



FPMC 2019

ASME/BATH 2019 SYMPOSIUM ON FLUID POWER AND MOTION CONTROL

CONFERENCE
October 7–9, 2019

Zota Beach Resort
Long Boat Key, Florida

Program

<https://www.asmeconferences.org/FPMC2019/>



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Welcome from the Conference Organizer

Dear Colleagues,

Welcome to the **ASME/Bath 2019 Symposium on Fluid Power and Motion Control** (FPMC 2019) held at the Zota Beach Resort, on the powdery white sands and brilliant turquoise waters of Sarasota's Longboat Key, Florida. I hope you will find the technical program of the symposium engaging. I also hope that you will enjoy the social events and further develop your network with colleagues.

The symposium has been jointly organized by the University of Bath and the American Society of Mechanical Engineers (ASME) and has been held every year, alternating between Bath and locations in the USA since 2009. This conference provides a forum for the international fluid power community from academia and industry to discuss recent developments and future challenges in fluid power technology.

For this edition of the Symposium, we received 78 submissions, with the final program including 56 papers. Following the tradition of the Bath Symposium offering a single-track conference, the 56 papers will be presented in 11 sessions distributed over the three days of the conference.

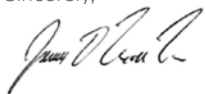
On Tuesday, we will have the Koski Lecture, presented by Dr. Peter Achten (the 2019 Koski Medal awardee). On the last day of the conference, we will have a panel session with representatives from well-known fluid power companies. The panel will focus on the emerging topic of connected and autonomous fluid power systems.

Each day of the conference includes social events. On Monday evening, there will be a picnic on the beach at the Zota Beach Resort. On Tuesday evening, we will have the Koski Banquet. During the banquet, the ASME Robert Koski Medal will be formally awarded to the 2019 recipient, Dr. Peter Achten. Beyond the evening events, lunches, and coffee breaks, there will be many opportunities to network within the fluid power community.

Many individuals and organizations have generously given their time and resources to make the 2019 ASME/Bath Symposium a success. I am really grateful to all the volunteers on the Organizing Committee, Program Committee, Editorial Board, and numerous others, who have given their support behind the scenes. I also would like to thank the outstanding group of Sponsors who have supported this event. At the end of this program, please find a page highlighting our generous sponsors. Without their contributions, it would not have been possible to organize a successful event.

I am confident that you will find this conference an exciting and technically rewarding event. Again, welcome, and thank you for your participation. Please enjoy the conference and this beautiful beach location.

Sincerely,



Jim Van de Ven
General Chair
University of Minnesota



Jim Van de Ven
General Chair
University of Minnesota

Program

FPMC 2019 Program	Sessions	Session Organizer
Event	Welcome / Opening Remarks	James Van de Ven
Monday Oct 7 8:00AM–8:15AM		
Session 1	Control Design Methodologies And Techniques For Fluid Power Systems 1	Damiano Padovani
Monday Oct 7 8:15AM–9:55AM		
Session 2	Modeling And Design Of Fluid Power Components	Andrew Plummer
Monday Oct 7 10:15AM–12:15PM		
Event	Lunch	
Monday Oct 7 12:15PM–1:15PM		
Session 3	New Approaches To System Modeling And System Design	Matthias Liermann
Monday Oct 7 1:15PM–3:15PM		
Session 4	Safety, Reliability, Fault Analysis And Diagnosis	Travis Wiens
Monday Oct 7 3:45PM–5:05PM		
Event	BBQ Picnic On The Beach	
Monday Oct 7 5:30PM–7:00PM		
Event	GFPS Meeting	
Monday Oct 7 7:15PM–8:15PM		
Session 5	Fluid Power Drives And Transmissions	Bernhard Manhartsguber
Tuesday Oct 8 7:45AM–9:45AM		
Session 6	Properties Of Hydraulic Fluids	QingHui Yuan
Tuesday Oct 8 10:15AM–12:15PM		

Event	Lunch	
Tuesday Oct 8 12:15PM–1:15PM		
Event	Koski Lecture	Dr. Peter Achten
Tuesday Oct 8 1:15PM–2:15PM		
Session 7	Hydrostatic Pumps And Motors 1	Noah Manring
Tuesday Oct 8 2:15PM–3:55PM		
Session 8	Hydrostatic Pumps And Motors 2	Nigel Johnston
Tuesday Oct 8 4:25PM–5:45PM		
Event	ASME FPST Executive Committee Meeting	QingHui Yuan
Tuesday Oct 8 5:45PM–6:45PM		
Event	Koski Reception and Banquet	
Tuesday Oct 8 7:00PM–10:00PM		
Session 9	Digital And Switched Fluid Power Systems	Rudolf Scheidl
Wednesday Oct 9 7:45AM–9:45AM		
Session 10	Hydraulic Control Valves	Steven Weber
Wednesday Oct 9 10:15AM–12:15PM		
Event	Lunch	
Wednesday Oct 9 12:15pm–1:15pm		
Event	Industry Panel	Michael Gust
Wednesday Oct 9 1:15PM–2:45PM		
Session 11	Control Design Methodologies And Techniques For Fluid Power Systems 2	Heikki Handroos
Wednesday Oct 9 3:15PM–4:55PM		

General Information

GENERAL INFORMATION

The Fluid Power Systems & Technology Division (FPST) of the American Society of Mechanical Engineers (ASME) and The University of Bath Centre for Power Transmission and Motion Control (PTMC) is an international symposium on fluid power and motion control. The Symposium will be of great interest and value to all practitioners and researchers in the fluid power, power transmission, and motion control community. The Symposium includes technical presentations and a keynote speech given by the 2019 recipient of the prestigious Robert E. Koski Medal.

