

# MODERN FLUID POWER

CHALLENGES · RESPONSIBILITIES · MARKETS

24th - 26th MARCH 2014 | **PROGRAMME**

9TH INTERNATIONAL FLUID POWER CONFERENCE



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9TH IFK | PROGRAMME

OVERVIEW OF COLORS & SYMBOLS

The general categories are separated in 4 chapters and colored as follows:

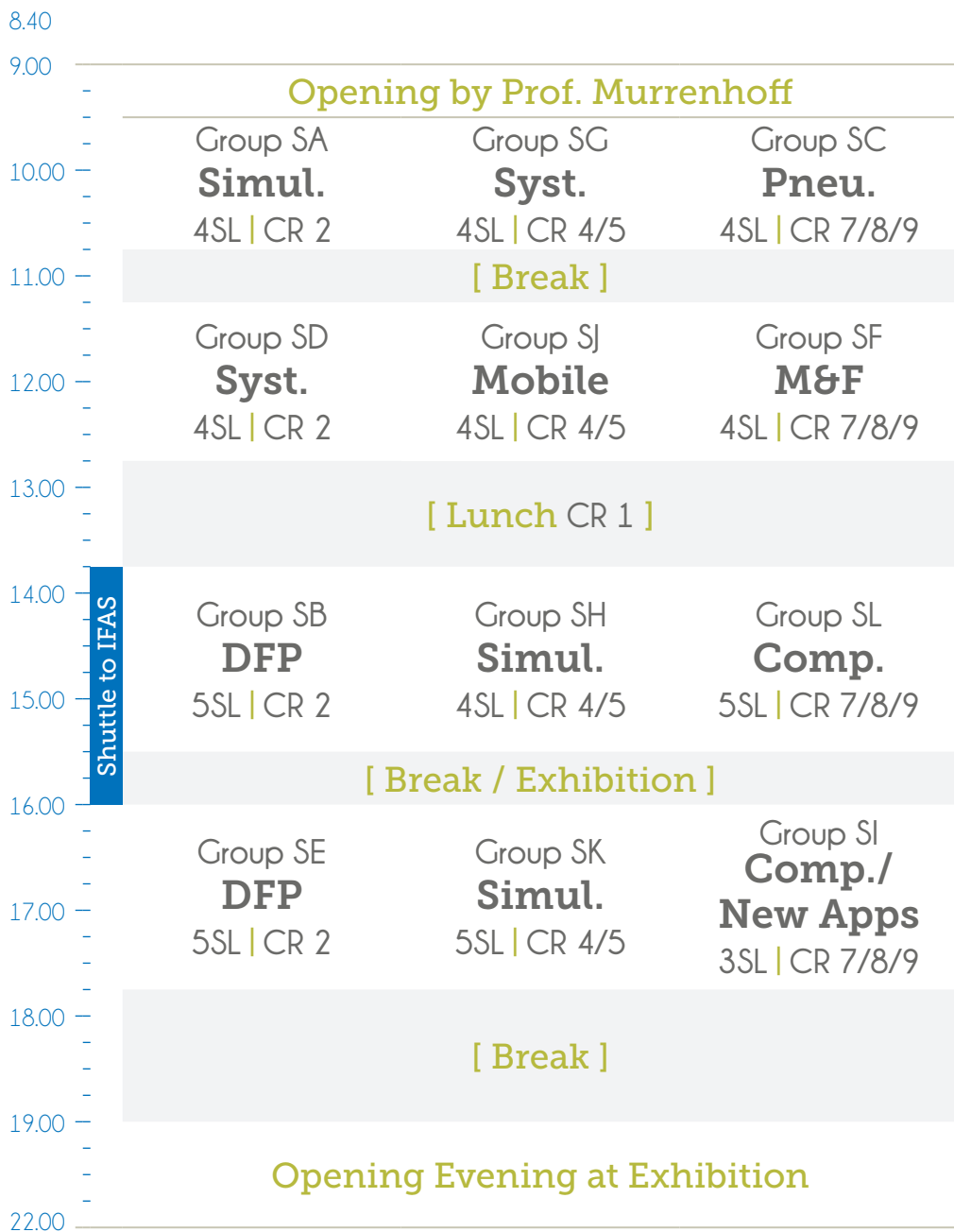
- LECTURES / CONFERENCE
- EXHIBITION & POSTER SESSION
- EVENTS
- GENERAL INFORMATION

Following symbols will help you to categorise each lecture by

- ENGLISH / GERMAN LANGUAGE
- PEER REVIEWED
- GL** GENERAL LECTURE
- PL** PLENARY LECTURE
- SL** SPECIALISED LECTURE
- EH** EUROPE-HALL
- BH** BRUSSELS-HALL
- CR** CONFERENCE ROOM
- DFP** DIGITAL FLUID POWER
- M&F** MATERIALS & FLUIDS
- F&S** FLUIDS & SYSTEMS
- SIMUL.** SIMULATION
- SYST.** SYSTEMS
- COMP.** COMPONENTS
- PNEU.** PNEUMATICS
- RNW.** RENEWABLE



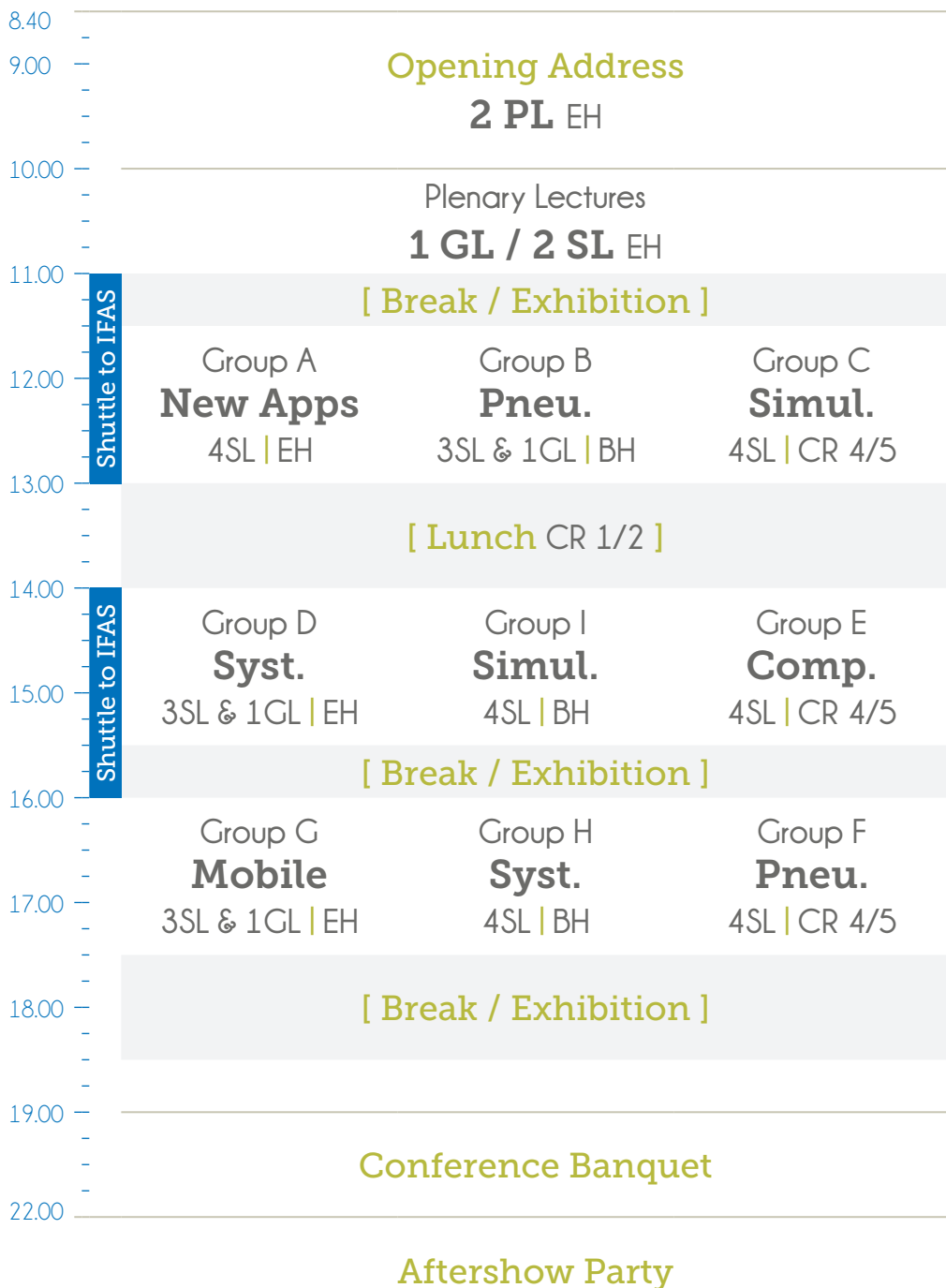
# CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH



Shuttle to IFAS

Scientific Poster Session

# CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH



Shuttle to IFAS

Shuttle to IFAS

Exhibition & Scientific Poster Session

CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

8.40			
9.00			
10.00	Group J <b>Simul.</b> 3 SL   EH	Group K <b>Mob. Apps</b> 4SL   BH	Group L <b>Comp.</b> 4SL   CR 4/5
	[ Break / Exhibition ]		
11.00			
12.00	Group M <b>Rnw. Energy</b> 4SL   EH	Group N <b>Syst.</b> 4SL   BH	Group O <b>Comp.</b> 4SL   CR 4/5
	[ Lunch CR 1/2 ]		
13.00			
14.00	Group P <b>Comp.</b> 4SL   EH	Group Q <b>Simul.</b> 4SL   BH	Group R <b>Autom.</b> 4SL   CR 4/5
	[ Break / Exhibition ]		
15.00			
16.00	Group S <b>Mob. Apps</b> 4SL   EH	Group T <b>New Apps</b> 4SL   BH	Group U <b>F&amp;S</b> 4SL   CR 4/5
17.00	Final Lectures / Farewell Address		
18.00	<b>2 PL + Farewell</b> EH		
	Shuttle to IFAS		
19.00	Laboratory Party		

Shuttle to IFAS

Shuttle to IFAS

Exhibition & Scientific Poster Session

# WELCOME TO THE 9th IFK!

On behalf of the Organizing Committee of the 9th IFK we are delighted that you have chosen to join us for this year's International Fluid Power Conference. Welcome to Aachen!

The IFK, one of the world's largest scientific conferences on fluid power, unites scientists with industry in an international forum to exchange knowledge in the area of hydraulic and pneumatic drives and control systems. The first conference was held in 1974 in Aachen. Since 1998 the Institute for Fluid Power Drives and Controls (IFAS) at RWTH Aachen University and the Institute of Fluid Power (IFD) at TU Dresden alternately organise the conference every two years.

This year we host 141 scientific contributions and speakers and attendees from 26 countries are registered. A special feature of the 9th IFK is the integrated Digital Fluid Power workshop (DFP) on Monday. In order to provide high quality of scientific contributions the authors of this year's scientific papers had the possibility to have their papers reviewed by a board of renowned scientists. Apart from the scientific programme an exhibition of 36 different companies provide the possibility to discover novel fluid power products.

