Thereby, electric drives are rumoured to have an efficiency of 80% up to 90% across the board. Pneumatic drives, however, are considered to have an efficiency in the range of 5%-10%. The current opinion is that the gap between these efficiency factors causes a much higher energy consumption of pneumatic drives in comparison to electric ones. But according to these efficiency factors and their underlying assumptions there are some doubts which are disproved in this article. This paper tries to clarify the common assumptions concerning the efficiency factors of the appropriate systems. It is shown that a comparison of pneumatic and electric systems is only valid if their motion and ...

Keywords: energy efficiency, pneumatic cylinder, electric drive, efficiency factor, shell scheme

Presenter Prof. Dr. Wolfgang Ertel
Hochschule Ravensburg-Weingarten
Germany
04:20 - 04:40
SL

Topic Model Free Diagnosis of Pneumatic Systems using Machine Learning

We address the task of model free fault detection in arbitrary pneumatic systems based on continuous air flow measurements and present a universal diagnostic module that treats the pneumatic system as a blackbox. This module can be applied to arbitrarily complex systems for which no mathematical models exist. We use machine learning algorithms for acquiring the diagnostic knowledge. The diagnostic module is trained on air-flow data of the pneumatic system in normal operation using the one-class-learning algorithm neighbour-data-description (NNDD). We achieve excellent classification results with zero error rate on a real pneumatic system.

Keywords: Model free diagnosis, machine learning, pattern matching, pneumatic systems, airflow.

Presenter Dr. Jan Bredau
Festo AG & Co. KG
Germany
04:40 - 05:00
SL

Topic Efficient use of compressed air in the body construction

One of the key sectors for pneumatics is the automotive industry. A typical area of application is body manufacture. Energy efficiency in the automotive industry, taking life cycle costs into account, is the subject of much discussion at present. Against the backdrop of rising energy prices and a greater focus on energy efficiency, pneumatics is coming under the spotlight for being „too expensive". Many car manufacturers are discussing the possible use of electric drives as a replacement for pneumatics. Does this make sense? This paper examines this issue and attempts to create transparency. Results from measurements on components and systems in the body construction are presented, comprehensive cost analyses are carried out and potential for improving energy efficiency is demonstrated.

Keywords: pneumatics, car body production, energy efficiency, total cost, welding guns

Presenter Albrecht Winter
J. Schmalz GmbH
Germany
05:00 - 05:20
SL

Topic Mechatronic System Engineering of Vacuum Gripping Systems

Vacuum gripping systems are increasingly used as universal solutions for automated handling tasks. New developments facilitate applications in various industry segments. New functions in automation enable the integration as cyber-physical systems into modern automation concepts. Efficient maintenance is possible through condition monitoring and predictive maintenance functions. Consistent and seamless engineering processes will be one key element of future automation systems. This paper will concentrate on the integration of vacuum gripping system into engineering today and will show the challenges from integration into tomorrow's automation concepts Engineering of vacuum gripping systems is characterized by two main elements: First element is the fluid power system ...

Keywords: Handling, Vacuum technology, Systems Engineering

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CONFERENCE

COLLOQUIUM
Wednesday 9:00 am - 6:10 pm

CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

SIMULATION

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

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

Presenter Tadej Tašner — 09:00 - 09:20
HAWE Hidravlika d.o.o.
Slovenia
SL

Topic Energy efficiency of different electrohydraulic drives

One of the nowadays main concerns when either developing or optimizing electrohydraulic drives is its energy efficiency. The two mostly used drive concepts in modern electrohydraulic systems are fixed displacement pump and variable speed motor or variable displacement pump and constant speed motor. Since there are two concepts a question arises: "Which concept has higher energy efficiency?". The energy efficiency of an actual electrohydraulic drive can be easily measured through input electrical power and output hydraulic power. But if we want to assess energy efficiency of an electrohydraulic drive before building it, we can evaluate its energy efficiency using computer simulations. This article presents an approach to compute energy efficiency using Matlab-Simulink package. In order to accurately ...

Keywords: efficiency, simulation, measurement, variable frequency drive, variable displacement pump

Presenter Lionel Broglia Patron — 09:20 - 09:40
LMS Imagine
France
SL

Topic Performance and Energy Consumption simulators of hydraulic hybrid off- highway vehicles

Off-highway vehicles manufacturers have now to face an increasing demand of high performances while reducing fuel consumption and pollutant emissions. Innovation is the answer, leading to the implementation of new technologies and methodologies for product design. In this context, mechatronic system simulation is certainly a precious ally to support not only component design and optimization, but also subsystem integration and architecture choices. The aim of the paper is to demonstrate the interest of system simulation at vehicle level to design energy recovery systems and estimate the benefits in term of energy consumption in the context of a full vehicle.

Keywords: Modern fluid power, Fuel Economy, Energy Recovery System, System simulation, Model-Based

Presenter Dr. Heiko Baum — 09:40 - 10:00
FLUIDON GmbH
Germany
SL

Topic Hybrid Pump Model for 1D Hydraulic System Simulation

This paper presents a novel approach to implement the dynamic displacement characteristic of a real pump into the 1D system simulation. In order to achieve this, the pump is measured under defined boundary conditions and these measurements then are used together with suitably adapted, classical physical modelling approaches to form a hybrid pump model. Central part of the hybrid pump model are measurement data of two different test rig constellations. At the first test rig the pump's characteristic pressure pulsations are measured against a line termination without reflection (RaLa). At the second test rig the pump impedance is measured by means of the 2p/2s-approach ....