CONFERENCE TOPICS:

- Modeling and design of fluid power components
- Control design methodologies and techniques for fluid power systems and applications
- Novel fluid power configurations, including efficiency and power saving circuits/architectures
- New approaches to system modeling and system design
- Safety, reliability, fault analysis, and diagnosis
- Noise and vibration
- Fluid power in renewable energy
- Fluid power in teleoperation and haptics
- Fluid power in self-powered, mobile, and industrial robots
- Environmental aspects of fluid power
- Fluid power drives and transmissions
- Smart fluids and materials
- Water hydraulics
- Digital and switched fluid power systems

AUDIOVISUAL EQUIPMENT IN SESSION ROOMS

A laptop will also be provided. Please bring your presentation on a thumb drive to upload onto the laptop prior to your session.

BADGE REQUIRED FOR ADMISSION

All conference attendees must wear the official ASME 2019 FPMC badge at all times in order to gain admission to the technical sessions, exhibits, and other conference events. Without a badge, you will NOT be allowed to attend any conference activities. Your badge also provides a helpful introduction to other attendees.

CONFERENCE NETWORKING BREAKS

Morning and afternoon breaks will be provided in the Zara Zota Ballroom Pre-function. Come and meet our exhibitors and join your fellow attendees for a few minutes of networking and discussion. The schedule is as follows:

Monday,	October 7	9:55AM–10:15AM	3:15PM–3:45PM
Tuesday,	October 8	9:45AM–10:15AM	3:55PM–4:25PM
Wednesda,	October 9	9:45AM–10:15AM	2:45PM–3:15PM

CONFERENCE BREAKFASTS, LUNCHES AND DINNERS

A Continental Breakfast, buffet Lunch will be served each day from 12:15PM to 1:15PM in the Viento Terrace. On Monday, October 7 from 5:30PM to 7:00PM join us at Sunset Sand Garden for a fun BBQ Beach picnic!

Breakfast Hours:

Monday,	October 7	7:30AM–8:00PM
Tuesday,	October 8	7:15AM–7:45PM
Wednesday,	October 9	7:15AM–7:45PM

KOSKI AWARDS BANQUET (TICKET REQUIRED FOR GUESTS ONLY)

Join us on Tuesday, October 8 from 7:00PM to 10:00PM in the Zara Zota Ballroom for a reception and gala banquet dinner, where we will honor and present the Robert E. Koski Medal to Dr. Peter Achten. The Robert E. Koski Medal recognizes individuals who have advanced the art and practice of fluid power motion and control through education and/or innovation.

CONFERENCE PROCEEDINGS

Each attendee will receive an email during/after the conference with an individual link for online access to all of the papers accepted for presentation at the conference. In the event you do not receive the email, send a request to toolboxhelp@asme.org. The official conference archival proceedings will be published after the conference and will not include accepted papers that were not presented at the conference. The official conference proceedings is registered with the Library of Congress and are submitted for abstracting and indexing. The proceedings is published on the ASME Digital Library.

REGISTRATION

Registration will be located in the Zara Zota Ballroom Pre-function area of the hotel. The hours are as follows:

Sunday,	October 6	4:00PM–6:00PM
Monday,	October 7	7:00AM–5:00PM
Tuesday,	October 8	7:00AM–6:00PM
Wednesday,	October 9	7:00AM–4:00PM

EXHIBIT HOURS

Exhibits will be located in the Zara Zota Ballroom Pre-function area of the hotel. The hours are as follows:

Monday,	October 7	7:00AM–5:00PM
Tuesday,	October 8	7:00AM–6:00PM
Wednesday,	October 9	7:00AM–4:00PM

REGISTRANTS WITH DISABILITIES

Whenever possible, we are pleased to make arrangements for registrants with disabilities. Advance notice may be required for certain requests. For on-site assistance, please visit the conference registration area and ask to speak with a conference representative.

HOTEL

Zota Beach Resort is located on the beautiful Gulf of Mexico. Longboat's newest luxury beach resort features modern architectural touches along with stylish accommodations and distinctive dining experiences that reflect the relaxed ambiance of Florida's West Coast. At Zota Beach Resort, you'll enjoy relaxed beachfront luxury along with easy access to the upscale shopping, entertainment, and restaurants at St. Armands Circle. You are also invited to indulge in a variety of resort amenities ideal for family vacations and romantic weekend getaways, including their sun-drenched outdoor pool area and chic wine bar and over 2,700 square feet of beachfront event space.

Zota Beach Resort

4711 Gulf of Mexico Drive
Longboat Key, Florida 34228
Phone Number: 941-383-2481

The Origins of Zota Beach Resort

Zota Beach Resort is inspired by the indigenous name for the area of Sarasota, Zara Zota. Historians believe that early Spanish explorers spotted the white sands on the barrier island from a distance and were reminded of the Sahara Desert. The native origin of the word Zota is blue waters; thus, the area became known as Zara Zota, the Sahara by the blue waters. Over time the name evolved to become what is known today as Sarasota

COMMITTEE MEETINGS

GFPS Meeting

Monday, October 7
7:15PM–8:15PM
Andrea Vacca
Private Dining Room

FPST Executive Meeting

Tuesday, October 8
5:45PM–6:45PM
Chair: QingHui Yuan
Private Dining Room

QUESTIONS ABOUT THE MEETING

If you have any questions or need assistance, an ASME representative will be located at the conference registration area.

ROBERT E. KOSKI MEDAL

Established in 2007, the Robert E. Koski Medal recognizes individuals who have advanced the art and practice of fluid power motion and control through education and/or innovation. The Medal was established by the Fluid Power Systems and Technology Division to honor Robert E. Koski's contributions to the field of Design Engineering and Dynamic Systems and Control.

ROBERT E. KOSKI MEDAL RECIPIENTS

2007	Wolfgang Backe
2008	Clifford R. Burrows
2009	Jan Ove Palmberg
2010	Yongxiang Lu
2011	Richard T. Burton
2012	Siegfried Helduser
2013	Wayne J. Book
2014	Hubertus J. Murrenhoff
2015	Monika Ivantysynova
2016	Kim Stelson
2017	Werner Dieter
2018	Luca G. Zarotti
2019	Peter Achten



Dr. Peter Achten

2019 E. Koski Medal Recipient

Dr. Peter Achten is the owner and director of INNAS, an engineering and innovation company in Breda, the Netherlands. He has a master's and doctorate degree from Eindhoven University of Technology.