The program begins on Monday morning with a symposium where researchers from mainly universities and other research facilities have the opportunity to present their research projects to a wide

international community of scientists. In the evening of the first day all participants are invited to the opening event that marks the start of the exhibition. The second day begins with the opening address followed by three plenary lectures. On Tuesday and Wednesday, there are seven groups of three parallel sessions of presentations covering a wide variety of application and technology oriented topics. In the evening of the second day, the conference banquet is held at the Coronation Hall of the Aachen town hall. The banquet will be followed by an after show party with cool beverages and snacks in the Aula Carolina.

The conference ends with two final lectures and the farewell address on Wednesday afternoon followed by the laboratory party at the IFAS.

During the conference, the cultural program offers a possibility to explore the antique surrounding of Aachen and the excursion following the conference on Thursday and Friday invites to learn more about industrial companies now and then.

Finally, we would like to express our thanks to all members of the program and organizing committee, scientific advisory board, plenary and keynote speakers, speakers, reviewers, chairmen and exhibitors for their time and commitment helping to conduct another successful and rewarding conference and we hope that you will enjoy the 9th IFK in Aachen.



H. Murrenhoff

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## ORGANISERS



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Society of Advancement for  
Fluid Power Technology, Aachen  
Chairman: [Dr. Frank Bauer](#)



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Institute for Fluid Power Drives and Controls,  
RWTH Aachen University  
Director: [Univ.-Prof. Dr.-Ing. H. Murrenhoff](#)



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Fluid Power Association of the German  
Engineering Federation (VDMA),  
Frankfurt am Main  
Chairman: [C. H. Kienzle](#)

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## SCIENTIFIC SUPPORT

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Institute for Fluid Power Drives and Controls,  
RWTH Aachen University  
Director: [Univ.-Prof. Dr.-Ing. H. Murrenhoff](#)



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TU Dresden, Institute for Fluid Power  
Director: [Univ.-Prof. Dr.-Ing. J. Weber](#)



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## SPONSORING



One of the most popular sports worldwide is football. Despite being an easy play, transferring the necessary skills of a good footballer to a machine is a challenging task. During a penalty from 11 m, the keeper must detect, react and catch the ball in less than 300 ms with ball forces greater than 900 N.

To fulfil these requirements using a robot, small and compact drives with good controllability are needed. Therefore, the first choice should be the use of a hydraulic system. The IFAS-Team has designed such a robot capable of image processing to demonstrate the known power density and high performance of hydraulic components. The ifKeeper is a carbon fibre laminated man, approximately the same height as Prof. Murrenhoff, and has a weight all in all of only 20 kg. For the rotary motion of the ifKeeper a compact actuator, operating according to the helical gear principle, applies a torque of more than 1300 Nm. The movement of both arms is realised by a rope drive and a small differential cylinder. The actuation power for the system is supplied by a compact power pack and a piston accumulator. For the control, servo valves and on/off valves are installed. An EtherCat system is implemented for the system control.

IFAS thanks the sponsors for their generous support:

Compact Aggregate, Accumulator, Sensors, Filter



Rotary Actuator



Servo Valves



On/Off Valves



System Design and Control



Carbon Fibre Lamination



## THE OPTIONAL PEER REVIEW

Many public institutions that support research projects require a regular publication of their results. To ensure that these results are in fact of scientific value, the assessment by a third party is often required. This process is known as peer-review and due to its demanding logistics is increasingly rare. The Institute for Fluid Power Drives and Controls (IFAS) and organisers of the 9th IFK in Aachen wanted scientists to have the opportunity to have their work reviewed accordingly, so as to demonstrate its scientific value.

By tradition, the IFK unites scientists with industry in an international forum to exchange their knowledge. Therefore, a peer-review only makes sense for some of the authors. At this juncture, the IFAS would like to point out that the peer-review is intended in no way to classify the papers, but only to support the need for review.

The reviewed papers and the corresponding presentations are tagged with the sign below in the Scientific Programme.



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# CONFERENCE

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SYMPOSIUM  
Monday, 09:00 a.m. - 05:45 p.m.

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## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### 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 09:20 - 09:40  
TU Darmstadt SL   
Germany

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 Karl Hartmann 10:00 - 10:20  
TU Braunschweig SL   
Germany

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

Topic Simulation of the tribological contact  
cylinder block / valve plate and influence  
of geometry and operating points on the  
friction torque in axial piston machines

In this paper a simulation program for the cylinder block / valve plate interface in axial piston machines 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: tribological contact, cylinder block, valve plate, viscous friction, solid friction, Reynolds equation

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

Topic Development of a new gerotor pump with  
innovative gerotor design and investigati-  
on 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

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### SYSTEMS

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




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

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 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 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 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,


## NOTES

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### PNEUMATICS

CHAIR Dr.-Ing. Rüdiger Neumann  
Festo AG  
Germany

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

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

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

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,

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

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

## NOTES

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### SYSTEMS

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


CR 2  
11:15 - 12:35 a.m.

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

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

Topic Energy-efficiency and thermo energetic be-  
haviour 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 Philipp Pöttgen 11:35 - 11:55  
TU Darmstadt SL   
Germany

Topic Technical Operations Research (TOR)  
exemplified by a Hydrostatic Power Trans-  
mission 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 Qihuyi Chen 12:15 - 12:35  
Zhejiang University SL    
China

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

## NOTES

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### MOBILE

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


CR 4/5  
11:15 - 12:35 a.m.

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

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

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

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

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


## NOTES

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### MATERIALS & FLUIDS

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


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

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

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

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

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

**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

## NOTES





## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### DIGITAL FLUID POWER

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



CR 2  
01:45 - 03:30 p.m.

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

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

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

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

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

## NOTES

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

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, retrofitable 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

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### SIMULATION AND VALIDATION

CR 4/5

01:45 - 03:30 p.m.

**CHAIR** Prof. Dr. -Ing. Yeh-Sun Hong  
Korean Aerospace University  
Korea

**Presenter** Dr. Mohamed Elgamil 01:45 - 02:05  
Cairo University SL [e](#)  
Egypt

**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** Prof. Dr. Victor Juliano 02:25 - 02:45  
De Negri SL [e](#)  
Federal University of Santa  
Catarina, Brazil

**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 been 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** Dr. David van Bebber 02:05 - 02:25  
Ford Forschungszentrum SL [e](#)  
Aachen  
Germany

**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** Johannes Willkomm 02:45 - 03:05  
Bosch Rexroth AG SL [e](#)  
Germany

**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

## NOTES

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### COMPONENTS

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


CHAIR Dr.-Ing. Christoph Boes  
Moog  
Germany

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

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

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

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

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 essential for efficient operation of such machines. The present work is focused on 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 capacitive sensors were installed on the pump body. In addition to the film thickness 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

## NOTES

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

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,

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### DIGITAL FLUID POWER

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

CR 2  
04:00 - 05:40 p.m.

Presenter Christoph Gradl 04:00 - 04:20  
Johannes Kepler University SL [e] [i]  
Austria

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 Christian Stauch 04:40 - 05:00  
ZeMA Zentrum für Mechatronik und Automatisierungstechnik GmbH, Germany SL [e] [i]

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 Mikko Heikkilä 04:20 - 04:40  
Tampere University of Technology SL [e] [i]  
Finland

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 Andreas Plöckinger 05:00 - 05:20  
Linz Center of Mechatronics GmbH SL [e] [i]  
Austria

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

## NOTES

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

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

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### SIMULATION

CHAIR Prof. Eric Bideaux  
INSA de Lyon  
France

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

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

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. Marat Gimadiev 04:40 - 05:00  
Samara State Aerospace University  
Russia 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 m<sup>3</sup> 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 Dr. Gudrun Mikota 04:20 - 04:40  
Johannes Kepler University Austria 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 Vasil Slavov 05:00 - 05:20  
University of Stuttgart Germany 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

## NOTES

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

## CONFERENCE PROGRAMME MONDAY, 24TH OF MARCH

### COMPONENTS

CHAIR Dr.-Ing. Sebastian Mundry  
Caterpillar Mining  
Germany


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

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

Topic A novel fault tolerant high precision  
roto-translating 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 Stefan Hein  
04:40 - 05:00  
TU Bergakademie Freiberg SL   
Germany

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,

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

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 bi-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

## NOTES

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# CONFERENCE

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COLLOQUIUM  
Tuesday 08.40 a.m. - 05.30 p.m.

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## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### PLENARY LECTURES


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

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

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


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

Topic Increasing the efficiency of hydraulic accu-  
mulators 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 ...

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

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.

## NOTES



Institute for  
Fluid Power  
Drives and  
Controls

## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### 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   
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 Dr. Peter Tappe 12:30 - 12:50  
Magnet-Schultz GmbH SL   
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 Thomas Jockenhöfer 11:50 - 12:10  
Hauhinco Maschinenfabrik SL   
C. Haussher, 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 Daniel Barfuß 12:10 - 12:30  
TU Dresden SL   
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, ...

## NOTES



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## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### PNEUMATICS

CHAIR Dr.-Ing. Peter Staffe  
Bosch Rexroth  
Germany

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

Presenter Prof. Dr. Peter Post 11:30 - 11:50  
Festo AG & Co. KG GL [e](#)  
Germany

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 Christian von Grabe 12:10 - 12:30  
RWTH Aachen University SL [e](#)  
Germany

Topic Efficiency Improvements by Air Recupera-  
tion 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

Presenter Dr. Wolfgang Gauchel 11:50 - 12:10  
Festo AG & Co. KG SL [e](#)  
Germany

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

Presenter Theodor Paulus 12:30 - 12:50  
Bosch Rexroth AG SL [e](#)  
Germany

Topic Vorsteuerventiltechnik für kompakte  
pneumatische Ventilsysteme

Not submitted in time

Keywords:

## NOTES

## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### SIMULATION & VALIDATION

CHAIR Dr.-Ing. Dirk Klug  
Schuler SMG  
Germany



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

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

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 Olivier Reinertz 12:10 - 12:30  
RWTH Aachen University SL    
Germany

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

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

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 12:30 - 12:50  
Eaton Hydraulic Group SL   
United States of America

Topic Flow Forces Investigation through Compu-  
tational 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)


## NOTES

## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### SYSTEMS

CHAIR Dr. Peter Synek  
VDMA  
Germany


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

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

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

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 found 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

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

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

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

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

## NOTES




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## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### SIMULATION & VALIDATION

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

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

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

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

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

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

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, ...

## NOTES

## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### COMPONENTS

CHAIR Dr.-Ing. Frank Bauer  
Hydac  
Germany

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

Presenter Prof. Dr. Wieslaw Fiebig 02:00 - 02:20  
Wroclaw University of Technology  
Poland 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 Dr. Liselott Ericson 02:40 - 03:00  
Linköping University  
Sweden 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 Dirk Schulze Schencking 02:20 - 02:40  
RWTH Aachen University  
Germany 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. Masashi Sasaki 03:00 - 03:20  
Mitsubishi Heavy Industries, Ltd.  
Japan 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<sup>®</sup> 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

## NOTES

## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### MOBILE

CHAIR Prof. Dr. Monika Ivantysynova  
Perdue University  
United States of America

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

Presenter Prof. Dr. Hubertus Murrenhoff 04:00 - 04:20  
RWTH Aachen University GL [e] [L]  
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 analogue and digital solutions with recuperation and regeneration ...

