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1880 — 2005

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PROCESS INDUSTRIES DIVISION

Fall 2005

Message from the Chair

Dr. Samuel Sami, P.E., Fellow ASME and ASHRAE

I am honored to serve a second year term as the Chairman of the Process Industry Division PID and it is my pleasure to welcome the Executive Committee, Technical Committees, ASME staff and particularly members of the PID to this Newsletter issue.

On behalf of the Executive Committee I would like to thank the members of the PID Division for their continued support and participation. This year, the division was proud to participate in organizing 2005 Heat Transfer Conference in San Francisco and welcomes future involvement in the International Mechanical Engineering Congress IMECE 2005 to be held in Orlando. Such meetings have become the focal point for addressing the different technical issues related to the process industry. Participation in the IMECE meetings along with other Division's sponsored meetings especially from industry has experienced gradually an increase over the past few years. The Process Industries are the back bone of the industrial societies throughout the world.

Our PID division is committed to providing technology transfer of engineering information by sponsoring conferences, workshops, seminars, tutorials, short courses, scholarships and student participation as well as communications with government agencies. The division is actively launching in depth dialogue with industry through sponsored seminars and forums to discuss and explore new process industry related issues and opportunities. We invite you to visit our sessions during this year IMECE 2005 and participate in our sponsored open discussion meetings.

Our four technical committees have been active in serving the various areas of process industry; heat exchangers, compressor's technology and water treatment. Our technical committee on cryogenic has extended its scope, to include low temperature industrial applications. This committee is currently headed by Dr. Mike Ohadi who is very dynamic leader. Please contact the chairs of our technical committees and join them in ensuring that PID has a strong participation and active programs to serve the industry. Your involvement is crucial to ensuring future growth and success.

Sharing ideas and developments within our engineering community is crucial to achieving our goals as stated in our strategic planning. Our intensions are to extend our networking and to increase student involvements in the division activity. To this end we have created a new technical committee; Industry Research and Developments to facilitate working with industry, promote the PID to industry, as well as to encourage industry participation through the development of joint projects with industry. The idea, mandate and benefits of this committee appealed to the Manufacturing Group Board and decided to establish a similar committee on the group level. Both committees are chaired by me, a strong believer in working and developing joint industry projects. Please join either

CONTINUED ON PAGE SIX

1st ASME Symposium on Advanced Computational Methods and Applications for Heat Exchanger Design

Steven Beale

This summer the PID Heat Exchanger Committee, together with the Heat Transfer Division K-10 committee, held the 1st ASME Symposium on Advanced Computational Methods and Applications for Heat Exchanger Design. The symposium was organized by PID members Steven Beale, Ahmad Fackeri and Arun Muley, and was held at the 2005 Summer Heat Transfer Conference in San Francisco which was collocated with the InterPACK conference of the Electronic and Photonic Packaging Division.

Conference keynote speaker, Brian Spalding opened the symposium by speaking to a full-house of delegates from both Divisions on the subject of "Solid-fluid-thermal analysis of heat exchangers" and shared his unique insight and experience

CONTINUED ON PAGE TWO

1st ASME Symposium

continued from page one

on the art and science of the use of computational fluid mechanics, heat transfer and stress analysis as a modern design tool, and especially how to use CFD in non-standard applications to solve novel problems.

Conference keynotes were also given to a packed audience by Prof. Danesh Tafti from VPI and Prof. Bengt Sundén, from Lund University Sweden. The subject of Prof. Tafti's talk was "Computational Insights into Air-side Flow and Heat Transfer in Compact Heat Exchangers" and he presented a series of extremely interesting results primarily for louvered-fin type heat exchangers widely used in the air conditioning industry. These flows are highly unsteady and three-dimensional requiring the use of very large computers and compute meshes.

Prof. Sundén's talk was on CFD in Design and Development of Heat Exchangers. He gave a very thorough review of CFD methods, turbulence models and presented results for the popular plate heat exchanger design, louvered geometries, and outlined some of the strengths and weaknesses of the current generation of computer methods in heat exchanger design.