Between 1982 and 1987, he worked at CE Delft, an independent research and consultancy organization, specialized in developing innovative solutions to environmental problems. In 1987 he founded his own company, INNAS, short for Innovation Associates. INNAS is a privately owned, independent R&D company located in Breda, the Netherlands. Peter Achten has been involved in numerous research and development projects, including work on alternative fuels for the International Energy Agency and the development of hybrid vehicles.

In 2008, the Mechatronics, Informatics & Control Group of the Institution of Mechanical Engineers awarded him with the Joseph Bramah Medal. Since 2010, he is a member of the editorial board of the Journal of Systems and Control Engineering. He has written and co-authored over 100 publications and holds more than 30 patents.

KOSKI MEDAL LECTURE PETER ACHTEN

Where is the coxswain?

The 2019 Koski lecture will be completely devoted to innovation. Industrial innovation is the ability and capability of an industry to adapt to changes in society, by means of developing new technical solutions for the market. The fluid power industry is facing many of such changes and challenges. But the industry seems to have lost the capability, and maybe even the ability to create any new, groundbreaking technical solutions. For certain, there is innovation, especially by adding electronics and sensors for diagnostics, control, and communication. But the fundamental flaws of hydraulic systems, such as energy efficiency and costs, are neglected.

Solving these issues is not only a necessity, but also offers an enormous opportunity for the hydraulic industry to grow in the future. There are no fundamental physical or economic reasons that would force hydraulic systems and components to have a poor efficiency or to be expensive. If hydraulic components and systems would be as efficient and cost-effective as mechanical transmissions (which is possible), it would allow the fluid power market to expand their business beyond the current constraints of the eroding market niche they are in.

Innovation demands dedication, focus, and mandated management support. It should be a continuous activity and standard business of any company. Innovation also needs to be based on projects. The development of the floating cup principle is such a project. This presentation will use this project as an example how to create and manage an ongoing innovation project over a period of more than 15 years.

Finally, innovation needs strong leadership. It needs a "coxswain" who steers and guides the boat towards the future, and who motivates the rowing team and keeps them safe. The final question is: where are the new fluid power coxswains?

Industry Panel

INDUSTRY PANEL - AUTOMATION, CONNECTIVITY AND BIG DATA IN FLUID POWER SYSTEMS AND OFF-ROAD VEHICLES

WEDNESDAY, OCTOBER 9

ZOTA BALLROOM

1:15PM-2:45PM

Panel Moderator: Mike Gust, *Center for Compact and Efficient Fluid Power*

Full or semi-autonomous vehicles, vehicle-to-vehicle or -jobsite connectivity, and the collection, analysis and conversion into useful information of large amounts of data are market trends affecting both current and future off-road vehicles. This impact will be felt throughout the entire value chain including fluid power components and systems. Join our esteemed industry panel as they discuss how their organizations are preparing for these disruptive market forces.

INVITED SPEAKERS

Jeffrey A. Bauer

Jeffrey A. Bauer is a Product Verification and Validation Staff Engineer for John Deere Construction and Forestry Division. He has over 23 years of hydraulic component and systems development in off-highway earthmoving and forestry harvesting equipment. Jeff is a subject matter expert in hydraulic fluids and serves in that role on the John Deere Enterprise Fluids Council. He is also active on several FPI, NFPA and SAE fluid power committees. Jeff received his BSME from the University of Iowa.

Meng (Rachel) Wang

Meng (Rachel) Wang is an Engineering Specialist with Eaton's Corporate Research and Technology Center. She is responsible for identifying, developing, and justifying commercialization of significant growth opportunities and driving technology strategy decisions and execution for electro-mechanical-hydraulic systems. Rachel has over 10 years of experience in hydraulic fluid power systems research and development. She earned her BEME from Shanghai Jiao Tong University, a MS in Electrical Engineering and Ph.D. in Mechanical Engineering from the University of Minnesota.

Qinghui Yuan

Qinghui Yuan is currently Director of Modeling and Data Science in Donaldson Company Inc. In his current role, he leads global data engineering and data science team to advance data mining and machine learning in the enterprise applications to unlock the value of data analytics and facilitate data driven culture. He is also responsible for developing and deploying multi-scale modeling and simulation capabilities to shorten time to market, reduce development cost, and optimize performance for Donaldson's advanced filtration technology, product, and service. He is the Chair of ASME Fluid Power System Technology Division. Prior to Donaldson, Qinghui served as Manager of Advanced Technology in Eaton Hydraulics Group, and other engineering leadership roles in Eaton Corporation. He earned his Ph.D. degree in Mechanical Engineering and Master's in Electrical and Computer Engineering from the University of Minnesota, Twin Cities.

Mike Gust (Moderator)

Mike Gust is the Industrial Liaison Officer for the Center for Compact and Efficient Fluid Power (CCEFP.org), a National Science Foundation Engineering Research Center headquartered at the University of Minnesota. His primary responsibility is to help facilitate the many interactions between CCEFP industry supporters, Center researchers and students, including commercialization of university research. In addition to his nine years at the CCEFP, Mike has over twenty years of industry experience in all aspects of product engineering, technology development and research. Mike operates a startup company, Innotronics LLC, with a University of Minnesota professor to commercialize a novel non-contacting magnetic field based position sensor.