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

Presenter Markus Schneider 04:40 - 05:00  
TU Dresden SL [e]  
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 Milos Vukovic 04:20 - 04:40  
RWTH Aachen University SL [e]  
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 Dr. Christian Stammen 05:00 - 05:20  
XCMG European Research Center GmbH SL [e]  
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:

## NOTES

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## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### SYSTEMS

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

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

Presenter Bert Brahmner 04:00 - 04:20  
Voith Turbo H + L Hydraulic SL [e](#)  
GmbH & Co. KG  
Germany

Topic Drives for Punching and Forming Machines:  
How Hydraulics compare to Current Elec-  
tromechanical 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

Presenter Ulrich Walter 04:40 - 05:00  
W.E.St. Elektronik GmbH SL [e](#)  
Germany

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

Presenter Juliane Weber 04:20 - 04:40  
TU Dresden SL [e](#)  
Germany

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

Presenter Prof. Dr. Željko Šitum 05:00 - 05:20  
University of Zagreb SL [e](#)  
Croatia

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-tN 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

## NOTES

## CONFERENCE PROGRAMME TUESDAY, 25TH OF MARCH

### PNEUMATICS

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

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

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

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

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

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

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

## NOTES

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# CONFERENCE

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COLLOQUIUM  
Wednesday 09:00 a.m. - 06:10 p.m.


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## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### SIMULATION

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




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

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

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

**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 (RoLa). 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

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

**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

## NOTES



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## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### MOBILE APPLICATIONS

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

### BRUSSELS-HALL

09:00 - 10:30 a.m.

Presenter Taghi Akbarian 09:00 - 09:20  
DEUTZ AG SL [e](#)  
Germany

Topic System integration and presentation of optimised drive solution with diesel engines in the Tier 4 emission level

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

Presenter Kalle Einola 09:40 - 10:00  
Ponsse Plc SL [e](#)  
Finland

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

Presenter Roman Krähling 09:20 - 09:40  
ARGO-HYTOS GmbH SL [e](#)  
Germany

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

Presenter Henri Hänninen 10:00 - 10:20  
Aalto University SL [e](#)  
Finland

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

## NOTES

## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### COMPONENTS

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

CHAIR Dr.-Ing. Harald Geis  
Thomas Magnete  
Germany

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

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

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

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. Kristian Müller-Niehuus 10:00 - 10:20  
Merkel Freudenberg SL   
Fluidtechnik GmbH  
Germany

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

## NOTES

## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### RENEWABLE ENERGY

CHAIR Dr.-Ing. Wolfgang Hahmann  
Hydac  
Germany

### EUROPE-HALL

11:00 - 12:30 a.m.

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

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

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

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

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

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

Presenter Dominic Diebel 12:00 - 12:20  
RWTH Aachen University  
Germany SL [e]

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, ...

## NOTES

# MOOOG

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## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### SYSTEMS

### BRUSSELS-HALL

11:00 - 12:30 a.m.


CHAIR Götz Sonderrmann  
Siempelkamp  
Germany

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

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

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


Keywords:

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

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 servomotor. 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 Tobias Corneli 12:00 - 12:20  
TU Darmstadt  
Germany  
SL 

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

## NOTES



Innovation in Miniatur




## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### COMPONENTS

CHAIR Michael Knobloch  
Hawe  
Germany




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

Presenter Dr. Tom Ströhlha 11:00 - 11:20  
TU Ilmenau SL   
Germany

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 Prof. Dr. Hong Ji 11:40 - 12:00  
Lanzhou University of Technology     
China

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 Prof. Dr. Jyh-Chyang Renn 11:20 - 11:40  
National Yunlin University of Science and Technology - Taiwan 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 Dr. Lucian Nascutiu 12:00 - 12:20  
Technical University of Cluj-Napoca   
Romania

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

## NOTES

## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### COMPONENTS

CHAIR Dr.-Ing. Lutz Lindemann  
Fuchs Petrolub  
Germany

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

Presenter Dr. Wolfgang Bauer 01:30 - 01:50  
ARGO-HYTOS GmbH SL [e](#)  
Germany

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 Martin Dimitrov 02:10 - 02:30  
TU Darmstadt SL [e](#)  
Germany

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 Dany Abboud 01:50 - 02:10  
CETIM SL [e](#)  
France

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

Presenter Dr. Stuart Lunt 02:30 - 02:50  
Parker Hannifin Corporation SL [e](#)  
United Kingdom

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.

## NOTES



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## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### 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** Björn Scherweit 02:10 - 02:30  
Caterpillar Global Mining SL [e](#)  
Germany

**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** Dr. Jochen Lang 01:50 - 02:10  
IST Ingenieurgesellschaft SL [e](#)  
für Strukturanalyse und  
Tribologie mbH - Germany

**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** Christian Schleihs 02:30 - 02:50  
RWTH Aachen University SL [e](#)  
Germany

**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



## NOTES

## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### AUTOMOTIVE TECHNOLOGY

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




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

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

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

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

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

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

## NOTES

## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### MOBILE APPLICATIONS

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




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

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

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

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

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 André Sitte 04:30 - 04:50  
TU Dresden SL    
Germany

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, electrohy-  
draulic control systems, mobile working machines

## NOTES



The logo for Hauhinco features the company name in a bold, blue, sans-serif font. The letters are contained within a dark blue, curved arch that spans the width of the text. Below the arch, there is a solid dark blue horizontal bar.


## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### NEW APPLICATIONS

CHAIR Dr.-Ing. Alfred Langen  
Linde Hydraulics  
Germany

### BRUSSELS-HALL



03:30 - 5:00 p.m.

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

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 Ingo Ernst 04:10 - 04:30  
LASCO Umformtechnik SL   
CmbH  
Germany

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

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

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

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

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

## NOTES

## CONFERENCE PROGRAMME WEDNESDAY, 26TH OF MARCH

### FLUIDS AND SYSTEMS

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



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

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

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

Fire-resistant fluids based on synthetic 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 Jan Schumacher 04:10 - 04:30  
TÜV Rheinland SL    
Energie und Umwelt  
Germany

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

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

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

## NOTES





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# SCIENTIFIC POSTER SESSION

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Monday 03:30 p.m. - 10:00 p.m.  
Tuesday 10:00 a.m. - 07:00 p.m.  
Wednesday 10:00 a.m. - 05:00 p.m.

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**GROUP 1 : SYSTEMS**

Research on hydraulic network control system for intelligent excavator

Min Yu | Zhejiang University, China

Experimental study of pressure pulse test stand based on servo

Shuang Wang | Zhejiang University, China

Use of common PLCs for closed loop hydraulic drives

Dr. Marian Blejan | Hydraulics & Pneumatics Research Institute, Bucharest, Romania

**GROUP 2 : SIMULATION AND VALIDATION**

Effective modeling and simulation of complicated fluid power systems

MD PhD Gunnar Grossschmidt | Tallinn University of Technology, Estonia

Load prediction-based energy-efficient hydraulic actuation of a robotic arm

Can Du | University of Bath, United Kingdom

Stability analysis of the robotic manipulators with time delay

Prof. Dr. Dragutin Debeljkovic | Harvard Medical School, USA

**GROUP 4 : ENERGY MANAGEMENT**

Energy regeneration and efficiency in an electro-hydraulic forklift with lithium-titanate batteries

Dr. Tatiana Minav | Aalto, Finland

Energy saving of intermittently operated pump unit with engine restart using hydraulic assist

Shuji Kasuya | Tokyo City University, Japan

Innovative drive and control technology for fluid pumps, especially positive displacement pumps

Bernd Freissler | ProMinent Dosiertechnik GmbH, Germany

Experimental research regarding the recuperation/recovery of rotational kinetic energy from equipments or mechanisms with hydraulic drive

Dr. Ing. Catalin Dumitrescu | Hydraulics and Pneumatics Research Institute, Romania

**GROUP 5 : PNEUMATICS**

Determination of acoustic characteristics of pneumatic exhaust silencers:

Proposal for a new standard

Xavier Carniel | Cetim, France

Offline trajectory planning of a pneumatically actuated, continuum manipulator on the example of the bionic handling assistant

Valentin Falkenhahn | University of Stuttgart, Germany

Feed-forward control of arbitrary pressure pulsation generator for testing gas flow meters

Dr. Tomonori Kato | Japan/Fukuoka Institute of Technology, Japan

Comparison study of three synchronous motion control strategies of a servo pneumatic system based on individual meter-in and meter-out

Dr. Xiaocong Zhu | Zhejiang University, China

**GROUP 6 : NEW APPLICATIONS**

Premixed high pressure abrasive water jet cutting under water

Prof. Dr. Yongjun Gong | Transport Equipment & Ocean Engineering Department, Dalian Maritime University, China

Design and control of pneumatic micromanipulation system

Prof. Dr. Ming-Chang Shih | National Cheng-Kung University, Taiwan

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

Stefan Hein | TU Bergakademie Freiberg, Germany

Condition monitoring for pumps in water-hydraulic accumulator systems

Hans-Joachim Dittmer | Engineer's Office for Fluid-Technology, Germany

**GROUP 7 : COMPONENTS**

A novel parallel piloted valve applied in servo die cushion with mechanical feedforward compensation of velocity difference

MD PhD Shizhen Li | Zhejiang University, China

Investigation on the power losses from hydrostatic piston shoe bearings for swash plate type axial piston pumps under mixed friction conditions

Prof. Dr. Yeh-sun Hong | Korea Aerospace University, Korea

2D electrohydraulic proportional direction valve integrated with direct and pilot operation

Dr. Bin Meng | Zhejiang University, China

**GROUP 10 : MOBILE APPLICATIONS**

Direct driven hydraulic drive

Dr. Tatiana Minav | Aalto University, Finland

Dynamic model of an axial piston pump for fast simulation of mobile machinery duty cycles

Luca Riccò | University of Parma, Italy

**GROUP 12 : DIGITAL FLUID POWER (DFP)**

Research analysis of dynamic processes occurring in pipelines with digitally controlled hydraulic valve

Prof. Dr. Ilcho Angelov | Technical University of Sofia, Bulgaria

Inspections on control performance of a digital hydraulic power management system supplying digital and proportional valve driven multi-actuator system

Matti Karvonen | Tampere University of Technology, Finland

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# EXHIBITION & POSTER SESSION

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Monday 7 p.m. - 10 p.m.  
Tuesday 10 a.m. - 7 p.m.  
Wednesday 10 a.m. - 5 p.m.

