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FPST

Fluid Power Systems & Technology Division Newsletter

Noah D. Manring, Editor *Summer 2002*

Message From the Past Chair

Gabriel Silva PhD

Dear Members: It is time to let a new group of qualified individuals continue to lead our FPST division in the pursuit of integration and growth for the next two years. David Edeal and Sanjay Mistry will lead our division as Chair and Vice Chair respectively for the next period. Dave and Sanjay also represent our own Fluid power industry, showing some of the changes that our division is making in leadership.

During the last two years while I was chair, FPST became more focused with more active participation of our members. We have become better at communicating our message through meetings, newsletter, and our new web page (http://www.asme.org/divisions/fpst/). FPST praises its members now through its new Best Paper Award Program and industry members have been more active in our conference panel sessions, which address the current status of our industry and discuss better ways for industry and academia to work together.

Our group is small compared to the vast numbers of engineers that are designing and using fluid power. Our overall visibility is low and our industry participation it is not high enough. Conference attendance is low. So what to do? We need to make the FPST membership worthwhile. When people join ASME they are expecting to know what their colleagues in their respective fields are doing. We need to make our information easily accessible to all persons in our field. ASME is doing a good job providing support to its members but we need connectivity with those who are not. We need to become part of the big worldwide circle that includes fluid power engineers. That exchange of ideas can only help us all become more knowledgeable and provide better improvements in our field. I believe Dave and Sanjay are going to lead these efforts and I will be supporting them along the way.

It was a great privilege to work with such a wonderful group of individuals and professionals that have a common interest and that strive for a continuing enrichment of the field of hydraulics. I will continue to serve and support the division in any way I can.

Thank you.

Gabriel Silva PhD, Past Chair
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Change in Executive Committee (website)

The Executive Committee of the ASME Fluid Power Systems & Technology Division is changing the guard. We wish to thank ***Gabriel Silva*** for his active role during the past two years as Chair and look forward to the incoming leadership provided by ***David Edeal*** and ***Sanjay Mistry*** as Chair and Vice Chair respectively. These leadership roles are critical to the successful operation of our Division and require a significant commitment on the part of each volunteer. Other Executive Committee appointments are located on our website at http://www. asme.org/divisions/ fpst/. Please visit this website to access Newsletters (like this one) and other information related to the Fluid Power Systems & Technology Division.

The National Fluid Power Association Hosts an Educator's Summit

NPFA held its first Educators' Summit in Cleveland, Ohio, on 18 and 19 October 2001. A project of NFPA's Education Committee, this 1 fi day event was a unique forum where association members and fluid power researchers came together to discuss their interests and research in fluid power and motion control.

Goals of the Summit included:

- Creating a community of interest in fluid power.
- Providing a forum where industry leaders and educators with research interests in and teaching responsibilities for fluid power and motion control technology could learn from each other.
- Launching discussions into the future of fluid power - its technology and the interest our industry holds for students.

The Summit program was extensive. First, 20 educators representing 14 U.S.-based engineering schools gave overviews of their current research. They were followed by educators from four of Europe 's leading universities, who discussed their work and the funding models that support it. The following universities were represented:

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The National Fluid Power Association Hosts an Educator's Summit
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U.S.-based:
University of Illinois
Oklahoma State University
Georgia Institute of Technology
The Pennsylvania State University
University of Wisconsin - Madison
Purdue University
Milwaukee School of Engineering
University Of Minnesota
University of Missouri - Columbia
Cleveland State University
The Ohio State University
University of Minnesota
Iowa State University
University of Dayton

European-based:
University of Bath
Technical University of Hamburg-Harburg
Institute of Fluidpower Transmission and Control, Aachen
Linköping University

Other speakers included a representative of Festo, who demonstrated a unique distance learning tool; a development and research manager at Caterpillar, Inc., who provided an overview of his company's experiences in funding research; and four educators who offered their ideas for funding models that could be developed in the U.S. A speaker from the National Science Foundation then discussed criteria that NSF uses in making funding decisions, stressing the importance of industry/university partnerships.