MONDAY, OCTOBER 7

WELCOME AND OPENING REMARKS **JIM VAN DE VEN**
UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MN 8:00AM–8:15AM

SESSION 1 TECHNICAL PAPERS

Track Organizer: **Eric Barth**, *Vanderbilt University, Nashville, TN, United States*

Track Co-Organizer: **Andrea Vacca**, *Purdue University, West Lafayette, IN, United States*

SESSION 1 – CONTROL DESIGN METHODOLOGIES AND TECHNIQUES FOR FLUID POWER SYSTEMS 1
ZARA ZOTA BALLROOM 8:15AM–9:55AM

Session Organizer: **Damiano Padovani**, *University of Agder, Grimstad, Aust Agder, Norway*

Model-Based Control of a Pressure-Compensated Directional Valve With Significant Dead-Zone

Technical Paper Publication. FPMC2019-1664

Santeri Lampinen, Janne Koivumäki, *Tampere University, Tampere, Finland*, **Jouni Niemi**, *Rambooms Oy, Lahti, Finland*, **Jouni Mattila**, *Tampere University, Tampere, Finland*

Active Ride Control for Construction Machines Based on Pressure Feedback

Technical Paper Publication. FPMC2019-1649

Riccardo Madau, Andrea Vacca, *Purdue University, West Lafayette, IN, United States*

Intelligent Machine Operator Identification to Develop Damage-Reducing Operating Strategies for Mobile Machines

Technical Paper Publication. FPMC2019-1643

Lars Brinkschulte, Marcus Geimer, *Karlsruhe Institute of Technology, Karlsruhe, Baden-Württemberg, Germany*

A Control Algorithm for Active/Passive Hydraulic Winches Used in Active Heave Compensation

Technical Paper Publication. FPMC2019-1710

Geir-Arne Moslåt, *National Oilwell Varco Norway, University of Agder, Kristiansand, Agder, Norway*, **Michael R. Hansen, Damiano Padovani**, *University of Agder, Grimstad, Norway*

SESSION 2 – MODELING AND DESIGN OF FLUID POWER COMPONENTS
ZARA ZOTA BALLROOM 10:15AM–12:15PM

Session Organizer: **Andrew Plummer**, *University of Santa Caterina, Florianópolis - SC, Brazil*

Theoretical Modeling, Analysis, and Experimental Results of a Hydraulic Artificial Muscle Prototype

Technical Paper Publication. FPMC2019-1654

Jonathon E. Slightam, Mark Nagurka, *Marquette University, Milwaukee, WI, United States*

Improving the Efficiency and Dynamic Properties of a Flow Control Unit in a Self-Locking Compact Electro-Hydraulic Cylinder Drive

Technical Paper Publication. FPMC2019-1671

Lasse Schmidt, *Aalborg University, Aalborg, Denmark*, **Søren Ketelsen**, *Aalborg University, Aalborg East, Denmark*, **Damiano Padovani**, *University of Agder, Grimstad, Aust Agder, Norway*, **Kasper Aastrup Mortensen**, *Bosch Rexroth A/S, Hvidovre, Denmark*

Mass Estimation of Self-Contained Linear Electro-Hydraulic Actuators and Evaluation of the Influence on Payload Capacity of a Knuckle Boom Crane

Technical Paper Publication. FPMC2019-1689

Søren Ketelsen, *Aalborg University, Aalborg East, Denmark*, **Torben Andersen**, *Aalborg University, Aalborg, Denmark*, **Morten Kjeld Ebbesen**, *University of Agder, Grimstad, Norway*, **Lasse Schmidt**, *Aalborg University, Aalborg, Denmark*

Modeling, Validation, and Investigation of an Electrohydraulic Crimping Hand Tool

Technical Paper Publication. FPMC2019-1653

Eric Norquist, *Milwaukee Tool, Brookfield, WI, United States*, **Jonathon E. Slightam, Mark Nagurka**, *Marquette University, Milwaukee, WI, United States*

Stirling Thermocompressor: Lumped Parameter Modeling and Experimental Impact of Displacer Motion Profile on Work Output

Technical Paper Publication. FPMC2019-1683

Seth Thomas, Eric Barth, *Vanderbilt University, Nashville, TN, United States*

Efficiency Optimized Pneumatic Pressure Booster

Technical Paper Publication. FPMC2019-1675

Olivier Reinertz, Katharina Schmitz, *RWTH Aachen University, Aachen, Germany*

Technical Program

SESSION 3 – NEW APPROACHES TO SYSTEM MODELING AND SYSTEM DESIGN

ZARA ZOTA BALLROOM

1:15PM–3:15PM

Session Organizer: **Matthias Liermann**, *University of Missouri, Columbia, MO, United States*

Concept Studies on a Multifunctional Unit for Hydraulic Supply and High Lift Actuation in Aircraft

Technical Paper Publication. FPMC2019-1678

Lennard Nordmann, Frank Thielecke, *Hamburg University of Technology, Hamburg, Germany*, **Peter Lücken, Martin Hamm**, *Airbus Operations GmbH, Bremen, Germany*

Influence of Inertia Terms on High Pressure Gap Flow Applications in Hydraulics

Technical Paper Publication. FPMC2019-1601

Felix L. Fischer, Andreas Rhein, Katharina Schmitz, *RWTH Aachen University, Aachen, Germany*

Modelling and Reducing Fuel Flow Pulsation of a Fuel-Metering System by Improving Response of the Pressure Control Valve During Pump Mode Switching in a Turbofan Engine

Technical Paper Publication. FPMC2019-1604

Seiei Masuda, Shimizu Fumio, Masaki Fuchiwaki, Kazuhiro Tanaka, *Kyushu Institute of Technology, Fukuoka, Japan*

H2-Optimal Low Order Transmission Line Models

Technical Paper Publication. FPMC2019-1688

Bernhard Manhartgruber, *Johannes Kepler University, Linz, Austria*

Physically Motivated Simulation of Dynamic Hydraulic Seals

Technical Paper Publication. FPMC2019-1635

Julian Angerhausen, Hubertus Murrenhoff, *RWTH Aachen University, Aachen, Germany*, **Bo N.J. Persson**, *Forschungszentrum Jülich, Jülich, Germany*, **Katharina Schmitz**, *RWTH Aachen University, Aachen, Germany*