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- 05 Entwicklungsbüro für Fluidtechnik (103)
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### POSTER

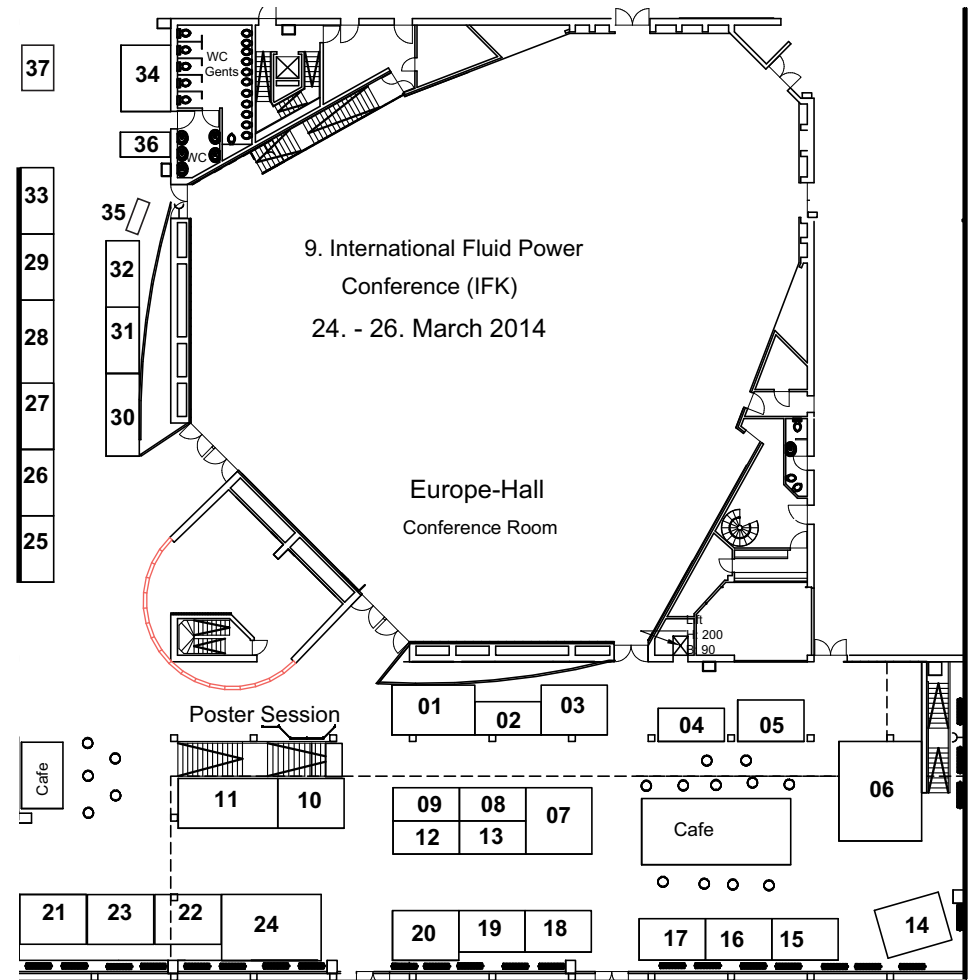
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## EXHIBITION

### EUROGRESS FOYER



## COMPANY PROFILE

### BALLUFF GMBH

BOOTH 30

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**BALLUFF**  
*sensors worldwide*

Balluff was founded in 1921 in Neuhausen a.d.F. The family-run business employs 2,600 people worldwide and represents innovative technology, quality and maximum customer orientation. As a leading provider for industrial automation, the family-run company offers a full range of high-quality sensors, system- and customer-specific solutions. In 2013 Balluff GmbH registered a turnover of approx. 335 million €. In addition to the central headquarters in Neuhausen, Balluff has production and development sites around the world, as well as 56 international subsidiaries and representative offices. This guarantees that customers have fast availability of the products, high application

assistance and perfect service directly on-site - worldwide.

For further information please visit [www.balluff.com](http://www.balluff.com)

### DELTA ENTWICKLUNGSGESELLSCHAFT MBH

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**DELTA**  
Entwicklungsgesellschaft

#### BUSINESS STRATEGIES

Since our company was founded in 1994, we have successfully completed a large number of contract developments. Our highly motivated team consists of engineers and experts on different fields such as mechanical engineering, electrical engineering, medical engineering and fluid technology. This team offers innovative developments of new products or troubleshooting for existing products.

also the possibility to make a feasibility study. On the basis of calculation and simulation we make concepts, drafts and computer-aided designs. Our production drawings are the base of our prototype building and testing. Finally we can offer the serial production or find a possible production partner.

We use our deep knowledge in fluidic drive and control systems to find outperforming solutions for our clients requirements.

#### CORE TECHNOLOGIES AND SERVICES

In the early stages of our process chain we usually work on a market- and competition study. Of course there is

Our electronic engineers develop and produce the matching electronic control system for the application.

## COMPANY PROFILE

### BUCHER HYDRAULICS GMBH

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**b** **BUCHER**  
HYDRAULICS

Hydraulics - as we all know - is the lore of liquid flow characteristics for signal, force and energy transmission. For us this means that we always work with the pressure of hydraulic oil. Not just from a purely physical perspective but also with respect to new ideas and adaptation to our customers' wishes. We focus our ideas on market requirements.

Under the influence of our hydraulics a fluid that is normally quite harmless in a stagnant state, i.e. oil is transformed into a tremendously powerful and constant force. We harness this power not only for our exceptionally durable products but also to ensure Bucher Hydraulics' long-term and steady existence as

a company.

The satisfaction of our customers and also of our employees is at the very top of our priority list. As we are anxious to be on the ball at all times we have built up very close contacts with our customers and jointly we work to find target-oriented solutions. This approach provides us with an unparalleled precision in communications and in implementing the various projects. This in turn results in cutting-edge product developments that fully reflect current trends. We are able to guarantee unmistakable quality in all aspects from the design stage to actual production.

### ENTWICKLUNGSBÜRO FÜR FLUIDTECHNIK

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Entwicklungsbüro  
für Fluidtechnik 

Profitable innovations are the indispensable condition for the survival of our industries. New products and product families have to be generated in a fast, safe and economical process. We accept this challenge in its entirety. For more than 25 years we are on duty as an enthusiastic and trustworthy team.

profitable products with a minimum of expense and time.

We offer the development of innovative products and systems as an integral engineering service and accompany our customer on his way to economic success. Our conception rectifies all steps of the development procedure to one aim: The creation of

This overall-prospect is our special tool to keep the balance between performance, cost and customer benefits. Our core competences are concept generation, calculation, design and advanced computer-aided technologies. On the other hand we supply valuable prototype production, conduct performance and endurance tests and produce computerised test rigs.

## COMPANY PROFILE

### ETO MAGNETIC GMBH

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The world wide operating ETO GROUP with its more than 1.500 employees at 6 locations is represented on the IFK Aachen by ETO MAGNETIC from Stockach and EKS Elektromagnetik from Vaihingen/Enz. We are specialized in electromagnetic components for vehicle and industrial applications. We develop, produce and distribute customer specific components and modules as well as standard products for OEMs and system manufacturers. The ETO GROUP product range contains solenoid valves, electromagnetic actuators and sensors for hydraulic, pneumatic and mechanical applications. As a long-term development partner of the automotive industry, we are certified

according to ISO/TS 16949/DIN EN ISO 9001/DIN EN ISO 14001. Our products, processes and methods are proven millions of times in numerous applications with world class customers. With production sites in America, Europe and Asia the ETO GROUP offers its customers a global service and worldwide availability of our products. Together with you we work for the success of your business. We find the solution to your problem quickly, efficiently and reliably.

### FLUIDESIGN

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We are a group of French companies, which are expert in manufacturing of small series with high level of industrial means. Innovation driven, we are ISO 9001, and our group has already filed five patents, including 2 in 2013. The knowhow of the group includes following fields:

**Hydraulics:** design and manufacturing of tailor made hydraulics valves and systems; we are the world wide specialist of flow divider for hydrostatic transmission. We have developed a strong knowledge in Simulation of hydraulics components and machines under AMESim and virtual lab.

**Electronics:** design and manufacturing of electronics

and mechatronic systems.  
**Training:** Design and manufacturing of specific didactic training equipment for industrial and mobile hydraulics  
Specific Hydraulic training by videoconference or on-site for hydraulic specialists

## COMPANY PROFILE

### FAMIC TECHNOLOGIES

BOOTH 16

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**Famic Technologies Inc.**

Founded in 1986, Famic Technologies offers a full range of quality products and services in the fields of software engineering and industrial automation. It develops integrates and markets CAD and simulation software solutions for electrical, hydraulics, pneumatics, automation and controls applications which support design operations, management and training. Famic Technologies provides innovative software solutions to help engineers, maintenance personnel and trainers substantially increase their efficiency in systems design, maintenance and training. Since January 2012, Famic Technologies has opened a sales and support office in Germany to better serve customers needs in Europe.

www.famictech.com  
Automation Studio™ is a leading software solution developed by Famic Technologies that helps reduce machine time-to-market and optimizes the entire workflow of a project or product or product lifecycle. It seamlessly integrates system design engineering simulation, prototyping, testing troubleshooting, diagnostics, maintenance, service, training and documentation, and is offered in 11 languages. Automation Studio™ is among the most complete trade-oriented system design and simulation software solutions in the fields of fluid power, electrical and automation.

### FLUIDON GMBH

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FLUIDON Gesellschaft für Fluidtechnik mbH in Aachen, Germany is a specialist in the field of simulation of mechatronic systems, especially in the area of fluid power applications. The company's customers, from the automotive, aerospace and general machinery industries, use FLUIDON products for the design and development of innovative products. The services include the complete development of mechatronic systems as well as the allocation and the development of the simulation software DSHplus and its support.

DSHplus is a simulation program especially developed for the dynamic nonlinear calculation of complex hydraulic and pneumatic systems and components.

DSHplus models also comprise 1D mechanical structures and controller elements of the mechatronic system. DSHplus is applicable for analysis of system dynamics, system revision, component selection, component development, fault diagnosis, as well as training purposes.

The FLUIDON specialists with their great fluid technical expertise are always eager to support engineers in the development, simulation and optimization of such innovative fluid power applications.

For more information please visit us in booth no. 4 or take a look at www.fluidon.com.



## COMPANY PROFILE

### HAUHINCO MASCHINENFABRIK GMBH & CO. KG

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Hauhinco Maschinenfabrik G. Hausherr, Jochums GmbH & Co. KG - Hauhinco in short - is one of the world's leading manufacturers of water hydraulic systems for mining and industrial applications. The company develops customised, comprehensive solutions for both areas of application.

In the mining field the spectrum ranges from high-pressure and spraying systems through to water treatment equipment. The high pressure systems for longwall hydraulics include so-called EHP-3K and EHP-5K pumps with electric motors, emulsion tanks, as well as high-pressure and return filters. The company also supplies control modules, hydraulic accumulators and

explosion-proof measuring instruments. Spray systems are used for the shearer water sprays, the coal plough operation and the cooling systems of drive motors. For industrial applications, Hauhinco offers water hydraulic systems for the nonferrous metal, light metal and automotive industries. The portfolio includes the full spectrum of components such as high-pressure pumps, valves, valve blocks, control systems and modular systems. One of the company's core competences is the development of press control and drive systems for all types of new and existing water hydraulic presses.

### INSTITUT FÜR FLUIDTECHNIK - TU DRESDEN

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The Institute of Fluid Power represents the research and education in hydraulic and pneumatic drive and control technology at the TU Dresden. It plays a leading role in the German and international research community and is a well-known research and development partner for companies. This leading position is based on a long tradition of excellent results in basic and application oriented research projects. All research topics are focused on actual industrial issues and have the following emphases:

- Virtual engineering of fluid-mechatronic components
- Fluid-mechatronic systems

- Alternative and energy efficient drive concepts
  - System integration
- The IFD team consists of motivated and qualified research assistants from the fields of mechanical, electronic and mechatronic engineering. For experimental research activities, the Institute of Fluid Power has a modern laboratory with a total area of 600 m<sup>2</sup>. It is divided into a hydraulic and a pneumatic area and is equipped with different test rigs for flow visualisation as well as two acoustic measuring laboratories.