A very well attended panel session was composed of Van Carey (U-C Berkeley), Sun-Eun Kim (Fluent Inc.) Ramesh Shah (RPI). Prof. Carey spoke about problems and issues relating to multi-phase flow in offset-fin and other heat exchangers. Dr. Shah, who also gave the Kern lecture on the subject of heat exchangers at the conference, discussed the many shortcomings that need to be addressed if CFD is to be widely adopted by the industry, apart from niche applications such as manifold design. Dr. Kim, on the other hand showed the audience how he had used large eddy simulations to analyze low Reynolds number turbulent flow in tube banks. The panel chair, Samuel Sami also made a presentation to the audience, and there was a lively debate at the session end.

In addition to keynote presentations and panel sessions, seven technical sessions were held where numerous distinguished scientists and engineers from around the world presented the results of their work, like the others were again filled to capacity.

In spite of being organized at short notice, this event was a great success and exposed both heat transfer workers and people involved in the electronic cooling industry to the activities of the PID Heat Exchanger Committee. We will be holding another symposium on this subject, probably in around 2 years.

It has been my privilege to serve as Chair of the PID Heat Exchanger Technical Committee, these last two years, and it is my pleasure to welcome Prof. Sundén as incoming chair. He brings a wealth of experience and knowledge in the field and will be a valuable resource to the ASME PID Heat Exchanger Technical Committee. ■

PID Compressor Technical Committee 2004/5

Chair: Norbert Müller, Michigan State University

The PID Compressor Committee provides a podium for exchange among peers in industry, government agencies and academia who are involved or interested in any kind of industrial compression technology. Its activities have been focused on the ASME International Mechanical Engineering Congress and Exposition (IMECE) as a major event for meeting peers and exchange knowledge in the branch.

In 2004, IMECE was held in Anaheim, CA. There the Compressor Committee organized five technical sessions. Three of them were grouped together as the International Symposium on Wave Rotor Technology. The latter meeting has been very successful with fourteen technical presentations presented at this symposium. With this it has been the internationally biggest public event since 1985 that features Wave Rotor Technology as a special and promising compression technology.

At the IMECE 2005 held in Orlando, November 5-11, 2005 (www.asmeconferences.org/congress05), the PID Compressor Committee sponsors a panel session on "Current and Future Trends in Compressor Industry and Research". This panel session is one of the eight PID sessions and is held Friday, November 11, 2005, 3:45-5:15 PM. Invited panel speakers for this panel session are Nickolas Cumpsty, from Imperial College, UK addressing "Relevant experience from aircraft engine compressors taken across to process machines", David Japikse from Concepts NREC, Steven Sommer from York International, and Charles Garris from George Washington University.

The Compressor Committee also invites interested members to join the PID luncheon at IMECE'05 on Thursday, November 10, at noon and specifically to the meeting of the Technical Committee afterwards at 2pm. The committee encourages interested ASME members to join the committee and engage in its activities. Also suggestions are welcome that can further broaden our work and address needs of our members and audience. For questions and suggestions please contact:

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email: mueller@egr.msu.edu;

Co-chair: Ahmed Abdelwahab,
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e-mail: Ahmed_Abdelwahab@praxair.com. ■

PID will be joining the AESD Luncheon at IMECE Orlando

Advanced Energy Systems Division Luncheon

Thursday November 10, 2005
12:00pm - 2:00pm
Southern Hemisphere III Ballroom, Ballroom Level

Sponsored By: The Advanced Energy Systems Division

Speaker: Dr. Rama Venkatasubramaniam, Director
Center for Thermoelectrics Research, RTI International

Topic: Recent Advances in Thermoelectric Materials and Energy Technologies

Ticket: $41
(for details see: http://www.asmeconferences.org/congress05/)

Multiphase Pumps (MPP) to Capture the Gas from Steam Recovery of Heavy Oil and Technological Challenges

by Dr P. Toma, P R Toma Consulting Ltd (ptoma@telus.net) and L. Anderson, President, L.O.P. Inc. (l.anderson@lopinc.com)

A summary of the PID invited paper IMECE # 2005-82892, Orlando, Nov. 11, 2005

Pumps and compressors designed to handle liquids and gases have been continuously improved and adapted to a large variety of fluids, flow rates, temperatures and pressures. Yet compressors and pumps don't like each other. Small amount of liquid can rapidly damage a conventional (say reciprocating or centrifugal) compressor, and, likewise, gas entering a pump is known to significantly reduce its efficiency and reliability.

Recent technologies for land and offshore gas-oil industry often require simultaneous gas-liquids handling. Pumping liquid oxygen in the rocket engine or liquid nitrogen for modern formation fracturing technologies pose similar problems.