A New Electro-Hydraulic Actuator (EHA) Designed for the Lower-Body Exoskeleton

Technical Paper Publication. FPMC2019-1630

Maowen Sun, *Zhejiang University, Hangzhou Zhejiang Province, China*, **Fan Jun**, *Army Aviation Institution–Army Aviation School, Beijing, China*, **Xiaoping Ouyang**, *Zhejiang University, Hangzhou, China*, **Jouni Mattila**, *Tampere University, Tampere, Finland*, **Huayong Yang**, *Zhejiang University, Hangzhou, China*

SESSION 4 – SAFETY, RELIABILITY, FAULT ANALYSIS AND DIAGNOSIS

ZARA ZOTA BALLROOM

3:45PM–5:05PM

Session Organizer: **Travis Wiens**, *University of Saskatchewan, Saskatoon, SK, Canada*

Application of Data Reduction Techniques to Dynamic Condition Monitoring of an Axial Piston Pump

Technical Paper Publication. FPMC2019-1685

Travis Wiens, Jon Fernandes, *University of Saskatchewan, Saskatoon, SK, Canada*

Investigating Fault Detection and Diagnosis in a Hydraulic Pitch System Using a State Augmented EKF-Approach

Technical Paper Publication. FPMC2019-1667

Magnus Asmussen, Henrik C. Pedersen, Lina Lilleengen, Andreas Larsen, Thomas Farsakoglou, *Aalborg University, Aalborg, Denmark*

Estimation of Prepressure in Hydraulic Piston Accumulators for Industrial Wind Turbines Using Multi-Model Adaptive Estimation

Technical Paper Publication. FPMC2019-1665

Fredrik Fogh Sørensen, Malte Severin von Benzon, Sigurd Stoltenberg Klemmensen, Kenneth Schmidt, Jesper Liniger, *Aalborg University, Esbjerg, Denmark*

Systematic Methodology for Reliability Analysis of Components in Axial Piston Units

Technical Paper Publication. FPMC2019-1620

Ivan Baus, Robert Rahmfeld, Andreas Schumacher, *Danfoss Power Solutions, Neumünster, Germany*, **Henrik C. Pedersen**, *Aalborg University, Aalborg, Denmark*

TUESDAY, OCTOBER 8

SESSION 5 – FLUID POWER DRIVES AND TRANSMISSIONS ZARA ZOTA BALLROOM 7:45AM–9:45AM

Session Organizer: **Bernhard Manhartsgruber**, *Johannes Kepler University, Linz, Austria*

A Hybrid Hydraulic-Electric Architecture (HHEA) for High Power Off-Road Mobile Machines

Technical Paper Publication. FPMC2019-1628

Perry Li, David Bigelow, Jacob Siefert, *University of Minnesota, Minneapolis, MN, United States*

On the Energy Efficiency of Dual Prime Mover Pump-Controlled Hydraulic Cylinders

Technical Paper Publication. FPMC2019-1642

Petter Goytil, Damiano Padovani, Michael R. Hansen, *University of Agder, Grimstad, Aust Agder, Norway*

Power Optimization of Series Hydraulic Hybrid Powertrain for Compact Wheel Loader

Technical Paper Publication. FPMC2019-1708

Qunya Wen, Feng Wang, Bing Xu, *Zhejiang University, Hangzhou, China*, **Zongxuan Sun**, *University of Minnesota, Minneapolis, MN, United States*

Influence of Hydraulic Accumulator Performance on the Hydraulic Hybrid Powertrain

Technical Paper Publication. FPMC2019-1709

Qi Zhang, Feng Wang, Bing Xu, *Zhejiang University, Hangzhou, China*, **Kim A. Stelson**, *University of Minnesota, Minneapolis, MN, United States*

Series, Parallel, and Hybrid Series-Parallel Hydrostatic Transmission Architectures for Ground Locomotion

Technical Paper Publication. FPMC2019-1690

Massimo Martelli, Pietro Marani, Silvia Gessi, *IMAMOTER - CNR, Ferrara, Italy*

Analysis of Power Distribution in the Hydraulic Remote System of Agricultural Tractors Through Modelling and Simulations

Technical Paper Publication. FPMC2019-1686

Xin Tian, Josias Cruz Gomez, Andrea Vacca, *Purdue University, West Lafayette, IN, United States*, **Stefano Fiorati, Francesco Pintore**, *CNH Industrial Italia S.p.A., Modena, Italy*

SESSION 6 – PROPERTIES OF HYDRAULIC FLUIDS ZARA ZOTA BALLROOM 10:15AM–12:15PM

Session Organizer: **Qinghui Yuan**, *Donaldson, Bloomington, MN, United States*

Effects of Oil Contamination Level, Flow Rate, and Viscosity on Pressure Drop Development and Dirt Holding Capacity of Hydraulic Filter

Technical Paper Publication. FPMC2019-1631

Anton Jokinen, Olof Calonius, Matti Pietola, *Aalto University, Espoo, Finland*, **Jagan Gorle**, *Parker Hannifin Manufacturing Finland Oy, Urjala, Finland*

Bio-Based Hydraulic Fluids in Mobile Machines: Substitution Potential in Construction Projects

Technical Paper Publication. FPMC2019-1636

Sebastian Deuster, Katharina Schmitz, *RWTH Aachen University, Aachen, Germany*

Air Solubility Measurements and Modeling of Brake Fluids

Technical Paper Publication. FPMC2019-1646

Andreas Eisele, Simon Sagmeister, *Technical University Munich, Garching, Germany*, **Michael Schneider**, *BMW Group, Munich, Germany*, **Markus Lienkamp**, *Technical University Munich, Garching, Germany*

Prediction of Particle Resuspension and Particle Accumulation in Hydraulic Reservoirs Using Three-Phase CFD Simulations

Technical Paper Publication. FPMC2019-1617

Lukas Muttenthaler, Bernhard Manhartsgruber, *Johannes Kepler University, Linz, Austria*