## COMPANY PROFILE

### HYDAC INTERNATIONAL GMBH

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With 7,000+ employees, 50 overseas subsidiaries and 1,000 sales and service partners worldwide, we are in close contact with our customers, providing engineering advice, production support, expert installation and superior service.

We are well-positioned to fulfill the exacting demands of the international market. Our interdisciplinary network links expertise, innovation, quality standards, customization and service all over the world. The knowledge and skill we have gained in over 50 years in the most demanding and diverse projects means HYDAC industry and product specialists speak your language. No matter what the job entails

and irrespective of location, we are able to help you find the best solution. With HYDAC's innovative engineering, our quality components and systems and our outstanding service, we've got you covered.

#### RANGE OF PRODUCTS

Filtration Technology, Filter Systems Technology, Process Filtration Technology, Cooling Systems, Accumulator Technology, Hydraulic Cylinders, System Engineering, Compact Hydraulics, Control Technology, Electronics and Diagnostic Technology, Accessories, Fluid Service.

### ITI GMBH

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*Supporting your visions*

Founded in 1990, ITI is one of the leading software and engineering companies for system simulation. SimulationX is our multi-domain simulation tool for physical modeling and dynamic analysis of complex fluid power systems with customizable models and libraries including MBS mechanics, power transmissions, magnetics and electronics amongst others. We support our customers in:

- modeling hydraulic-mechanical components and systems
- designing virtual prototypes
- HiL and SiL simulations
- optimizing energy efficient drives for mobile

machinery

- dimensioning machine controls.

SimulationX offers various interfaces to other CAD/CAE programs as well as real-time platforms and supports Modelica® and FMI. More than 700 companies including Aker Solutions, Baker Hughes, Bosch Rexroth, Cameron, Hitachi, Husky, Norgren, Oilgear, Liebherr, Siemens, ThyssenKrupp and Voith Hydro benefit from the software. SimulationX is also used in academic research worldwide.

For more details, visit  
www.simulationx.com.

## COMPANY PROFILE

### KONZELMANN GMBH

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**Web** www.konzelmann-gmbh.de



Our main application fields are product applications with complicated geometrical shapes, where technically high-quality plastics and high-performance polymers are involved. As a system supplier we develop fluid power system and tribological applications, such as seal rings, valves, pistons, slide bearings, slide rings, etc. Using application test benches for rectangular rings, thrust washers and slide bearings, we drive our basic development as well as the optimization of your components. Different refining technologies enable you to acquire complete module assemblies. We accompany you from your first idea up to series production of your product.

### LEE HYDRAULISCHE MINIATURKOMPONENTEN GMBH

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**Web** www.lee.de



**Innovation in Miniatur**

INNOVATIVE VALVES FOR GASES AND LIQUIDS!  
For more than 65 years, „The Lee Company“ has been a leading supplier of high-precision, miniature hydraulic components THE LEE COMPANY was founded by Leighton Lee II in 1948. One of his many inventions was the LEEPLUG expansion plug which was also adopted in precision screens, check valves, pressure relief valves, shuttle valves and screens etc. In 1974, the first LEE miniature solenoid valves were introduced to the market. Today, they continue to be used in many different kinds of fluidic systems in the areas of medicine, pharmaceuticals, chemicals and science. Further developments resulted in a new family

of even smaller, fast-switching dispensing valves and peripheral components.  
At the beginning of the 90s, the new product range „IMH“ was developed. These comprise check valves, precision restrictors, valve/restrictor combinations and screens for industrial use. Designed primarily for the automotive sector, the precision and quality of these products meant that they were soon also being used in medical technology as well as in machine engineering and tool construction and in general industrial applications. Indeed, Lee is represented in all areas where precision microfluidic components are required.

## COMPANY PROFILE

### KTR KUPPLUNGSTECHNIK GMBH

BOOTH 18

Rodder Damm 170  
48432 Rheine  
Germany

**Tel** +49 (0)5971 79-80  
**Fax** +49 (0)5971 79-86 98  
**Email** mail@ktr.com  
**Web** www.ktr.com



As a leading manufacturer of high quality drive components we are the right partner for all those who want to set things in motion. KTR supplies mechanical couplings, hydraulics components, high-power brakes, clamping sets, torque measuring systems and torque limiters all around the world. With more than 50 years experience in mechanical power transmission and in hydraulics, we are trendsetters in the development of coupling technology and offer customised solutions to all industries. The KTR trademark characterises quality and innovation, speed, reliability, flexibility and a close working relationship with customers.

### LINZ CENTER OF MECHATRONICS GMBH

BOOTH 33

Altenbergerstraße 69  
4040 Linz  
Austria

**Tel** +43 (0)732 2468-6002  
**Fax** +43 (0)732 2468-6005  
**Email** office@lcm.at  
**Web** www.lcm.at



The Linz Center of Mechatronics GmbH (LCM) was able to establish itself as number 1 in applied mechatronics research at the interface between research and industry. LCM is considered a reliable partner for its customers, the most diverse of companies, from SMEs to global players.

LCM's focuses of activity are:

- Development of electrical drives and power electronics, motor tests
- Development of hydraulic drives, digital valves, test engineering
- Simulation of components and processes, simulation of dynamic problems, control

- technology
- Rapid prototyping, production of prototypes and small batch sizes
- Active and passive vibration damping and noise reduction
- Sensor technology, virtual sensors, wireless communication, localisation technologies
- Early detection of errors in plants and machinery
- Overall device development
- Support in serial launch and commissioning
- Consultancy in the use of new technologies

## COMPANY PROFILE

### MAGNETBAU SCHRAMME

BOOTH 34

Zur Ziegelhütte 1  
88693 Deggenhausertal  
Germany

**Tel** +49 (0)7555 9286-0

**Fax** +49 (0)7555 9286-30

**Email** info@magnetbau-schramme.de

**Web** www.magnetbau-schramme.de



Since 40 years Schramme develops and produces customized solenoids and valves. We are bench mark in proportional technology. Our customers recommend Schramme because flexibility and excellence to design into customers application also for small- and mid-quantities is unique.

- Customized proportional solenoids and valves
- Top quality
- Electronics at and inside the actuator
- New LVDT generation
- High-grade in flexibility, developing and production

### MOOG GMBH

BOOTH 14

Hanns-Klemm-Str. 28  
71034 Böblingen  
Germany

**Tel** +49 (0)7031 622-0

**Fax** +49 (0)7031 622-100

**Email** info.germany@moog.com

**Web** www.moog.com

Moog Inc. is a worldwide designer, manufacturer and integrator of precision control components and systems. Moog's Industrial Group designs and manufactures high performance motion control solutions combining electric, hydraulic, and hybrid technologies with expert consultative support in a range of applications including energy production and generation machinery, industrial production machinery and simulation and test equipment. We help performance-driven companies design and develop their next-generation machines.

For more information please visit  
[www.moog.com/industrial](http://www.moog.com/industrial).

## COMPANY PROFILE

### MAGNET-SCHULTZ GMBH & CO. KG

BOOTH 01

Allgäuer Straße 30  
87700 Memmingen  
Germany

**Tel** +49 (0) 8331 104 0

**Fax** +49 (0) 8331 104 333

**Email** info@magnet-schultz.de

**Web** www.magnet-schultz.de



**MAGNETSCHULTZ**

Magnet-Schultz Memmingen (MSM) is an internationally dynamic family-operated group, employing 2350 employees in Germany, Switzerland, the USA, UK and Italy. We are leaders in high-tech electromagnetic actuators and sensors for top quality requirements of various capital goods industries. Our products and services shall provide safety to our customers and employees. Careful education, motivating working atmosphere, substantial investment, strong innovation and presence in world markets maintain our pole position.

Responsible engineering for a Human-Oriented Future!

### PARKER HANNIFIN GMBH

BOOTH 24

Pat-Parker-Platz 1  
41564 Kaarst  
Germany

**Tel** +49 (0)2131/4016-0

**Fax** +43 (0)2131/4016-9199

**Email** parker.germany@parker.com

**Web** www.parker.com



As the global leader in motion and control technologies, Parker Hannifin is present in almost every area of industrial and mobile applications and employs about 58,000 people in 49 countries. With its expertise in nine major technologies: Hydraulics, Pneumatics, Electromechanical, Filtration, Fluid & Gas Handling, Climate Control, Process Control, Sealing & Shielding and Aerospace, Parker provides comprehensive competence from one single source.

As a solution provider, Parker helps its customers to achieve increased productivity and profitability by developing efficient and reliable systems. Creativity, know-how and experience are crucial to the success

of applications with hydraulic, electromechanical and pneumatic drive and control systems. Parker employs dedicated teams around the world to support its customers in developing challenging systems and offers incomparable global availability of genuine Parker products and services.

## COMPANY PROFILE

### RHEINTACHO MESSTECHNIK GMBH

POSTER

Waltershofener Straße 1  
79111 Freiburg  
Germany

**Tel** +49 (0)76145130  
**Fax** +49 (0)761445274  
**Email** info@rheintacho.de  
**Web** www.rheintacho.de



As a manufacturer of measuring devices, speed sensors and accessories for rotational speed recording and monitoring, RHEINTACHO has been offering first-class solutions for a wide range of applications for more than 100 years.

Our rich experience in rotational speed measurement is reflected as much in our standard products as in the special solutions we develop for our customers.

RHEINTACHO speed sensors are designed to withstand the harshest conditions and record the rotation of machine parts without contact. They can

withstand high pressures, are waterproof, can be used within a wide temperature range and are resistant to oil, salt and acid.

Based on excellent products and our experience, RHEINTACHO is a valued supplier to some of the most well-known companies in hydraulics.

### SONCEBOZ SA

BOOTH 15

Rue Rosselet Challandes 5  
CH-2605 Sonceboz  
Switzerland

**Tel** +41 32 488 11 11  
**Fax** +41 32 488 11 00  
**Email** info@sonceboz.com  
**Web** www.sonceboz.com



SONCEBOZ core competencies consist of design, development and production of mechatronic drive systems and electric motors that operate in harsh environments and that are customised to your needs. Our motion solutions are able to withstand the most challenging off-highway operating conditions.

Our products portfolio includes stepper motors, stepper linear actuators, brushless DC motors and customized drive mechatronic systems. From the concept drawn in advanced research to the complete development and assembly, SONCEBOZ offers tailored drive solutions with emphasis on innovation, flexibility and 0 ppm.

## COMPANY PROFILE

### SCHIENLE MAGNETTECHNIK + ELEKTRONIK GMBH

BOOTH 11

In Oberwiesen 3  
88682 Salem, Neufrach  
Germany

**Tel** +49 (0)7553 8268793  
**Fax** +49 (0)7553 826862  
**Email** troth@schienle.de  
**Web** www.schienle.de

**SCHIENLE**  
MAGNETTECHNIK

Schienle Magnettechnik + Elektronik GmbH is an internationally established provider of professional and robust linear actuator solutions.

Since 1976, Schienle Magnettechnik + Elektronik GmbH has been producing actuator solutions for valves and mechanical applications. The best possible flexibility in batch size and variant solutions backs up our claim to be leaders in service.

As the leading provider of explosion-proof solenoids and sensors, Schienle has world-wide approvals at its disposal for the production and sale of explosion-proof products, including in the mining and oil industries.