Keywords: Impedance measurement, flow pulsation, pump simulation, pump test rig, measurement service

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MOBILE APPLICATIONS

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

CHAIR Prof. Dr.-Ing. Jürgen Weber
TU Dresden
Germany

Presenter Taghi Akbarian
DEUTZ AG
Germany
09:00 - 09:20
SL e

Topic Energy efficiency of different electrohydraulic drives

Over the last 15 years diesel engine developments have focused on complying with emission limits. This has led to a substantial increase in complexity of modern diesel engines. On the one hand, the installation of the new engines, including exhaust gas after treatment in mobile working machines, involves considerable effort and represents a major challenge for equipment manufacturers and engine suppliers. On the other hand, the optimal tuning of the engine in line with machine hydraulics, transmission and drive trains offers considerable potential for the reduction of fuel consumption and increase in equipment performance. This paper is based on the experience gained from the application work on mobile working machines. Various solutions for the installation of the Stage IV engines including the optimization of a drive train

Keywords: System integration, energy efficient, hybrid systems

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Presenter Roman Krähling
ARGO-HYTOS GmbH
Germany
09:20 - 09:40
SL e

Topic Integration of Online Condition Monitoring (OCM) Sensor Systems for Hydraulics in Remote Interrogative Systems

The scope of this paper is to emphasize the benefits of the integration of online oil condition monitoring sensor systems and remote access to them in fluid powered systems. In different application examples for a broad range of hydraulic machines the present sensor technology and its functionality is presented. For each application example the individual advantage for the customer of an automated online condition monitoring with the integration, data acquisition and remote access of sensor data is underlined.

Keywords: Oil monitoring, condition sensors, remote data management, condition based maintenance

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Presenter Kalle Einola
Ponsse Plc
Finland
09:40 - 10:00
SL e

Topic Dimensioning and Control of a Hydraulic Hybrid System of a Cut-To-Length Forest Harvester

A novel, simple hydraulic hybrid system for a Cut-To-Length forest harvester is presented and its main advantages and challenges are discussed. The main components of said system are dimensioned based on the earlier collected work cycle data. A simulation model is used to study the functionality of the system and to compare its performance and fuel efficiency with a respective conventional hydraulic system. A control approach for the said hydraulic hybrid system is also proposed. Based on the simulation results it seems to be possible to manage the power demands in an advantageous way and reasonable fuel efficiency savings seem to be available.

Keywords: Hydraulic hybrid, forest machinery, cut-to-length harvester, power management

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Presenter Henri Hänninenv
Aalto University
Finland
10:00 - 10:20
SL e

Topic Improving Energy Efficiency of Reach Truck Utilizing Hydraulic Transformer Based Recovery System

A previously studied direct hydraulic recovery system was proven to be a very viable option in constant load scenarios, with energy consumption reductions exceeding 50 per cent. However, when deployed to a mixed goods warehouse the consumption reduction would be significantly lower. In this study, an alternative hydraulic recovery system topology is designed and adapted to a full size reach truck test bench. This system utilizes indirect hydraulic energy recovery realized with a custom build hydraulic transformer. Measurements with different loads, lift ranges and accumulator configurations were carried out. Results indicated that the indirect system outperformed the direct one in variable load scenarios at the cost of lower peak efficiency when operating with constant loads. The measured ...

Keywords: Reach truck, energy recovery, hydraulic transformer, hydraulic accumulator

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COMPONENTS

CR 4/5
09:00 - 10:30 a.m.

CHAIR Dr.-Ing. Harald Geis
Thomas Magnete
Germany

Presenter Dr. Siegfried Lösch
LCE Lösch Cellular Engineering Ziviltechniker GmbH - Austria
09:00 - 09:20
SL e

Topic Piston with regular structured cellular core – Cellular Piston

Most modern hydraulic piston machines are usually equipped with nine or seven pistons. Their behaviour during operation has influence on many characteristics such as performance and efficiency. These pistons provide dynamic essentially a reciprocating mass fraction. If it is possible to reduce the mass of the piston that has a positive effect on the control system of axial piston pump, the force on the piston system and, consequently, the wear. Lighter pistons also enable the pump speed to increase in order to achieve higher pressures and / or a higher flow and thus contribute directly to improve performance. The subject mass reduction of the piston, taking the example of the open piston, is achieved by filling a cylindrical cavity with metallic cellular material suitable. This has two effects: on the one hand, by ...

Keywords: Piston, mass reduction, cellular material, higher efficiency

Presenter Klaus Mössinger
ARGO-HYTOS GmbH Germany
09:20 - 09:40
SL e

Topic A New Approach – Injection-Moulded Hydraulic Tanks for Mobile Applications

Hydraulic tanks for mobile machines are basically made of steel or are rotationally moulded from non- reinforced polyolefin or polyamide. The market increasingly requires more complex tank geometries, higher integration density and temperatures above 80° Celsius. In order to fulfil all these requirements it is essential to create new hydraulic tank concepts. Injection-moulded hydraulic tanks, along with the entire spectrum of materials and connection processes related to them, lead to such a new concept.