Method for the Experimental Determination of the Bunsen Absorption Coefficient of Hydraulic Fluids

Technical Paper Publication. FPMC2019-1702

Andris Rambaks, Katharina Schmitz, *RWTH Aachen University, Aachen, Germany*

Fluid Effects on Mechanical Efficiency of Hydraulic Pumps: Dynamometer Measurements and Molecular Simulations

Technical Paper Publication. FPMC2019-1712

Paul Michael, *Milwaukee School of Engineering, Milwaukee, WI, United States*, **Pawan Panwar, Michelle Len**, *University of California, Merced, Merced, CA, United States*, **Ninaad Gajghate**, *Milwaukee School of Engineering, Milwaukee, WI, United States*, **Ashlie Martini**, *University of California, Merced, Merced, CA, United States*

Technical Program

KOSKI LECTURE

ZARA ZOTA BALLROOM

1:15PM–2:15PM

SESSION 7 – HYDROSTATIC PUMPS AND MOTORS 1

ZARA ZOTA BALLROOM

2:15PM–3:55PM

Session Organizer: **Noah Manning**, *University of Missouri-Columbia, Columbia, MO, United States*

Multi-Objective Optimization of Modified Cycloidal-Toothed Gerotor Pumps by Genetic Algorithm

Technical Paper Publication. FPMC2019-1696

Andrew Robison, Andrea Vacca, *Purdue University, West Lafayette, IN, United States*

A Numerical Method for the Analysis of the Theoretical Flow in Crescent-Type Internal Gear Machines With Involute Teeth Profile

Technical Paper Publication. FPMC2019-1605

Dinghao Pan, Andrea Vacca, *Purdue University, West Lafayette, IN, United States*

Novel Pressure Adaptive Piston Cylinder Interface Design for Axial Piston Machines

Technical Paper Publication. FPMC2019-1645

Shanmukh Sarode, Lizhi Shang, *Purdue University, West Lafayette, IN, United States*

Piezoelectric Actuation to Reduce Pump Flow Ripple

Technical Paper Publication. FPMC2019-1611

Nathan Hagstrom, Michael Harens, Arpan Chatterjee, *University of Minnesota, Minneapolis, MN, United States*, **Matthew Creswick**, *Eaton Hydraulics, Eden Prairie, MN, United States*

SESSION 8 – HYDROSTATIC PUMPS AND MOTORS 2

ZARA ZOTA BALLROOM

4:25PM–5:45PM

Session Organizer: **Nigel Johnston**, *University of Bath, Bath, United Kingdom*

Modeling and Optimization Study of a Tightly Integrated Rotary Electric Motor-Hydraulic Pump

Technical Paper Publication. FPMC2019-1626

Garrett Bohach, *University of Minnesota Twin Cities, Minneapolis, MN, United States*, **Nishanth Fnu, Eric L. Severson**, *University of Wisconsin-Madison, Madison, WI, United States*, **James D. Van de Ven**, *University of Minnesota, Minneapolis, MN, United States*

Automated Design and Analysis of a Variable Displacement Linkage Motor

Technical Paper Publication. FPMC2019-1677

Nathaniel J. Fulbright, Grey C. Boyce-Erickson, Thomas Chase, Perry Li, James D. Van de Ven, *University of Minnesota, Minneapolis, MN, United States*

A More Accurate Definition of Mechanical and Volumetric Efficiencies for Digital Displacement® Pumps

Technical Paper Publication. FPMC2019-1668

Chris Williamson, *Danfoss Power Solutions, Ames, IA, United States*, **Noah Manning**, *University of Missouri-Columbia, Columbia, MO, United States*

Measuring the Losses of Hydrostatic Pumps and Motors: A Critical Review of ISO4409:2007

Technical Paper Publication. FPMC2019-1615

Peter A J Achten, Robin Mommers, *INNAS BV, Breda, Netherlands*, **Takao Nishiumi**, *National Defense Academy, Yokosuka, Japan*, **Hubertus Murrenhoff**, *RWTH Aachen University, Aachen, Germany*, **Nariman Sepehri**, *University of Manitoba, Winnipeg, MB, Canada*, **Kim A. Stelson**, *University of Minnesota, Minneapolis, MN, United States*, **Jan-Ove Palmberg**, *Linköping University, Linköping, Sweden*, **Katharina Schmitz**, *RWTH Aachen University, Aachen, Germany*

WEDNESDAY, OCTOBER 9

SESSION 9 – DIGITAL AND SWITCHED FLUID POWER SYSTEMS

ZARA ZOTA BALLROOM

7:45AM–9:45AM

Session Organizer: **Rudolf Scheidl**, *University of Bath, Bath, United Kingdom*

Experimental Testing of a Variable Displacement Pump/Motor That Uses a Hydro-Mechanically Timed Digital Valving Mechanism to Achieve Partial-Stroke Piston Pressurization (PSPP)

Technical Paper Publication. FPMC2019-1693

Allissa Montzka, Nathan Epstein, *University of Minnesota, Minneapolis, MN, United States*, **Michael Rannow**, *Eaton Corporation, Eden Prairie, MN, United States*, **Thomas Chase, Perry Li**, *University of Minnesota, Minneapolis, MN, United States*

Monitoring Digital Technologies in Hydraulic Systems Using CUSUM Control Charts

Technical Paper Publication. FPMC2019-1603

Farid Breidi, *University of Southern Indiana, Evansville, IN, United States*, **Abdallah Chehade**, *University of Michigan-Dearborn, Dearborn, MI, United States*, **John Lumkes**, *Purdue University, West Lafayette, IN, United States*

Danfoss Digital Displacement® Excavator: Test Results and Analysis

Technical Paper Publication. FPMC2019-1669

Joseph Budden, Chris Williamson, *Danfoss Power Solutions, Ames, IA, United States*