A strong need for a more forgiving pump or compressor, capable to handle both gases and liquids has been addressed and "hybrid" equipment, (not yet found in the thermodynamic books) was created, mainly by adapting existing pumping or compression technologies.

For some unjustified reasons, the newly created hybrid was named "Multiphase Pump" (MPP) and was indeed "treated and dressed" as a pump. This may include a common procedure to assess its volumetric efficiency by calculating the amount of liquid flowing from higher to lower pressure stages (leakage) and, the assumption that only a negligible amount of heat is released during the compressing/pumping process of gas-liquid mixture, a mixture sometimes containing more than 90% gas.

The MPP has gained a widespread attention and a specialized group (Multiphase Pump User Roundtable –MPUR fostered by Texas A&M University under Prof. S. Scott) has been formed to share problems and solutions among manufacturers, users and academics.

Unfortunately, competition among various manufacturers (not willing to shear more than "successful field cases" and the chronic lack of resources for performing R&D studies left many MPP problems to be still addressed, debated and solved.

The IMECE # 2005-82892 invited presentation is a summary of a recent study attempting to explain the potential source of a strong vibration regime observed when a near-saturation mixture of condensate-vapor-gases is compressed using an MPP equipment for improving the separation and marketing of volatile organic components, a by product in the thermal recovery process of heavy oil.

Fig. 1 Field Pilot using Multiphase Pumping (MPP) equipment for improved recovery of organic volatiles resulting from thermal recovery of heavy oil, after MPUR 2003

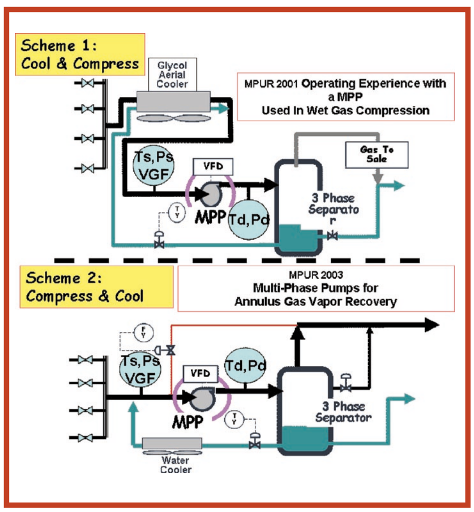

Fig. 2 Two schemes used for MPP compressing of vapor-gas-condensate resulting from steam recovery of heavy oil in Alberta, Canada

Fig. 1 is a snapshot from a field pilot using MPP in Alberta, Canada and illustrates the size of equipment used and the magnitude of potential associated-problems. Fig. 2 is a schematic illustration of two possible schemes using MPP for improved separation and marketing of volatiles produced in thermal recovery fields. The "Cool & Compress" appears to better protect the MPP equipment, while the overall effectiveness of separation process is reduced as compared to "Compress & Cool" scheme; however the "Cool & Compress" appears to expose in a lesser degree to a near-saturation suction condition.

The following "risk" factors have been considered and investigated in this study:

1. The MPP operates for long periods as a "wet compressor" e.g. 90-98% gas,
2. Compression ratios in excess of 7-9,
3. Fluids (steam, volatiles and condensates) enters the MPP in a near-saturation thermodynamic condition,
4. For high gas void fractions, the MPP performs as a "compressor" – this explains a higher than unity volumetric efficiency observed in the field
5. Under high void fraction conditions, an "annular flow pattern" is developed inside of a high speed, twin-screw MPP (similar to the flow pattern observed in conventional upward gas-liquid flow – for high gas velocities – high shear conditions),
6. High discharge-suction temperature differences, typical to polytropic gas compressions are not observed (field).

Item #6 would suggest strong heat transfer between the relatively cold liquid and the hot, compressed gas. However, inside the (MPP- twin-screw) high-speed equipment, reaching the gas-liquid temperature equilibrium cannot be reached and significant temperature differences developed between the hot gas and relatively cooler (water) droplets are the main source of a violent boiling condition: flash boiling.

The model proposed and discussed in the paper assumes an instability condition generated by a high-speed, periodic flash-vaporization of droplets (generated in the "annular-like" flow pattern inside the rotating screw pump/compressor and a subsequent, partial, condensation due to pressure increase effect. This was postulated as **C**ompression-**B**oiling-**I**nstability (**CBI**).