Keywords: Integration density, modules, market target, simulation

Presenter Dr. Olaf Stelling
Parker Hannifin Manufacturing Germany GmbH & Co. KG
09:40 - 10:00
SL e

Topic Composite High Pressure Hydraulic Actuators for Lightweight Applications

During the last decades, the market share of products made of reinforced plastics increased rapidly. The low density, corrosion resistance and high fatigue performance of such materials provide a wide range of benefits for different applications. Parker Hannifin has developed fully composite hydraulic cylinders for 380 bar applications which are up to 60 % lighter than their standard steel cylinder equivalents. The fully composite cylinders were tested extensively under various mechanical and environmental influences to verify the robustness of the products. The results confirmed that the new composite barrel technology for hydraulic actuators is competitive to standard metal solutions while providing further benefits in terms of weight and corrosion resistance.

Keywords: Composites, Hydraulic Actuators, Lightweight, Robustness

Presenter Dr. Kristian Müller-Niehuus
Merkel Freudenberg Fluidtechnic GmbH Germany
10:00 - 10:20
SL e

Topic Size optimized sealing systems via systematic integration of functional areas

Regarding sealing technology, there is a strong market trend to minimize the housing space of sealing systems. Simultaneously, the performance must not suffer, and most often has to also include additional sealing functions. In order to follow this trend, the most promising solution is to integrate previously separated, functional sealing areas into a defined multi-purpose seal. Main target is to reduce the number of seals involved. Reduced space – enhanced functionality, both perspectives have a vice versa characteristic in respect to mere size. Therefore, new multi-functional seals are considered to be state of the art. In this paper we would like to present tools, able to break down existing systems into functional areas and recombining these areas to new, functionally optimized multi-purpose seals taking less ...

Keywords: Optimization, multi-purpose seal, housing space, radial shaft seal, deflector

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RENEWABLE ENERGY

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

CHAIR Dr.-Ing. Wolfgang Hahmann
Hydac
Germany

Presenter Dr. Niels Diepeveen
Delft University of Technology
Netherlands
11:00 - 11:20
SL

Topic Preliminary Design of the Hydraulic Drive Train for a 500kW Prototype Offshore Wind Turbine

The Delft Offshore Turbine (DOT) concept for the drive train of offshore wind turbines is to have the rotor shaft directly coupled to an oil-hydraulic pump in the nacelle. The hydraulic motor is located at the base of the turbine tower, where it is coupled to a seawater-hydraulic pump. The pressurized flow of seawater from each turbine converges to a hydro-power-like generator station where it is converted to electricity using Pelton turbines. All related studies and experiments until now have confirmed the technical feasibility and economic potential of this technology. The next step in its development is demonstration by implementing it in a real wind turbine, offshore. This paper reveals the preliminary design of the DOT Demonstrator and the steps toward realization.

Keywords: Offshore wind, offshore technology, fluid power transmission, renewable energy

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Presenter Johannes Schmitz
RWTH Aachen University
Germany
11:20 - 11:40
SL

Topic Hydrostatic transmission for wind turbines – Comparison of different configurations and their applicability

In this paper a number of new concepts of split path transmissions for wind turbines are compared to fully hydrostatic drive trains. By switching on and off single components in the hydrostatic path overall efficiency can be improved, especially in partial load. Two sites have been selected to evaluate the results and to see which range of operation a system needs to be optimised for. By weighting the power output of the different concepts with the relative occurrence of each wind speed it is possible to determine the medium power output of a concept. Using this approach earnings due to power delivered to the grid can be compared.

Keywords: Wind power, split path transmission, efficiency, hydrostatic drive train

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Presenter Yukio Kamizuru
Bosch Rexroth AG GmbH
Germany
11:40 - 12:00
SL

Topic Development of Hydrostatic Drive Trains and Dielectric Elastomer Generators for Wave Energy Conversion

Wave energy converters can be equipped with different power take-off technologies. Usually fluid power is chosen since hydrostatic drive trains are well proven, mass produced and considered to be state of the art. Besides, a promising technology are dielectric elastomers. This technology has the ability to directly convert mechanic power into electric power via the control of electric charge during compression and expansion of an elastomeric structure. The paper discusses an exemplary hydrostatic drive train for wave energy converters and describes its operational behaviour and efficiency. A dynamic wave-to-wire simulation taking into account the efficiency of the PTO components is introduced to assess and optimise the performance. Intended to go further ...

Keywords: wave energy, power take-off, hydrostatic drive train, dielectric elastomer, simulation

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Presenter Dominic Dießel
RWTH Aachen University
Germany
12:00 - 12:20
SL

Topic Analysis of Characteristics for Transmissions in oscillating marine Wave Energy Converters

Marine wave energy has great potential for future energy generation. Up to now many different Wave Energy Converter (WEC) concepts have been proposed. Additionally, a range of different transmissions or Power-Take- offs to transform the energy of the WEC into electric energy have been designed conceptually. Nevertheless, no comparability between the concepts has been achieved. Thus, in this paper requirements for transmissions of WEC with an oscillating buoyant body are presented. They are analysed in order to develop characteristics defining the behaviour and quality of a transmission in combination with a WEC and certain electric grid requirements. The characteristics are then used to evaluate exemplary transmissions.

Keywords: Wave Energy, Transmission, Power-Take-Off, Drive train, Comparison, Grid connection, ...