Definition of Performance Requirements and Test Cases for Offshore/Subsea Winch Drive Systems With Digital Hydraulic Motors

Technical Paper Publication. FPMC2019-1670

Sondre Nordås, Morten Kjeld Ebbesen, *University of Agder, Grimstad, Norway*, **Torben Andersen**, *Aalborg University, Aalborg, Denmark*

Switch-Mode Power Transformer in a Wave-Powered, Reverse Osmosis Desalination Plant

Technical Paper Publication. FPMC2019-1647

Jeremy Simmons, *University of Minnesota, Twin Cities, Minneapolis, MN, United States*, **James D. Van de Ven**, *University of Minnesota, Minneapolis, MN, United States*

Experimentally Validated Models for Switching Energy of Low Pressure Drop Digital Valves for Lightweight Portable Hydraulic Robots

Technical Paper Publication. FPMC2019-1651

Saeed Hashemi, Hannah Mitchell, William Durfee, *University of Minnesota, Minneapolis, MN, United States*

SESSION 10 – HYDRAULIC CONTROL VALVES

ZARA ZOTA BALLROOM 10:15AM–12:15PM

Session Organizer: **Steven Weber**, *Sun Hydraulics LLC, Sarasota, FL, United States*

A Ceramic Flat Slide Valve for Hydraulic Applications

Technical Paper Publication. FPMC2019-1640

Stefan Aengenheister, Chao Liu, Christoph Broeckmann, Katharina Schmitz, *RWTH Aachen University, Aachen, Germany*

2D CFD Analysis of Servovalve Main Stage Internal Leakage

Technical Paper Publication. FPMC2019-1705

Paolo Tamburrano, *University of Bath, Bath, United Kingdom*, **Andrew R. Plummer**, *Centre for Power Transmission and Motion Control/Bath University, Bath, United Kingdom*, **Phil Elliott, William Morris, Sam Page**, *Moog Aircraft Group, Tewkesbury, United Kingdom*, **Elia Distaso, Riccardo Amirante, Pietro De Palma**, *Polytechnic University of Bari, Bari, Italy*

Lumped Parameter Modeling of Counterbalance Valves Considering the Effect of Flow Forces

Technical Paper Publication. FPMC2019-1650

Annalisa Sciancalepore, Andrea Vacca, *Purdue University, West Lafayette, IN, United States*, **Oscar Pena, Steven Weber**, *Sun Hydraulics LLC, Sarasota, FL, United States*

A Method for Anti-Erosion of Water Hydraulic Valve Plug Based on Variable Stiffness and Energy Mitigating Mechanism

Technical Paper Publication. FPMC2019-1612

Feng Sun, He Xu, Liye Jiao, Zitong Zhao, Min Cheng, *Harbin Engineering University, Harbin, China*

Mechanical and Hydraulic Actuation Strategies for Mainstage Spool Valves in Hydraulic Motors

Technical Paper Publication. FPMC2019-1687

Grey C. Boyce-Erickson, Nathaniel J. Fulbright, *University of Minnesota, Minneapolis, MN, United States*, **John A.F. Voth**, *University of Minnesota-Twin Cities, Minneapolis, MN, United States*, **Thomas Chase, Perry Li, James D. Van de Ven**, *University of Minnesota, Minneapolis, MN, United States*

Optimization of a Snap Through Spring for a Hydraulic Valve With Hysteresis Response Behavior

Technical Paper Publication. FPMC2019-1680

Matthias Scherrer, Rudolf Scheidl, Bernhard Manhartgruber, *Johannes Kepler University, Linz, Austria*

INDUSTRY PANEL - AUTOMATION, CONNECTIVITY AND BIG DATA IN FLUID POWER SYSTEMS AND OFF-ROAD VEHICLES

ZARA ZOTA BALLROOM 1:15PM–2:45PM

Panel Moderator: **Michael Gust**, *Center for Compact and Efficient Fluid Power, Minneapolis, MN*

SESSION 11 – CONTROL DESIGN METHODOLOGIES AND TECHNIQUES FOR FLUID POWER SYSTEMS 2

ZARA ZOTA BALLROOM 3:15PM–4:55PM

Session Organizer: **Heikki Handroos**, *Lappeenranta University, Lappeenranta, Finland*

Energetically Passive Bilateral Teleoperation of a Pneumatic Crawling Robot

Technical Paper Publication. FPMC2019-1681

Venkat Durbha, Perry Li, *University of Minnesota, Minneapolis, MN, United States*

Immersive 3D Vehicle Simulation for Hardware-in-the-Loop Testing of Mobile Hydraulic Controls

Technical Paper Publication. FPMC2019-1706

Matthias Liermann, Christian Feller, Florian Lindinger, Dirk Runge, *Danfoss Power Solutions, Neumünster, Germany*

Designing an Improved Controller for a Pump Direct Driven Electro-Hydraulic System Using a Nonlinear Flow Mapping

Technical Paper Publication. FPMC2019-1699

Bobo Helian, *Zhejiang University, Hangzhou, China*, **Zheng Chen**, *Zhejiang University, Zhoushan, Zhejiang, China*, **Bin Yao**, *Purdue University, West Lafayette, IN, United States*, **Can Yang**, *Zhejiang University, Hangzhou, China*

Parameter Identification for Model-Based Control of Hydraulically Actuated Open-Chain Manipulators

Technical Paper Publication. FPMC2019-1656

Lionel Hulttinen, Janne Koivumäki, Jouni Mattila, *Tampere University, Tampere, Finland*

Nonlinear Model-Based Control Design for a Hydraulically Actuated Spherical Wrist