Conference IMECE

The ASME International Mechanical Engineering Congress & Exposition (IMECE) is being held November 17–22, 2002 in New Orleans, LA. At this conference, the Fluid Power Systems and Technology (FPST) Division will hold four paper sessions and two panel sessions related to ongoing research and developments in the field of Fluid Power. Industry and academic representatives will present their most recent results and will be available to dialogue concerning future activities. Specific topics to be presented will relate to design, performance testing, analysis, modeling, and control of fluid power components or systems. Research activities associated with hydraulic and pneumatic actuators, pumps, motors, and modulating components as well as complete fluid circuits and systems will also be presented. A new industry panel session will also be added to discuss Lessons Learned in Fluid Power Research and Development. This panel session will provide a useful forum for academics to inquire about the needs and future trends of the Fluid Power Industry. It also will provide the industry with a mechanism for directing the Fluid Power Research activities that are ongoing within the university. Information pertaining to the conference can be found at http://www.asme.org/congress/. Don't miss this year's IMECE.

The *International Journal of Fluid Power* Needs Your Subscription

The *International Journal of Fluid Power* is the only existing journal that is exclusively dedicated to the dissemination of Fluid Power research. The aim of the journal is to provide the engineering community with high quality information concerning developments in research, design and application of Fluid Power technology. Special emphasis is placed on papers concerned with components and system integration by embracing key aspects of:

- Analysis, modeling, and control,
- Monitoring and fault diagnosis,
- Artificial intelligence applications,
- Component and system design
- Computer software and hardware interfacing, and
- Computer aided engineering for both static and dynamic analysis of Fluid Power systems.

In addition, the *Journal* commissions and publishes state-of-the-art reviews on both existing and emerging technologies, and with a philosophy of maintaining scientific rigor and the practical realities of Fluid Power. The International Editorial Board is composed of leading members of the Fluid Power community having expertise covering the broad spectrum of Fluid Power. All papers are peer reviewed by at least two experts. Technical quality and integrity are considered crucial to the review process. The Associate Editors and the Editorial Board also undertake an active role in ensuring that this is achieved. Currently, three issues are planned for 2002, but the journal is moving towards quarterly publication. The *International Journal of Fluid Power* is abstracted and indexed in: Cambridge Scientific Abstracts, European Environmental Information Database, CEDEFOP-Training Village.

Since the *Journal*'s inception in 2000, its readership has not increased to a level of support that can maintain the viability of the journal at its current subscription rate. To cover the cost of publication, the *Journal* needs the subscription of individuals, companies, and universities. If you are regularly engaged in Fluid Power activities, this journal is a must for gathering updated information on the progress of technology in this field. Annual subscription rates are $85 (98 Euros) or single-issue rates are $32 (37 Euros). These rates include postage and packing. Ordering information can be obtained at the following website: http://journal.fluid.power.net . For such a low investment, why not subscribe to this journal and circulate it through your organization? The *International Journal of Fluid Power* contains information that will contribute to your long-term success.

Fluid Power Activities at the Technical University of Hamburg-Harburg

The research activities of the *Fluid Power Group* at the *Institute for Aircraft Systems Engineering*, at the Technical University of Hamburg-Harburg (directed by Prof. Dr.-Ing. Monika Ivantysynova, M.Ivantysynova@tu-harburg.de), focus on two major areas. The system group concentrates on energy saving hydraulic drive systems. Current activities include projects on new circuit solutions, appropriate mathematical modelling and simulation strategies, new control concepts, system optimization strategies including system design algorithms and methods for online-diagnostics of hydraulic systems for mobile machines.