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MOOG

SYSTEMS

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

CHAIR Götz Sondermann
Siempelkamp
Germany

Presenter Arkadiusz Winnicki
Warsaw University of Technology
Poland
11:00 - 11:20
SL e

Topic A New Concept of Hybrid Displacement-throttled Control of Electro-hydraulic Servo Systems

In this paper were presented disadvantages and advantages of both main principles of hydraulic energy control: throttled and displacement control. Both solutions have their drawbacks. In the first solution we have a very large energy losses. In the second instance we have a worse response times of drive and adverse phenomena at low speeds of motor and pump. For this reason a novel hybrid hydraulic displacement-throttled system control is proposed. The performance and energy efficiency of the new control concept is then verified by experimental results, which show low energy losses and short drive time response proposed conception of control.

Keywords: Modern fluid power, throttled control, displacement control, energy efficiency

Presenter Can Du
University of Bath
United Kigndom
11:20 - 11:40
SL e

Topic Load Prediction-based Energy-efficient Hydraulic Actuation of a Robotic Arm

In this paper the motion of a two-joint robotic arm is controlled by a variable supply-pressure valve-controlled (VPVC) hydraulic system. It has a fixed capacity pump driven by a brushless servo-motor. The minimum required supply-pressure for the demand motion is predicted. It is computed from the predicted piston force, by applying Lagrange's equations of the-second-kind. The supply-pressure for the whole system is the higher one of the two load branches; the other branch is controlled by throttling. The supply-pressure is varied by controlling motor speed. Simulated and experimental results are shown and discussed. A power consumption comparison with fixed supply-pressure system shows up to 73% saving is found experimentally.

Keywords: Load prediction, energy-efficiency, hydraulic actuation, motion control

Presenter Dr. Richard Käsler
WEBER-HYDRAULIK GmbH
Germany
11:40 - 12:00
SL e

Topic Zukunftsweisende elektro-hydraulische Linearsysteme; Erfahrungsberichte und Potentiale am Beispiel elektro-hydraulischer Lenksysteme

Keywords:

Presenter Tobias Corneli
TU Darmstadt
Germany
12:00 - 12:20
SL e

Topic Employing Hydraulic Transmission for Light Weight Dynamic Absorber

A new dynamic absorber concept, called Fluid Dynamic Absorber (FDA), is presented. The absorber employs hydrostatic transmission to reduce weight and material need. At the same time the functionality compared to classical dynamic absorber is improved. The absorber is built out of a double-sided piston of cross section connected by elastic elements (spring, beam, ...) to the vibrating structure. Both piston sides communicate due to a closed loop pipe of cross section and length. Due to the piston movement the fluid mass is accelerated. The piston movement and the fluid movement is geared by the factor . With this transmission factor the effective absorber mass is given . The concept of hydraulic absorber is known already to reduce the dynamic force transmission by hydraulic mounts ...

Keywords: Absorber, oscillations, weight reduction

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LEE®
Innovation in Miniatur

COMPONENTS

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

CHAIR Michael Knobloch
Hawe
Germany

Presenter Prof. Dr. Jyh-Chyang Renn
National Yunlin University of Science and Technology - Taiwan
11:00 - 11:20
SL

Topic Two-stage Large-stroke Proportional Linear Motor

In this paper, a novel two-stage large-stroke proportional linear motor for fluid power valve technology is developed. It is found that the linear effective stroke is around 10 mm and the maximal output force reaches 15 N for the maximal excitation current of 1 A. In the design of the larger 2nd-stage linear motor, the hollow stator with embedded coil and permanent magnet covers and incorporates the smaller 1st-stage linear motor. It is also observed that both the stator and the armature of the 1st-stage linear motor are independently movable and form translational two- dimensional motion. Experiments further prove that such a two-stage large-stroke proportional linear motor can produce diverse modes of motion output even though the motions of the two armatures in the two-stage ...

Keywords: Linear Motor, Hydraulics & Pneumatics, Proportional Technique, Fluid Power, Flux2D

Presenter Prof. Dr. Hong Ji
Lanzhou University of Technology
China
11:20 - 11:40
SL

Topic Mechanism of relief valve pressure maladjustment induced by solid particles

Two-dimensional axisymmetric gap flow field with pressure groove of pilot-operated relief valve main spool was calculated. Eulerian-Eulerian Model of software FLUENT is used in research pressure maladjustment. The research results showed that the solid particles gather densely in pressure groove. The volume fraction of solid particles around semilunar zone is ten times higher than that of inlet, but it is low near the main stream and the bottom of pressure groove. When the direction of the spool motion reverses to the pressure gradient, the gap near pressure groove outlet approaches to semilunar zone. Some particles implant into the gap followed pressure groove leading to spool sticking and inducing pressure maladjustment.

Keywords: pilot-operated relief valve, pressure maladjustment, pressure groove, particles gathering ...

Presenter Dr. Tom Ströhla
TU Ilmenau
Germany
11:40 - 12:00
SL

Topic Fast Switching and Low Power Valve using Polarised Resonance Electromagnets

Fast acting valves play a more and more important role for lots of pneumatic, hydraulic and automotive applications. Further impulses for the development of modern valve systems are given by efficiency demands of the policy. These both contrary optimisation targets can be fulfilled by polarised electromagnets using the resonance principle. A demonstrator of a miniaturised low power 3/2-port valve and 2/2-port valve with an innovative integrated armature-string system was developed in the research project SCHWINGER. Experiments with a system construed for 25 Hz showed that a maximum pressure of 7 bar can be switched with a 7 V excitation and at 2.5 bar pressure with 5 V USB supply, respectively. The current can be limited to 500 mA peak or 100 mA continuously. The paper explains ...