Technical Paper Publication. FPMC2019-1663

Pauli Mustalahti, Jouni Mattila, *Tampere University, Tampere, Finland*

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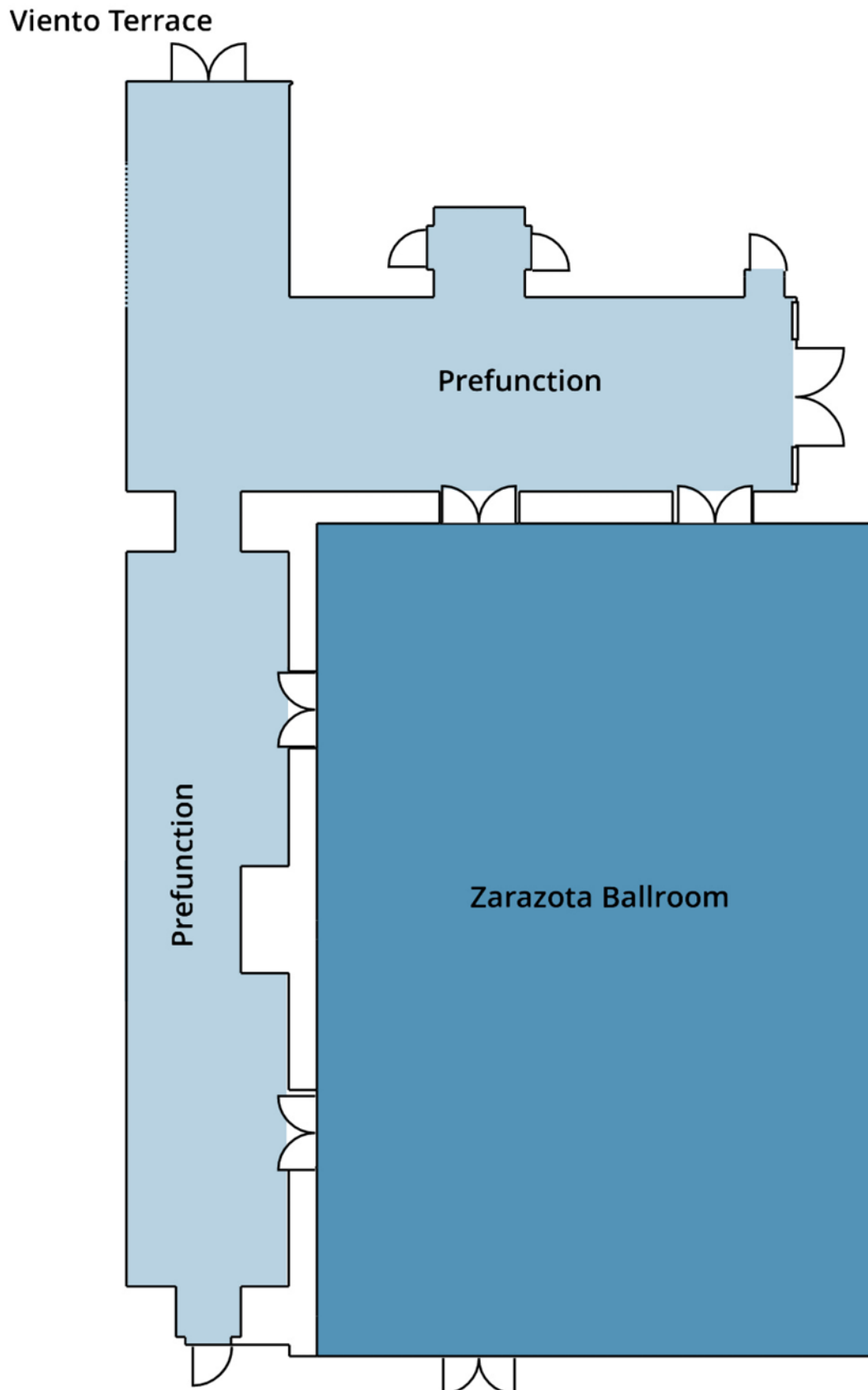
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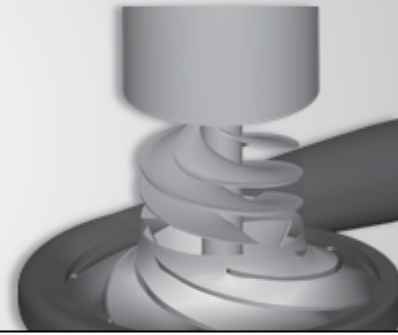
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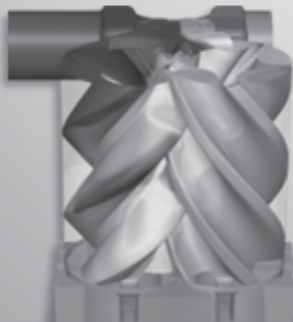
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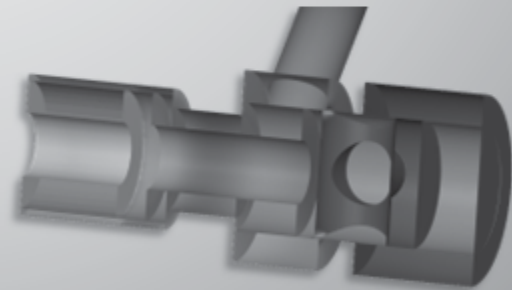
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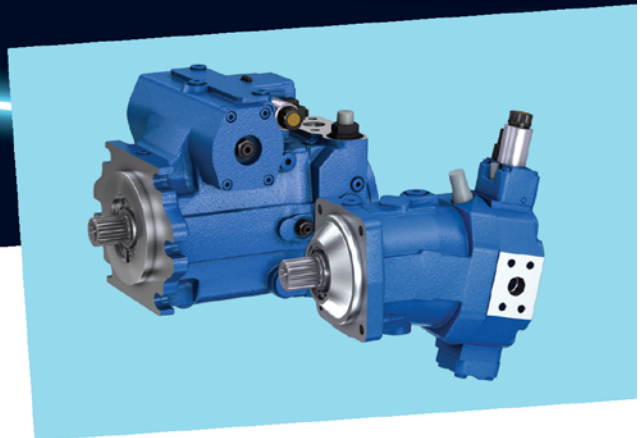


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