Applications for our existing products and solutions:

- Explosion proof
- Hydraulics
- pneumatics
- Medical technology
- Environmental technology of Food industry

### STEINBEIS MECHATRONIK GMBH

BOOTH 13

Werner-von-Siemens-Str. 12  
98693 Ilmenau  
Germany

**Tel** +49 (0)3677 / 4627-0  
**Fax** +49 (0)3677 / 4627-11  
**Email** info@stz-mtr.de  
**Web** www.stz-mtr.de



The Steinbeis Mechatronik is an innovative and efficient company in the fields of the development and optimization of mechatronic systems and the determination of magnetic properties.

For over 20 years we have been developing mechatronic drive systems at the highest technical level from the idea to the finished product.

These systems are used as rotational and translational drives (BLDC, synchronous and asynchronous motors), resonance and micro actuators, as well as electromagnets (DC solenoids, polarized magnets)

in a wide variety of industries including automotive, automation, home and security technology, precision mechanics, optics, etc.

With the patented measuring method MagHyst® the real behavior of electromagnetic actuators can be sensorless detected. MagHyst® offers the unique possibility to analyze actuators throughout the entire life cycle, from the development, over the production to the application.

For more information, visit our website at [www.stz-mtr.de](http://www.stz-mtr.de).

## COMPANY PROFILE

### TAKAKO INDUSTRIES, INC.

BOOTH 31

1-32-1 Housononishi, Seikacho Sourakugun  
6190240 Kyoto

Japan

**Tel** +81 (0)774 95 333-6

**Fax** +81 (0)774 95 333-7

**Email** h-kosodo@takako-inc.com

**Web** www.takako-inc.com



The world smallest class Axial Piston Pump and Axial Piston Pump Unit!

Takako Industries Inc., a world leading manufacturer of axial piston pump components, would like to introduce our brand product Micro Axial Piston Pump Series.

This series of pumps consists of five displacement models ranging from 0.4 cc to 6.3 cc. The size is among the world smallest, which could be hold in hand. The pumps can generate maximum pressure of 21MPa. A spherical valve plate (SVP) design is applied, which realized extremely stable and highly efficient performance at wide range of input speed. Additional characteristics achieved by the SVP design are

'higher contamination resistance' and 'more efficient sucking performance'.

The pumps are already applied in many fields and mounted in Forklift, Injection Molding Machine, Robot, Inspection Equipment. Also, application on automobile is becoming more and more likely.

Takako also launched Micro Axial Piston Pump Unit in which Pump, Valve and Tank are integrated. Complete hydraulic system could be obtained just by adding motor and actuator.

### VOITH TURBO H+L HYDRAULIC GMBH & CO. KG

BOOTH 25

Schuckertstraße 15  
71277 Rutesheim  
Germany

**Tel** +49 (0)7152 992-577

**Fax** +49 (0)7152 992-400

**Email** sales-rut@voith.com

**Web** www.voith.com



The hydraulic systems and components from Voith are highly dynamic, precise and sturdy. Unique advantages are at the forefront in the development of the customized hydraulic solutions. Voith systems often reach a level of efficiency that is two to three times better than a common solution.

The product portfolio includes hydraulic systems (with hydraulic power pack, actuators, control system, hardware and software for control and process monitoring), internal gear pumps, servo pumps (variable speed pump drives), valves, hydraulic power packs.

Voith Turbo H + L Hydraulic is a subsidiary of Voith Turbo. Voith Turbo, a division of Voith GmbH, specializes in intelligent drive solutions and systems. Our customers in the oil and gas, energy, mining and metals processing, marine propulsion, rail and utility vehicles industries rely on solutions from Voith.

Voith sets the standards in the energy, oil & gas, paper, raw materials and transportation & automotive markets. Founded in 1867, Voith employs more than 43,000 people, generates €5.7 billion in sales, operates in over 50 countries around the world and is today one of the biggest family-owned companies in Europe.

## COMPANY PROFILE

### THOMAS MAGNETE GMBH

BOOTH 21

San Fernando 35

57562 Herdorf

Germany

**Tel** +49 (0)2744 9290

**Fax** +49 (0)2744 929 290

**Email** info@thomas-magnete.com

**Web** www.thomas-magnete.com



Thomas Magnete is involved in the development and production of customized electromechanical and fluid actuator systems for Mobile Hydraulics and the automobile industry.

Innovative products based on permanent Research and Developing are for example

- Proportional/On-off hydraulic valves (e.g. for clutch and gear control systems, pump and valve control systems, adjustable oil pumps )

- On-off/Proportional solenoids (e.g. for clutch and gear control systems) metering pumps (e.g. for auxiliary heaters, lubricants, SCR and HC-closing)

### WALTER HUNGER GMBH & CO. KG

BOOTH 02

Rodenbacher Str. 50  
97816 Lohr am Main  
Germany

**Tel** +49 (0)9352-501-0

**Fax** +49 (0)9352-501-106

**Email** info@hunger-hydraulik.de

**Web** www.hunger-hydraulik.de



THE HUNGER HYDRAULICS GROUP - KNOWN THROUGHOUT THE WORLD FOR QUALITY Since 1945 the name Hunger has established itself as a specialist for the design and manufacture of hydraulic systems and technology.

The main focus of its business today is directed on problem solutions that require intensive consulting services in the hydraulic and automotive fields. The hydraulic business segment ranges from - in particular large and special - hydraulic cylinders, surface coatings, seals, abrasives, machines and power units, hydraulic components like rotary distributors, valves or rod ends to commissioning and repair services.

The automotive business segment comprises the fields of fully hydraulic semi-trailer and trailer couplings as well as sheet metal processing.

The interplay of decades of experience, the use of state-of-the-art technologies and the application of hydraulic components to customer specific systems is the basis for fulfilling customer requirements at the highest quality level.

The company group operates internationally with its subsidiaries in Europe, USA, China, India, and a number of agencies worldwide.

## COMPANY PROFILE

### WEMA NV

De Arend 14,  
8210, Zedelgem  
Belgium

**Tel** +32 (0)50 50 20 35  
**Fax** +32 (0)50 38 91 39  
**Email** stefan.sanders@wema.be  
**Web** www.wema.be

WEMA nv is founded in 1959 and has now 160 employees and 110 CNC machines. WEMA nv is a subcontractor in mechanical and hydraulic precision components and assembled and tested parts. WEMA nv produces spools, sleeves, valve groups, cartridges, blocks, assembled and tested hydraulic manifolds and mechanical precision components. All of these products are made to customer design. WEMA nv is specialized in medium to large volumes but also with a production unit for prototypes and small volumes.

Our equipment: CNC-turning lathes, CNC-machining centers, CNC-external and internal grinding, honing mach., lapping mach., CNC-straightening mach., deep hole drilling mach., thermal deburring mach., assembly facilities + hydraulic test units, measuring and inspection. Our customers: Main OEM's of earthmoving equipments, agriculture, hydraulics, off-highway and automotive industries. 70% of our production is exported worldwide. ISO9001-ISO14001. Caterpillar spec: MQ11005.



### BOOTH 07

## EXHIBITION AND POSTERSESSION

### ARGO-HYTOS GmbH (Booth 23)

Industriestraße 9, 76703 Kraichtal  
Germany

+49 (0)7250 76-0  
 +49 (0)7250 76-199  
 info.de@argo-hytos.com  
 www.argo-hytos.com

### CFD Consultants GmbH / Simerics Inc. (Booth 27)

Gartenstraße 82, 72108 Rottenburg  
Germany

+49 (0)7472 96946-0  
 +49 (0)7472 96946-11  
 cfd@cfconsultants.de  
 www.cfdconsultants.de

### EKS Elektromagnetic GmbH (Booth 20)

Steinbeissstraße 50, 71655 Vaihingen  
Germany

+49 (0)7042 107-0  
 +49 (0)7042 107-112  
 info@eks-magnete.de  
 www.eks-magnete.de

### IFAS der RWTH Aachen (Booth 06)

Steinbachstraße 53, 52074 Aachen  
Germany

+49 (0)241 802-7512  
 +49 (0)241 802-2194  
 post@ifas.rwth-aachen.de  
 www.ifas.rwth-aachen.de

## EXHIBITION AND POSTERSESSION

### Ingenieurgesellschaft IGH (Booth 08)

Heinz-Bäcker-Straße 34, 45354 Essen  
Germany

+49 (0)201 360 14-0  
 +49 (0)201 360 14-14  
 info@igh-essen.com  
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### LaVision GmbH (Booth 32)

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37081 Göttingen  
Germany

+49 (0)551 9004-0  
 +49 (0)551 9004-100  
 info@lavisoin.com  
 www.lavisoin.com

### SCANWILL Fluid Power APS (Booth 29)

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Denmark

+45 (0)74 4234-50  
 +45 (0)74 4234-30  
 info@scanwill.com  
 www.scanwill.com

### Wolfgang Bott GmbH & Co. KG (Booth 28)

Maybachstraße 4-8, 72116 Mössingen  
Germany

+49 (0)7473 9468-0  
 +49 (0)7473 9468-20  
 info@bott-gmbh.com  
 www.bott-gmbh.com

### RST – Rüdener Software Technology (Booth 23)

c/o KIT, Rintheimer Querallee 2,  
76131 Karlsruhe  
Germany

+49 (0)176 / 200 411 54  
andreas.ruedenauer@  
cross-connected.com  
 www.cross-connected.com

### Liebherr-Werk Nenzing GmbH (Booth 36)

Dr. Hans Liebherr Str. 1, 6710 Nenzing  
Austria

+43 50809 41146  
 +43 50809 41600  
 Andre.Baranowski@liebherr.com  
 www.liebherr.com

### PSA Peugeot Citroën (Booth 37)

75, avenue de la Grande Armée,  
75116 Paris  
France

contact-corporate@mpsa.com  
 www.psa-peugeot-citroen.com/fr

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# EVENTS

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## EVENING EVENTS

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Conference participants are welcome to attend the following social events:

### OPENING EVENT

Monday, 24th March, 2014, starting 7.00 p.m.

On Monday evening an informal opening event will take place in the foyer of the Eurogress starting at 7 p.m. Participants and accompanying persons are invited to socialize with attendees and to discuss new trends during snacks and cold beverages. With this event the commercial exhibition is opened. Conference documents can be picked up the whole evening at the conference office.



### CONFERENCE BANQUET

Tuesday, 25th March, 2014, starting 7.00 p.m.

On Tuesday evening, the conference banquet is the formal evening event of the conference and is allocated in the atmospheric Coronation Hall of the Aachen city hall. A rich banquet accompanied by the traditional entertainment programme performed by the IFAS staff promises a memorable social event. Please note that to attend this event special vouchers are needed.



### LABORATORY PARTY

Wednesday, 26th March, 2014, starting 7.00 p.m.

On Wednesday evening all participants and accompanying persons are invited to visit the IFAs laboratory. A rich country-style buffet and cold beverages will be served to allow an outstanding closure of the conference.

A shuttle service back to the city will be provided until midnight.



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## EXCURSION

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To get an insight into everyday's business life of two international companies and scientific institutes, a two-day excursion following the conference is offered to interested participants.

### VELTINS - ARENA, GELSENKIRCHEN

Thursday, 27th March, 2014, starting 8.00 a.m.

We will leave Aachen at 8.00 a.m. At 10.00 a.m. we will arrive the VELTINS-Arena in Gelsenkirchen. Due to its multifunctionality, the stadium of FC Schalke 04 sets new standards. Among a roll-out pitch and mobile stands the retractable roof is one of the highlights of this building.