Keywords: Fast Switching and Low Power Valve, Polarised Resonance Electromagnets

Presenter Dr. Lucian Nascutiu
Technical University of Cluj-Napoca
Romania
12:00 - 12:20
SL

Topic High Performance Actuators for Fluid Power Drives

A new actuator based on voice coil motor (VCM) is proposed in this paper. The actuator, which uses Lorentz principle to generate force, is a new-style direct drive motor with special geometry of the magnetic circuit. A particular arrangement of three coils leads to an improvement of its transient behaviour by decreasing the electrical time constant. The use of magnetic fluids within the electromagnetic circuit yields an increase in the force factor, improves the damping, the thermal behaviour and the linearity. Easy to be controlled, with high acceleration, high speed, high force and fast actuation makes it an alternative replacement for expensive and sensitive actuators. Numerical simulations were performed with dedicated software, in order to complete experimental research and to predict some further developments.

Keywords: high speed valves, actuators, voice coil motors

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COMPONENTS

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

CHAIR Dr.-Ing. Lutz Lindemann
Fuchs Petrolub
Germany

Presenter Dr. Wolfgang Bauer
ARGO-HYTOS GmbH
Germany
01:30 - 01:50
SL e

Topic 4/3 proportional valve with only one solenoid: A new technology for position control in suspension systems

Position control of suspension is essential for hydropneumatic suspension systems. This paper explains the implementation of a new approach from the first concept to the hardware test on a tractor. The basis for this concept is a special 4/3-proportional valve, which needs only one solenoid to adjust the position in both directions. The valve is arranged in a circuit in combination with a pilot operated check valve. Compared to today`s position control hydraulics, the new design offers proportional and therefore faster and more accurate position adjustment at reduced design space and with only one electric wire connection.

Keywords: position control, proportional valve, suspension

Presenter Dany Abboud
CETIM
France
01:50 - 02:10
SL e

Topic Condition monitoring of gear pumps using cyclostationarity

Gear volumetric pumps produce high level of vibrations and fluidic pressure fluctuations even in normal operating conditions. Cyclostationary models have proven their usefulness for machines diagnosis where faults in rotating components typically produce a repetitive release of energy. Moreover, when the cyclostationary framework is used with the angular variable of the machine rather than the time variable, it makes it possible to localise precisely the fault thus simplifying extremely its detection. In this paper, several parameters are calculated using cyclostationarity analysis of the downstream pressure signal coming from an accelerated life time test. Finally, it is proved that using cyclostationarity improves wear detection in gear pumps and the extracted diagnostic information ...

Keywords: Condition monitoring, cyclostationary signals, features extraction, fault detection and isolation

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Presenter Martin Dimitrov
TU Darmstadt
Germany
02:10 - 02:30
SL e

Topic Measurement System by Printed Thin Pressure Sensor Array

At the Chair of Fluid Systems a system for measuring high dynamic surface pressure has been developed. This measurement system is used for detection of surface stress due to cavitation. A piezoelectric PVDF-membrane is used to build the measurement system and to detect of higher frequencies events. The thin membrane has many advantages concerning the usage in the context of fluid machines. The electrodes were manufactured on the sensor surface in various ways, including printing technologies. The printed electrodes are realized by the Institute of Printing Science and Technology.

Keywords: piezoelectric sensor, PVDF-membrane, spatial and temporal resolution, cavitation.

Presenter Dr. Stuart Lunt
Parker Hannifin Corporation
United Kingdom
02:30 - 02:50
SL e

Topic Onboard Laboratory: Latest Developments in Oil Condition Monitoring for Mobile and Industrial Applications

Oil condition monitoring is a vital part of integrated asset health management. With an increasing impetus towards real-time decision making, delays incurred in offline laboratory oil analysis are becoming less acceptable. At present, several oil quality parameters can be monitored by commercially available sensors, and active research and development programmes are being pursued by both academic and industrial researchers to develop robust, cost effective sensors for the remaining key oil condition parameters. This paper presents an overview of currently available oil sensors, their advantages and limitations and looks at some recent developments, particularly in the following three areas: Contamination by metallic wear debris, measurement of ...

Keywords: Modern fluid power, condition monitoring, asset management.

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SIMULATION & VALIDATION

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

CHAIR Dr.-Ing. Robert Rahmfeld
Danfoss Power Solutions
Germany

Presenter MD PhD Cristian Ferrari 01:30 - 01:50
Imamoter-C.N.R. SL e
Italy

Topic Methods of Computational Fluid Dynamics for a CVT Transmission Lubrication System of Agricultural Tractor

In this paper, a Method of Analysis based on Computational Fluid Dynamics is presented to evaluate the behaviour of a lubrication circuit of a CVT gearbox. The study of lubrication in gearboxes is an important issue in off-road machines design because reliability depends mostly from lubrication performance, as well as machine lifetime and overall energy efficiency of the transmission. In the paper the methodology will be presented step by step and finally a complete map of operation condition will be disclosed. The result will be contextualized commenting the fluid dynamics phenomena involved and the influence parameters on flow rate distribution.