The second research group focuses on the design and optimization of displacement machines, where a fundamental understanding of the complexity of physical effects on the sealing and bearing gaps of displacement machines is developed. The goal is to improve the efficiency, life time and reliability of hydraulic pumps and motors. The CASPAR simulation program, developed by the institute allow the complete simulation of flows, forces and pressure distribution inside the sealing and bearing gaps of a displacement machine, as long as no mixed friction operating conditions occur. The projects currently include the improvement of CASPAR in include hydroelastic effects at the piston/cylinder assembly, experimental investigations of the tribological behaviour of the piston/cylinder assembly, investigation on the micro and macro surface structure of the piston on the energy dissipation inside

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Fluid Power Activities at the Technical University of Hamburg-Harburg

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the gaps as well as theoretical and experimental investigation of the elasto-hydrodynamic effect on the pressure distribution inside the piston/cylinder assembly.

The fluid power laboratory occupies approx. 600 m^2. It includes displacement controlled actuator test rigs for linear and rotary hydraulic motors. A pump and motor test rig allows efficiency measurements at all operating conditions of hydraulic displacement machines from 1 to 7000 rpm. The transmission test rig was designed to investigate new control concepts for mobile machines with a hydrostatic power transmission. For tribological investigations a special test rig was developed to carry out friction measurements on the piston/cylinder assembly of a swash plate machine under real operating conditions. A test rig for measuring the pressure distribution inside the displacement chamber under real conditions is also part of the laboratory. A climate chamber allows low and high temperature actuator test rig setups for investigations from -70 to +180 °C.

Currently seven PhD Students are working in the Fluid Power Group of the institute. It has approx. 10 Graduate Students involved in the current research activities and about 30 undergraduate students. The annual budget amounted 400.000 C in the year 2002. For more information please visit us at: http://www.tu-harburg.de/fst.

FPSTD Best Paper Award

The Best Paper Award at the 2001 IMECE was given to Emanuelle Guglielmino and Kevin A. Edge[1] for their paper entitled, "A study of an Electro-hydraulically-Activated Friction Damper in a Vehicle Application." The overall study is concerned with an investigation, both theoretical and experimental, on the feasibility of using a servo-driven dry-friction damper in vibration control. The thrust of the investigation is an automotive application to a controlled semi-active suspension. However applications potentially exist in other fields (e.g. structural engineering).

In a motor vehicle suspension, the friction damper device comprises, in essence, a friction pad fixed to the wheel which acts on a plate attached to the chassis of the car (Figure 1). The normal force between the pad and the plate, and hence the friction force is controlled by a hydraulic drive which modulates pressure. Various design options have been investigated for the drive. The final design entailed the use of a proportional underlapped control valve used in pressure control mode (exploiting the pressure gain characteristics). Because of the force-control scheme employed, the energy consumption of this system is relatively low.

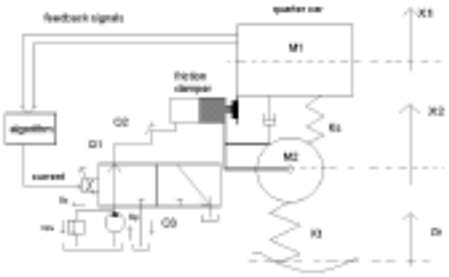

Figure 1. *Schematic diagram of hydraulic circuit for one axis*

A model of the hydraulic drive and of the vehicle has been developed and validated experimentally. A robust control strategy has been employed to tackle the problem of the inherent parameter uncertainties of the plant (particularly the friction coefficient), hence Variable Structure Control schemes have been investigated, namely sliding mode control and switched state feedback.

The controller performs a spring force tracking control, thereby reducing the total force experienced by the chassis. Additional pseudo-viscous damping can also be added. A Lyapounov-based method has been employed for the synthesis of the criterion which defines the change in the system structure.

Extensive simulations have been performed. Experimental work has been undertaken, initially on a pilot rig; subsequently a novel prototype of a friction damper has been designed, installed and tested on a car. A preliminary numerical investigation of the problem of controlling independently four dampers, constituting a full car suspension, has been also carried out.

The model developed has predicted sufficiently accurately the actual system behaviour, particularly as far as the hydraulic drive is concerned. The variable structure controller has achieved the targets of providing both the desired robustness and producing an overall improvement of vehicle ride, particularly in terms of RMS chassis acceleration reduction (Figure 2).