After a tour through the arena a visit of the Schalke museum is possible.

### FORD - WERKE, KÖLN

Thursday, 27th March, 2014, starting 8.00 a.m.

The Fiesta Factory in Cologne-Niehl is one of the most efficient car factories in Europe. In addition to the Fiesta and Fusion assembly in Cologne-Niehl engines, transmissions, forging and cast parts are produced. After lunch and a company presentation we will attend a two-hour plant tour through the car assembly. Thereafter we will return to Aachen and arrive at about 8 pm.

### ZECHE ZOLLVEREIN, ESSEN

Friday, 28th March, 2014, starting 8.00 a.m.

At 8.00 a.m. we will start to Zollverein UNESCO World Heritage, which is known as the "world's most beautiful coal mine" with its shafts and the central coking plant. Within a guided tour we will follow the whole way from the coal to coke. At about 5.00 p.m. we will arrive Aachen.

Solid footwear and weatherproof clothing are recommended.

On the way back a stopover at Düsseldorf International Airport and its train station can be organized.

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Date: 27th - 28th March 2014

Charge: 150 € per person (without overnight stay)

Please note that the contingent is limited!



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## CULTURAL PROGRAMME TUESDAY, 25TH OF MARCH

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### **THE HISTORICAL DISTRICT OF AACHEN, CATHEDRAL AND "PRINTEN"** Tuesday, 25th March 2014, starting 9.15 a.m.

On the first day the focus lies on Aachen and its historical district, its cathedral and its "Printen". Starting with a guided tour, which gives an insight into the history of one of the most interesting cathedrals in Western Europe. In the following, we will proceed with the treasury of the cathedral, which is considered the most important clerical treasury north of the Alps. In the afternoon a "Printen-bakery" will be visited, where the ingredients as well as the baking process will be explained in detail. The program will come to an end around 3.30 p.m.

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Meeting Point: 9.15 a.m., Lobby Eurogress  
9.45 a.m., Karl's fountain marketplace  
End of Tour: approx. 3.30 p.m.



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## CULTURAL PROGRAMME WEDNESDAY, 26TH OF MARCH

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### **SCHLOSS DRACHENBURG (CASTLE) IN KÖNIGSWINTER AND WINETASTING** Wednesday, 26th March 2014, starting 9.00 a.m.

After a common lunch a visit of the Palais Schaumburg is offered. On 5th November, 1949, Konrad Adenauer declared the Palais the official residence of the German chancellor. Up to 1976 all chancellors officiated the affairs of state in the building that was built in 1860. Afterwards the Palais served for representative purposes before it was appointed as the second residence of the chancellor in Bonn in the year 2000. During a guided tour you will gain insight into the every day work of the Chancellors from Konrad Adenauer to Helmut Schmidt.

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Meeting Point: 9.00 a.m., Lobby Eurogress  
End of Tour: approx. 5.00 p.m. in Aachen



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# VISIT OF THE IFAS LABORATORY

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Conference participants are welcome  
to visit the experimental and test  
facilities of IFAS

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## VISIT OF THE IFAS LABORATORY



The test facilities of the Institute for Fluid Power Drives and Controls (IFAS) are open to visitors from Monday, 24th March to Wednesday, 26th March. The institute staff is looking forward to outline and demonstrate the test benches.

A shuttle service from the Eurogress to the laboratory is available at various times during the conference, please consider the shuttle schedule.

*Kindly note that the parking space around the laboratory is very rare and recently managed and controlled by the university! Parking tickets are available in the laboratory or at the conference office. Free parking after 6.00 p.m. A map with designated parking areas can be found on the last page of this brochure.*

### SHUTTLE BUS SCHEDULE

Monday, 24th March	Tuesday, 25th March	Wednesday, 26th March
	Eurogress -> IFAS 11.15 a.m.	Eurogress -> IFAS 10.45 a.m.
	IFAS - Eurogress 12.25 a.m.	IFAS -> Eurogress 12.00 a.m.
Eurogress -> IFAS 01.45 p.m.	Eurogress -> IFAS 01.50 p.m.	Eurogress -> IFAS 01.25 p.m.
IFAS -> Eurogress 03.35 p.m.	IFAS -> Eurogress 03.25 p.m.	IFAS -> Eurogress 02.55 p.m.
		Eurogress -> IFAS 06.30 p.m.
		IFAS -> City 11.59 p.m.

## VISIT OF THE IFAS LABORATORY

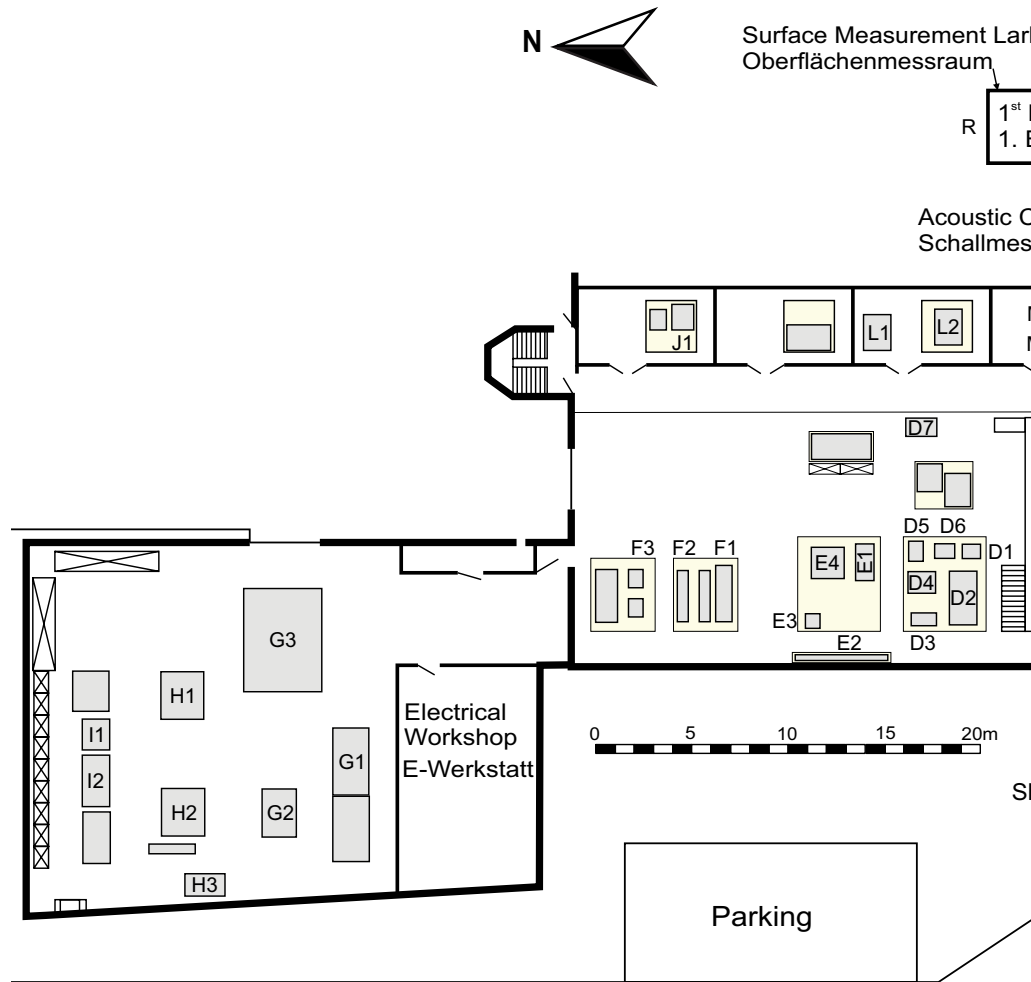
### POS. TITEL

- B1 Pneumatic Flow Rate Test Rig
- B2 Hose Test Bench
- B3 Hydrolysis Test Rig
- B4 Oxidations Test Rig
- B5 System Efficiency Test Rig
- C1 Central Pressure Supply
- C2 Test Rig for Wind Turbine Transmissions
- C3 Electrostatic Test Rig
- C4 Hydraulic Valve Test Rig
- D1 Rotational Tribometer
- D2 Single Piston Test Rig
- D3 Volume Flow Test Rig
- D4 Radial Piston Test Rig
- D5 Turbulent gap flow test Rig
- D6 Hydraulic Accumulator Test Rig
- D7 Cavitation Test Rig
- E1 Self-Energising Electro-hydraulic Brake (SEHB)
- E2 Dust Entrainment Test Rig
- E3 Seal Friction Force Test Rig
- E4 Large Cylinder Friction Test
- E5 Decentral Load-Sensing Valve System for Mobile Machines
- F1 Hydrostatic Drive Train for Wave Energy Converters
- F2 End Positioning Cushioning Test Rig
- F3 Control Module Test Rig