Keywords: Hydraulic CFD, Lubrication Systems, Off Road Vehicles Transmissions

Presenter Dr. Jochen Lang 01:50 - 02:10
IST Ingenieurgesellschaft für Strukturanalyse und Tribologie mbH - Germany SL e

Topic Simulation Methods for Elastohydrodynamically Coupled Hydraulic Components

This paper presents state of the art simulation techniques to analyse and evaluate mechanical systems with fluid film coupling. The algorithms are implemented in a stable and user-friendly software, which considers the hydrodynamic pressure build-up in the lubricated gaps as well as states of mixed lubrication when surface roughness gets into contact. Under high loads, the consideration of the interaction of the local elastic surface deformations and the pressure build-up is absolutely necessary. The analysis of the calculated tribological parameters like gaps, pressures, friction power losses and mixed lubrication areas help to optimize the design of the bearings and their elastic surroundings. The capability of elastohydrodynamic simulation is shown exemplarily on the ...

Keywords: Simulation, Tribology, Multi Body Systems, Elastohydrodynamics, High-Pressure Fuel Pumps

Presenter Björn Scherweit 02:10 - 02:30
Caterpillar Global Mining Germany SL e

Topic Longwall Mining Simulation

In underground coal mining the longwall method is very popular. In this technique a system of a cutting machine, a conveyor and a huge amount of roof supports is used to extract the coal. Especially the roof supports together with a pump station and the piping form a huge hydraulic system. To get better information about influences from pump capacity, pipe and hose diameters and different changes in the internal roof support circuit this simulation project was initiated. Starting from first tests in the lab over single roof support simulations a concept of simulating a system with more than 1000 functions was developed. This leads to a tool to simulate a complete longwall in dependency of the cutting machine which sets the speed. With the new results systems can be designed for the ...

Keywords: Simulation, Modelling, Optimization, Longwall Mining

Presenter Christian Schleihs 02:30 - 02:50
RWTH Aachen University Germany SL e

Topic 3D-CFD simulation of an axial piston displacement unit

A transient dynamic computational fluid dynamics (CFD) simulation of a swash plate axial piston pump including a cavitation model is presented in this paper. The simulative investigation concentrates on the accurate representation of the cylinder pressure build up, reproduction of the self-priming speed and the qualitative identification of cavitation critical areas. The pressure build up is validated by pressure measurements inside the rotating cylinder. Another key aspect of the simulation is set on the identification of cavitation critical areas inside the pump in order to optimize the pump design.

Keywords: CFD, axial piston machine, cavitation, self-priming speed

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AUTOMOTIVE TECHNOLOGY

CR 4/5
01:30 - 03:00 p.m.

CHAIR Univ.-Prof. Dr.-Ing. Sigfried Helduser
TU Dresden
Germany

Presenter Werner Döhla
Rausch & Pausch GmbH
Austria
01:30 - 01:50
SL e

Topic Further development of valve technology in vehicle's hydraulic roll control systems

In this paper we present new hydraulic valve systems designed for the application in hydraulic roll control systems of passenger cars. An overview of hydraulic architectures already in use is given. For a standard solution with pressure control and directional valves remarkable improvements of the dynamic response have been realised by optimisation of valve damping. An entirely novel 4/3 pressure reducing valve enables pressure control in both actuator volumes. The variety of simulation and test methods used on component and system level is presented. Furthermore we describe design and fabrication of key functional parts and newly developed assembly processes under the conditions of mass production.

Keywords: hydraulic roll control system, pressure control valves, optimisation, series production

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

Topic Design of an Active Air Spring Damper

Since 2009 an active suspension system is under development at the Chair of Fluid Systems at TU Darmstadt. Aim of the project is to control uncertainties of load-bearing systems by adjusting the axial force via altering the effective area of the air spring bellows. This project is part of the Collaborative Research Center (SFB) 805, founded by the German Research Foundation DFG. The working principle is realised by radially moveable piston segments. A prototype has already shown the potential of this concept. In the next phase of this project the prototype will be scaled and experimentally investigated in a Daimler W221 S-Class test car. The infrastructure of the installed Active Body Control System by Daimler will be used to power the new active suspension system hydraulically.

Keywords: active suspension, active air spring damper

Presenter Sarah Flottmeier
University of Paderborn
Germany
02:10 - 02:30
SL e

Topic Test Rig for the Hardware-in-the-Loop Simulation of Mechatronic Axles

In this article we present a new test rig concept for the Hardware-in-the-Loop (HiL) simulation of automotive axles with active suspension, also called "mechatronic" axles. The concept provides for a combination of Rapid Control Prototyping (RCP) and HiL techniques and intends to support the development process of such axles. It requires high performance test rigs and control systems. As present test rigs do not fulfil these demands appropriately, a new test rig was developed. Here, we present its concept, design and an exemplary control scheme for the parallel kinematic excitation unit, whose effectiveness is demonstrated by means of multi body system (MBS) simulations.

Keywords: Automotive Axles, Parallel Kinematics, Hexapod, Control Systems, HiL Simulation

Presenter JiBin Hu
Beijing Institute of Technology
China
02:30 - 02:50
SL e

Topic Research on the Speed Ratio Follow-up Control of Hydro-mechanical Transmission

In order to speed up the application of hydro-mechanical transmission, research on the speed ratio control for hydro-mechanical transmission becomes more and more important. Based on the principle analysis of geometric type hydro-mechanical transmission, the speed ratio equation and the range-shift condition are investigated in this paper. And the speed ratio follow-up control effect is analyzed by simulation and experiment. Results show that through the speed ratio follow-up control, the hydro-mechanical transmission can make vehicle engine work under the desired speed no matter how the external load is changed, which can improve the vehicle power and economy performance greatly.