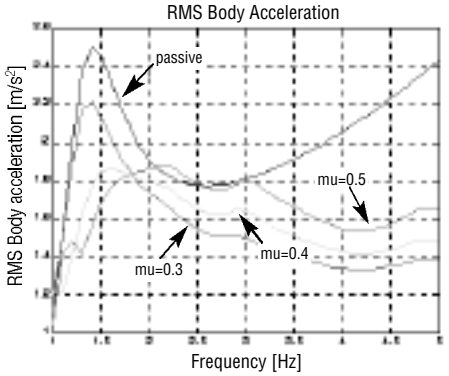

Figure 2. *Predicted RMS chassis acceleration transmissibility curves, for different friction coefficients*

[1]Centre for Power Transmission and Motion Control, Department of Mechanical Engineering, University of Bath, Bath BA2 7AY, UK. Contact: k.a.edge@bath.ac.uk.

NSF Funds Research Supporting Fluid Power Technologies

University of Minnesota - Twin Cities

The National Science Foundation is currently supporting research at the University of Minnesota to develop two new classes of electro-hydraulic valves and to demonstrate them in applications. The research grant (9/2000–8/2003, $180,000, with matching funds from the University of Minnesota) is administered by the Dynamic Systems, Sensors and Control program in the Civil and Mechanical Systems Division within the Engineering Directorate and is under the direction of Professor Perry Li.

The first type of valves - *unstable valves*, aim to address the bandwidth and flow rate limitations that single stage proportional control valves, which are inherently cheaper and more reliable than multistage valves, experience. These limitations are due to the fact that at high frequencies and flow rates, large forces are needed to stroke the valve spools quickly. This requires larger and larger solenoid actuators. To alleviate this limitation without using very large and expensive solenoids, our research approach is to exploit the transient fluid flow forces so as to improve the agility of the spool. Transient flow forces are associated with the acceleration of the fluid inside the valve and are generally manifested as damping to the spool. In this research, the valve geometry is designed so that negative damping is achieved, thus rendering the valve potentially open loop unstable. Similar to high performance aircrafts whose aerodynamics are designed to be open loop unstable requiring active feedback control, the unstable valve system also has to be stabilized using closed loop feedback.

The second type of valves - *passive valves*, are targeted for applications in which the hydraulic machines are under direct human operation. In the area of haptics and teleoperation, it is well recognized that systems that have the *passivity* property are generally safer and more natural to interact with. Roughly speaking, a passive system is one, which does not generate energies of its own. The concept of a passive valve is that the valve, even with the pump connected, behaves like a passive two-port device, with one port being the hydraulic port (for connection to the hydraulic actuator) and the other port being a control command port. This is achieved either by mechatronic feedback or by structural modifications to

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NSF Funds Research Supporting Fluid Power Technologies

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existing valves. Passification of various types of control valves is being developed. Once passive valves have been developed, stable and high performance teleoperation of hydraulic systems with force reflection capabilities using force feedback joysticks become feasible. To dig further see:

1. K. Krishnaswamy and P. Y. Li, "On Using Unstable Valves for Control", ASME Journal of Dynamic Systems, Measurement and Control, March. 2002 (To appear). Also in 2000 ACC.
2. Q.-H. Yuan and P. Y. Li, "Experiemental Study on the Use of Unstable Valves for Control", Proceedings of the American Control Conference, Anchorage, AS. (To appear)
3. P. Y. Li, "Towards safe and human friendly hydraulics: the passive valve" ASME Journal of Dynamic Systems, Measurement and Control. Vol. 122, No. 3, pp. 402–409, Sept. 2000
4. K. Krishnaswamy and P. Y. Li, "Passive Bilateral Teleoperation of a Hydraulic Actuator using an Electrohydraulic Passive Valve", Proceedings of the 2001 American Control Conference, Arlington VA, June 2001.