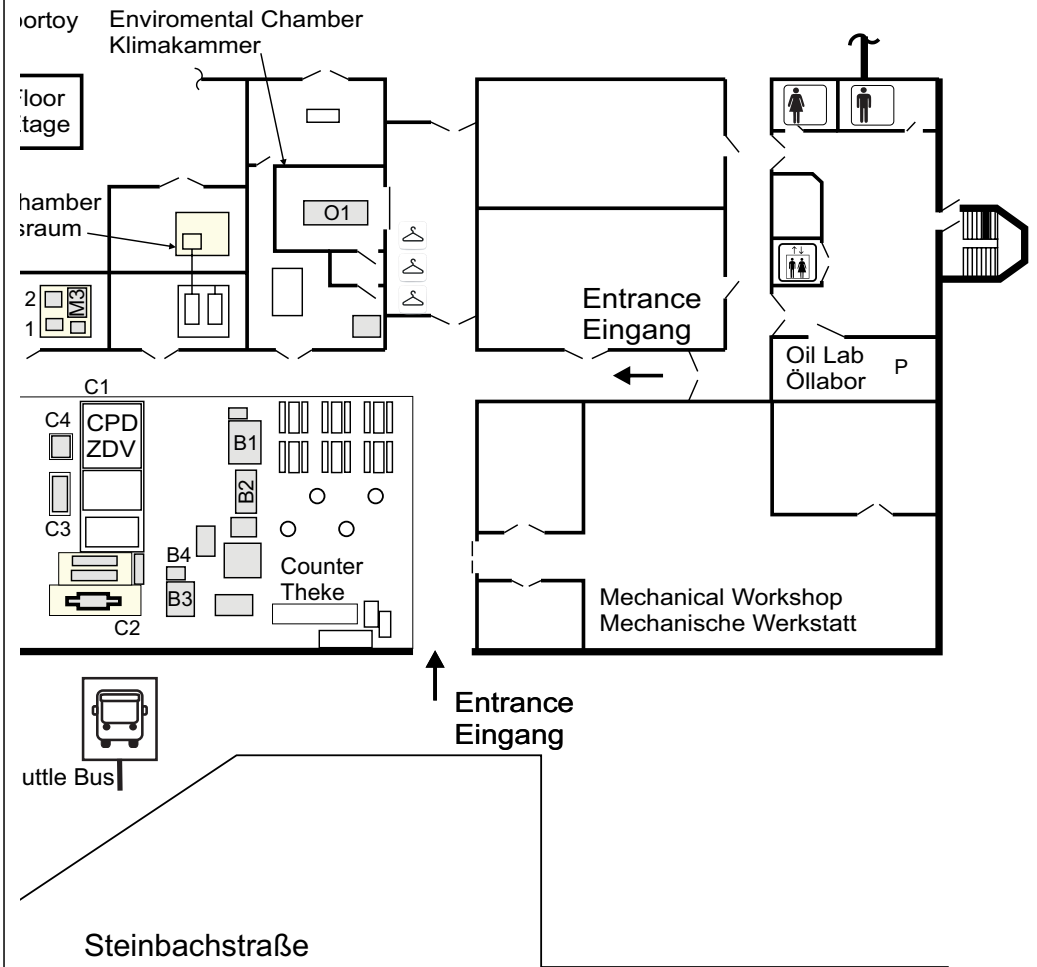
### POS. TITEL

- G1 Air in Hydraulic Systems
- G2 Mobile Hydraulics Test Rig
- G3 Holistic Approach for Mobile Hydraulic Systems (STEAM)
- H1 Fast Charging System for Electric Busses
- H2 Air Bubble Test Rig
- H3 Metrology Equipment Test Rig
- I1 Aachen-IFAS-Hand
- I2 Demonstrator for Air Recuperation
- J1 Bio-Oil Efficiency Test Rig
- L1 Short Term Ageing Test Rig for Hydraulic Valves
- L2 Radial Piston Unit with Axial Cone Valve Plates
- M1 Tailor-Made Fuels from Biomas Tribometer
- M2 High Pressure Test Rig
- M3 Friction Force Test Rig for Common-Rail-Pumps
- N Acoustic Test Chamber
- O Environmental Chamber
- P Oil Laboratory
- R Surface Laboratory

VISIT OF THE IFAS LABORATORY



VISIT OF THE IFAS LABORATORY



# INFORMATION

### EUROGRESS CONGRESS CENTRE

 Mohnheimsallee 52, 52062 Aachen, Germany

 + 49 (0) 241/91-312 30

 + 49 (0) 241/91-312 00

 [www.eurogress-aachen.de](http://www.eurogress-aachen.de)

### CONFERENCE OFFICE

 Foyer Brussel-Hall, Eurogress

 + 49 (0)241/9131 528

### IFAS RWTH AACHEN UNIVERSITY

 Steinbachstraße 53, 52074 Aachen, Germany

 + 49 (0) 241 80 275 12

 [www.ifas.rwth-aachen.de](http://www.ifas.rwth-aachen.de)

### POLICE

 110

### EMERGENCY

 112

### LOCAL TAXI

 + 49 (0) 241/666 666

 + 49 (0) 241/344 41

### LOCAL PUBLIC TRANSPORT (BUS)

 [www.aseag.de](http://www.aseag.de)



### PUBLIC TRANSPORT (TRAIN)

 [www.db.de](http://www.db.de)

### LOCAL TOURIST INFORMATION

 + 49 (0) 241/18 02 960

 [www.aachen-tourist.de](http://www.aachen-tourist.de)

## REGISTRATION

Through the registration process you can register for:

- PhD-student a person, with a valid PhD-student ID
- Referent a person, giving at least one presentation
- Participant all other persons

## CONFERENCE FEES AND DATES

Group of Participants	1 day colloquium (25th or 26th March)	2 days colloquium (25th & 26th March)	Symposium (24th March)
<b>Ph.D. student</b>	€ 350,-	€ 480,-	€ 350,- (€ 125,-)
<b>Referent</b>	€ 450,-	€ 600,-	€ 350,- (€ 125,-)
<b>Participant</b>	€ 650,-	€ 850,-	€ 350,- (€ 125,-)

The fees include:

- Conference participation at the corresponding days and a conference brochure.
- The conference proceedings, provided in digital form on a USB-stick and on a CD (with ISBN). An additional printed version will be available for € 40. You can order it at our website with your conference registration.
- Cold and warm beverages during the breaks as well as lunch.
- Free entrance to the opening event (24th March) at the Eurogress including beverages and snacks.
- Shuttle service to the laboratories of IFAS.
- Free entrance to the laboratory party (26th March) at IFAS including beverages and warm buffet.

## PRICES FOR ADDITIONAL OPTIONS (GROUP-INDEPENDENT)

Offer	Description	Price per pers.
<b>Conference banquet + After show - party (25th March 2014) !Limited contingent!</b>	Banquet in the Coronation Hall incl. dishes, beverages and entertainment After show party at Aula Carolina incl. beverages and snacks	€ 66,-
<b>Cultural programme (25th and/or 26th March) !Limited contingent!</b>	Sightseeing of cultural interests incl. beverages, dishes and care	€ 60,- (per day)
<b>Excursion (27th and 28th March) !Limited contingent!</b>	Excursion to companies and places of technical interest, incl. beverages, dishes and care (day trip, no hotel)	€ 150,-

## BEVERAGES

During the whole conference cold and warm beverages are available at several bars at the exhibition or will be served by the service.

## KIOSK

For light snacks besides lunch, a Kiosk with sweets, cakes and sandwiches etc. is placed at the entrance of Eurogress. Please notice, that the offerings are not included in the conference fee. Prices are available at the kiosk.

## HOT SPOT

In the foyer of the Brussel-Hall and in the vicinity a free hot spot for internet is provided. The name of the network is 9.IKF-HOTSPOT.

## DIGITAL AND PRINTED PROCEEDINGS

For the 9th IFK, the organising committee has decided to hand out a digital version of the conference proceedings, only. This was done due to the decreasing demand of printed proceedings. Each participant gets an USB-Stick and a CD (with ISBN) together with the conference documents. For those who prefer a printed version, a hardcopy is available at the conference office at a cost price of 40 €.

## OPENING HOURS CONFERENCE OFFICE

### Monday, 24th March 2014

Eurogress Foyer Brussel-Hall 8.00 a.m. - 10.00 p.m.

### Tuesday, 25th March 2014

Eurogress Foyer Brussel-Hall 8.00 a.m. - 6.00 p.m.

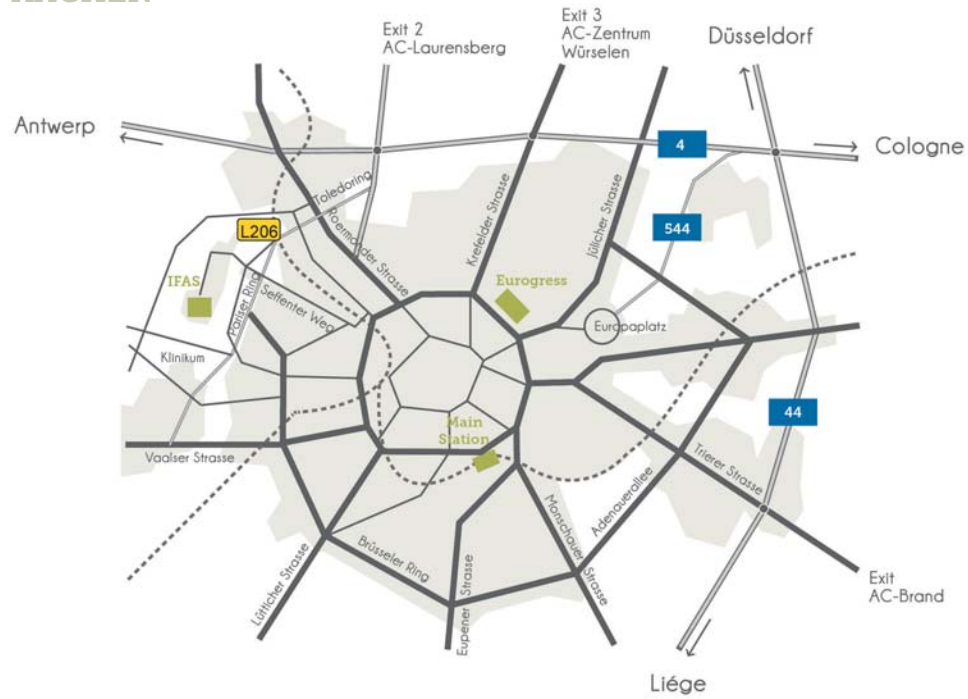
### Wednesday, 26th March 2014

Eurogress Foyer Brussel-Hall 8.00 a.m. - 6.30 p.m.

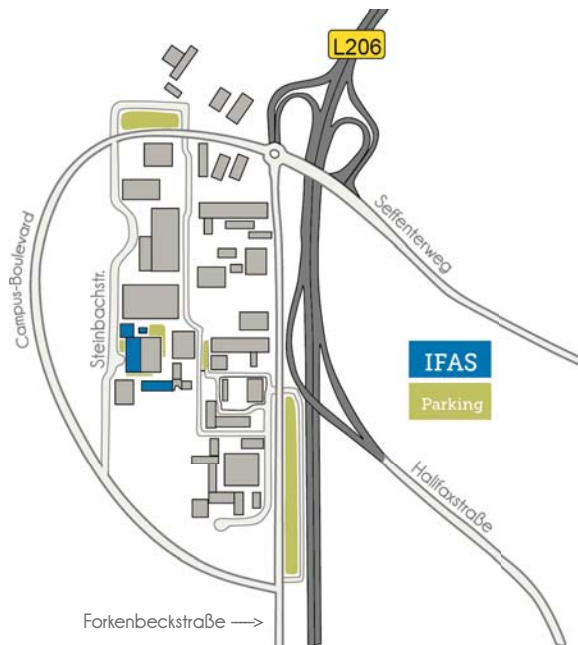
At the conference office you received some voucher. Please pay attention to these, because we can distribute the vouchers only once.

Please wear your name badge all the time during the conference and social events.

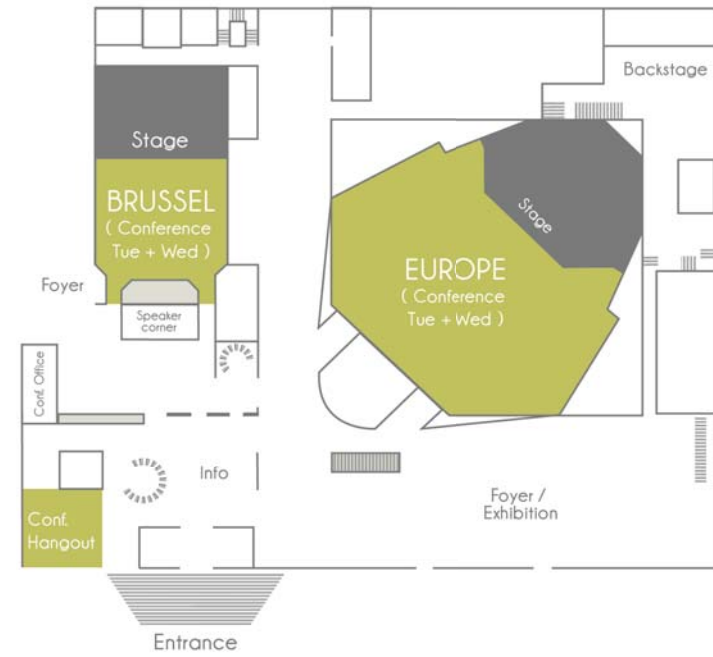
## AACHEN



## IFAS



## EUROGRESS, Ground Floor



## EUROGRESS, Upper Floor