Keywords: Hydro-mechanical transmission, Follow-up control, Shift condition, Speed ratio adjustment

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MOBILE APPLICATIONS

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

CHAIR Univ-Prof. Dr.-Ing. Marcus Geimer
Karlsruher Institute for Technology
Germany

Presenter Dr. Martin Inderelst — 03:30 - 03:50
XCMG European Research Center GmbH
Germany
SL

Topic Rating of Efficiency Improvements in Mobile Hydraulic Systems

In times of increasing costs for fossil fuels and raising salaries, construction machinery needs more output power and lower fuel consumption. To fulfil these conflicting requirements and be able to comply to new governmental regulations, development of these machines needs assistance to select the most promising approaches instead of doing various tests with prototypes. Simulation can be used as an effective tool to obtain information at an early point in time. However, simulation does still not meet reality and can require high computing time when elaborate simulations. For the purpose of reducing simulation time while still maintaining a good quality of results, this paper presents a simplified way to rate efficiency improvements.

Keywords: Energy Efficiency, Rating, Mobile Hydraulics, Simulation, Improvements

Presenter Emmanuel Viennet — 03:50 - 04:10
Liebherr Machines Bulle SA
Switzerland
SL

Topic Hybrid Systems Set New Requirements on Hydrostatic Units

With the need for a better energy efficiency of mobile machinery and the emergence of promising technologies such as hybrid solutions or alternative hydraulic systems, new requirements have been set for today's hydrostatic units. In addition to the design modifications imposed by higher working loads and longer durability of every component, the engineering challenge is also shifting on increasing the control dynamics of variable- displacement units. The present paper illustrates this new requirement with the example of a displacement- controlled axial-piston swash-plate unit and points out the possible ways available for improving its control dynamics by reducing its settling time. On the basis of both simulation and measurements, key design parameters are identified and their contribution ...

Keywords: axial-piston machine, swash-plate torque, control dynamics, time response

Presenter Jan Schröter — 04:10 - 04:30
RWTH Aachen University
Germany
SL

Topic Development of High Speed Electrical Drives for Mobile Machinery – Challenges and Potential Solutions

Electrical drive technology for traction drives of mobile machinery is yet a niche application, due to low power density and high costs. Compared to the established hydraulic-mechanical drive technology, electrical automotives have some advantages, such as temporary emission-free operation and better partial-load efficiency. For applications in the automotive sector, power density increases significantly by increasing the speed of the electrical motor. Goal of the project „High Speed Electrical Drives" is to show this potential of high speed electrical drives for mobile machinery and to prove their suitability. The high speed requires the development of appropriate electrical machines, control units and gears. Relevant research and development ...

Keywords: electrical drive, electrical motor, mobile machinery, high speed planetary gear, TEAM

Presenter Andrè Sitte — 04:30 - 04:50
TU Dresden
Germany
SL

Topic Design of independent metering control systems

This contribution aims to develop and investigate new electro-hydraulic control systems using independent control edges. Based on a systematic elaboration and analysis of the possible solution space, both the supply and the valve-structures and in particular their interaction in form of control concept are subject of investigation. As a result, the synthesis of the drive system yields in structures, which are characterized by a simple valve design and a low component effort (proportional valves, sensors, magnets). The system behaviour can be further improved by examining the limits and possibilities of operating and control strategies. Exemplary results from simulations are used to clarify the correlations.

Keywords: independent metering, valve structures, electrohydraulic control systems, mobile working machines

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NEW APPLICATIONS

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

CHAIR Dr.-Ing. Alfred Langen
Linde Hydraulics
Germany

Presenter Cord Neemeyer
Rexroth Pneumatics GmbH
Germany
03:30 - 03:50
SL

Topic DIVO® - Utilize pneumatic technology to reduce the burden of drowning in scuba diving

The paper characterizes the development of an innovative device for the scuba diving industry, named DIVO®. Following an explanation of the principle function of this purely pneumatically controlled system, the article introduces findings reached from designing a compensated operational valve named KOV. That valve represents a sub-function of the overall DIVO® system and guarantees the constant filling of a reference volume by taking into consideration both, different water pressures at different water depths as well as different 1st stage pressures. The 1st stage attaches to the scuba tank and reduces the pressure from the tank to an intermediate pressure, which varies depending on the manufacturer. Via simulation and mathematical calculation relevant data has been determined and verified in a test thereafter.

Keywords:

Presenter Dr. Reinhard Schiffers
KraussMaffei Technologies GmbH
Germany
03:50 - 04:10
SL

Topic Wizard-based operator guidance for finding the energetic optimal machine setting in hydraulically driven injection moulding machines

Injection moulding machines are mainly used for processing thermoplastic plastics. These machines melt the plastic and inject it in a cyclic process into a cavity in a mould. In the mould the warmth of the plastic melt is extracted until the injected material solidifies in the new shape. Taking a look at the markets it can be stated that the specific energy consumption of injection moulding machines is a crucial criterion for the investment decision. In addition to the physically needed energy required to plasticize the plastics feedstock there are different hydraulically driven axes and auxiliary functions that have to be realized in an injection moulding machine.