University of Missouri - Columbia

The National Science Foundation is currently supporting research at the University of Missouri to develop an advanced axial-piston pump. The research grant (8/2001–7/2003, $125,557, with matching funds from the University of Missouri) is administered by the Division of Civil and Mechanical Systems within the Engineering Directorate and is under the direction of Professor Noah Manring.

This project is aimed at conducting a dynamic analysis of the control and containment requirements for a high performance, axial piston, hydrostatic pump. Over the last thirty years, a great deal of information has been added to the literature which describes the control requirements for a standard swash-plate pump design; however, virtually nothing has been written on the topic of swash-plate containment. Also, within the pump industry itself, a few innovative companies have identified certain advantages in using a non-standard swash-plate design, which utilizes a variable primary swash-plate angle and a fixed secondary swash-plate angle; but, again, nothing has been added to the literature to generally describe and apply these advantages to a broad range of pump designs. In this research, a rigorous analysis of the non-standard swash plate will be conducted to ascertain the control and containment requirements for this design. Furthermore, this work will go a step beyond current-day practice by considering the general case when both the primary and secondary swash-plate angles vary. The outcome of this study will be to identify the mechanical and control requirements for this novel machine and to theoretically prove the advantages of implementing the design.

If successful, the work of this research will be used to significantly enhance the performance of axial piston pumps that are widely used in fluid power applications today. The improved performance will be demonstrated in increased operating efficiency and quieter pumps. These improvements will be achieved by optimizing the internal pressure transients of the pump for operating conditions that may vary over a wide range during the normal duty cycle of the machine. A secondary impact will be to reduce valve-plate erosion within the pump. The overall objectives of this work are to reduce waste and to increase the productivity of axial-piston pump technology. The successful accomplishment of these objectives will manifest itself in lower pump operating costs, longer product life, and a reduction in engineering time for product maintenance and design. A first publication from this work is being presented at the 2002 American Control Conference, May 8-10, Anchorage, AK. Other publications are forthcoming.

Fluid Power Education at Purdue

A project to develop a new fluid power technology laboratory at Purdue University has received $340,000 from the Otto J. Maha endowment for the next four years. The project will be jointly completed by faculty from the departments of Mechanical Engineering Technology[2], and Agricultural and Biological Engineering. Additional industry support and donations are sought to help bring the lab to the state-of-the-art level. Both departments offer numerous scholarships for students excelling in fluid power courses, thanks to generous donations from industry and the Fluid Power Educational Foundation.

MET Fluid Power Laboratory, which is part of the project, has been recently equipped with new pressure sensors and display units, Automation Studio 3, and upgraded to LabVIEW 6 software for data acquisition. The laboratory supports MET 230 Fluid Power, MET 334 Advanced Fluid Power, MET 382 Controls and Instrumentation for Automation, MET 432 Hydraulic Motion Control Systems, and MET 436 Pneumatic Motion Control Systems courses taken by 300 students per year. Additionally, MET offers the use of its rapid prototyping machine to support design projects in all courses. Students learn how to use CAD solid modeling software to build clear working hydraulic models made out of epoxy.

In spring 2002 Automation Studio 3 software has been included in several fluid power courses with great success. Students learn to design hydraulic, pneumatic, and electric (relay and PLC logic) circuits, and simulate them. The next step will be to connect the software to the hydraulic and pneumatic test stands to create a virtual factory. Automation Studio 4, expected this year, will allow for a dynamic analysis of the circuits. Currently MET uses HYSAN software for this purpose, while ABE department offers more advanced Easy5 software developed by Boeing.

[2]Jan T. Lugowski is an assistant professor of mechanical engineering technology at Purdue University. He gained industrial experience in the maintenance of mobile equipment, technology of aircraft engines, and design of fluid power systems. He teaches courses in fluid power, controls, and data acquisition.

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FACT:
U.S. R&D SPENDING TO EXCEED $287 BILLION
(source: National Science Foundation)

FPST DIVISION LEADERSHIP 2002 - 2003

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