Keywords: Automated optimization, energy consumption, injection moulding, intelligent features

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Presenter Ingo Ernst
LASCO Umformtechnik GmbH
Germany
04:10 - 04:30
SL

Topic Energy recuperation with a hydraulic LASCO servo direct drive for a 8.000 kN deep-drawing press

Among production industries, the suppliers to the automotive industry see the most intense cost pressure. Therefore this industrial sector is seeking for highest efficiency and fastest processes, and most decisions for deep-drawing production lines are made for the benefit of mechanical eccentric presses. LASCO Umformtechnik now found a way to reopen the market for the hydraulic presses with its new servo direct drive. The benchmark which is required to be achieved is 40 strokes/min and 20% less energy consumption than a for a standard hydraulic press. This demand does not allow for the time loss of switching valves nor waiting for pressures to build up in the piston and pipes. With the experience of how precisely a servo synchronous motor can be controlled gained from the newly designed ...

Keywords: Energy recuperation, servo direct drive, 40 strokes/min, highest efficiency

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Presenter Dr. Markus Krach
Marco Systemanalyse und Entwicklung GmbH
Germany
04:30 - 04:50
SL

Topic Energy efficient hydro piston accumulator with sensor system

We present an energy efficient hydro piston accumulator with a sensor system using an ultrasonic distance measurement sensor for the determination of the piston position. Additionally, in the sensor system a pressure and a temperature sensor are available. The gas compartment of the hydro piston accumulator is equipped with a heat buffer to achieve an approximately isothermal change of state during the compression of the gas. In this way, in the presented hydro piston accumulator we realize the precise determination of the piston position - allowing a continuous recording of the operating status - as well as reduced energy loss and increased accumulator capacity by the use of the heat buffer in the gas compartment. The hydro piston accumulator is of great interest for the use in fully hydraulic excavators.

Keywords: efficient fluid power, piston accumulator, sensor system, condition monitoring, hydraulic hybrid

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FLUIDS AND SYSTEMS

CR 4/5
03:30 - 5:00 p.m.

CHAIR Univ.-Prof. Dr.-Ing. Pelz
TU Darmstadt
Germany

Presenter Wolfgang Bock
Fuchs Europe Schmierstoffe GmbH
Germany
03:30 - 03:50
SL

Topic Fire-Resistant Hydraulic Fluids for Industrial and Mining Application - New Developments in Water-Free HFDU Fluids -

Fire-resistant fluids based on synthethic ester (water-free) are used in mining equipment, Steel and Aluminium Industry and mobile hydraulic systems. The paper shows new developments in ester based HFDU fluids. Especially new developments with regard to high ageing stability, excellent copper and yellow metal compatibility and good fire protection properties are discussed. The properties of new developed HFDU fluids according to DIN EN ISO 12922 - minimum requirements for fire resistant hydraulic fluids [3] are shown.

Keywords: Fire-resistant hydraulic fluids, water-free HFDU fluids, fire-resistance, spray ignition test, ...

Presenter Felizia Saile
Bosch Rexroth AG
Germany
03:50 - 04:10
SL

Topic New fluid rating procedure and fluid test at Bosch Rexroth

Over the past few years, it has become evident that fluids that just meet the DIN or ISO standards no longer satisfy all of the requirements of hydraulic applications under high load. Bosch Rexroth defined a new fluid rating procedure that helps determine the suitability of hydraulic fluids across the wide range of Rexroth hydraulic equipment. The goal of the fluid rating procedure is to minimize the risk of damage to Rexroth hydraulic equipment due to under-performing fluids. The procedure is applicable to Rexroth hydraulic pumps and motors.

Keywords: hydraulic fluid rating, hydraulic fluid testing, axial piston pumps and motors

Presenter Jan Schumacher
TÜV Rheinland Energie und Umwelt
Germany
04:10 - 04:30
SL

Topic Will it Work? Fluid Power and Functional Safety

The importance of the reliability of safety related components is demonstrated, if they doesn't work in case of emergency. The bigger the disaster is, the bigger is the echo in the news. To prevent the world from huge environmental impacts and mankind from dead people, manufactures of safety related components and operators from technical facilities have to observe standards like IEC 61508. It will be shown how to use the standard for mechanical components in a correct way.

Keywords: Functional Safety, SIL, Bathtub Curve, IEC 61508

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FINAL LECTURES & FAREWELL ADDRESS

EUROPE HALL
05:15 - 06:15 p.m.

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

Presenter
Prof. Kim Stelson
University of Minnesota
United States

05:15 - 05:35
PL e

Topic
Fluid Power Research in the U.S.A

Since it's creation seven years ago, the Center for Compact and Efficient Fluid Power (CCEFP) has led a renaissance academic fluid power research in the United States. The CCEFP is a network of seven universities and more than fifty companies organized into three thrusts: efficiency, compactness and effectiveness. CCEFP fluid power research is demonstrated on six test beds spanning a range of six orders-of-magnitude of power and weight: precision pneumatics for MRI guided surgery, orthosis, patient mover, passenger car, excavator and wind power generator. Several developments with high commercialization potential will be presented along with examples of industry-university collaboration.

Presenter
Prof. Huayong Yang
Zhejiang University
China

05:35 - 05:55
PL e

Topic
Recent Research Activities in China

Not submitted in time

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

05:55 - 06:15
PL e

Topic
Closing Remarks

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