More generally, process instability may be defined as the result of two or more competing forces when small system perturbations leads to amplified, sizable, "path-change" actions.

In particular the postulated CBI condition, is the result of rapid heating of the compressed gas mixture to a temperature much above the (bulk) saturation temperature of the droplets in core flow leading to a violent vaporization and of vapor compression leading to condensation. As a result, the

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Multiphase Pumps (MPP)

continued from page three

droplet temperature rises and reaches superheating values of 5-20 °C above saturation condition (estimated for local partial vapor pressure). At this condition, a spontaneous, bulk nucleation will lead to a large population of vapor bubbles and an explosive fragmentation of droplets into much smaller units which will further vaporize extremely fast. As a result, the latent heat of vaporization is transferred through direct gas-liquid-vapor large contact area conditions, cooling the gas to near-saturation temperature level. An important pressure oscillation regime appears to be directly related to a cycle of flash-boiling repetitive phenomena.

Fig.3 CBI - Non-equilibrium compression-heating and cooling events during the MPP compression of the gas-vapor-liquid system and specific required conditions

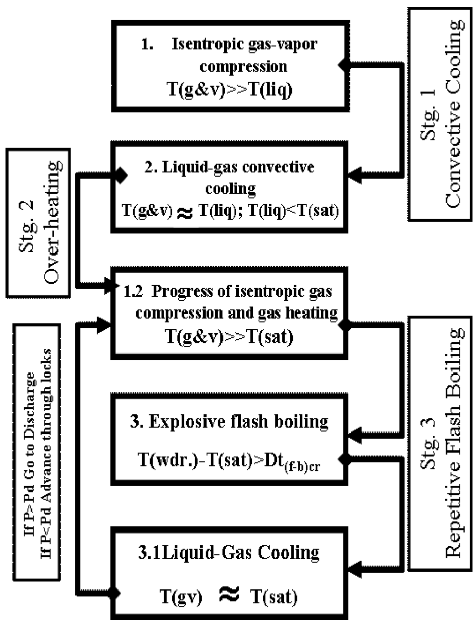
Details are presented in the paper to be distributed during the PID – IMECE Meeting in Orlando, Thursday, Nov. 10, 8AM.

How this is going to be demonstrated and further used for avoiding such potentially destructive conditions?

First, a high-speed pressure oscillation measurement is now attempted (in the discharge plenum) of the MPP. This may not be the "best location" but is a "convenient" one.

Second, field parameters are used now to map a critical instability-vibration regime is mapped based on field parameters.

Third, improved control and cooling conditions strategies are on the drawing board right now, to better address the "risk operations" items discussed in this presentation. ■



Fig, 3 illustrates a sequence of CBI used to quantify the magnitude and even frequency of this condition.

PID - Serving Mechanical Engineers Around The World In the Process Industries Areas - An open platform of communication exchange

Vision:

Foster and lead the promotion of the art, science and practice of Mechanical Engineering as related to Process Industries in key industrial aras such as:

1. Compressor applications
2. Heat Exchangers
3. Water Purification/Treatment Technologies
4. Low Temperature Industrial Applications

PID Goals:

1. Become a prime source of global knowledge, innovation and practice on the Process Industries,
2. Size, address, discuss and adapt to changes in engineering environment,
3. Foster and encourage PID programs to benefit the existing and the potential new ASME members and their associated industries,
4. Foster and encourage cross-fertilization through partnerships and group discussions - achieve individual and group pre-eminence,
5. Wise and prodent management of PID's human and monetary resources needed to stimulate these goals. ■

Wave Rotor Technology

Norbert Müller, Michigan State University, mueller@egr.msu.edu

At the ASME International Mechanical Engineering Congress and Exposition (IMECE) in Anaheim, CA, November 2004, the PID Compressor Committee organized the International Symposium on Wave Rotor Technology. This became the biggest public event since 1985 that showcased Wave Rotor Technology as a special and promising compression technology.

A wave rotor is a dynamic pressure exchanger that exchanges energy from a high pressure fluid to a low pressure fluid via the means of moving shock waves that are generated in an appropriate geometry by exposing the ends of flow channels alternatively to high pressure and low pressure ports (Figure 1). Hence in difference to conventional compressors no mechanical parts like pistons or blades are required to accomplish the energy transfer.

The potential for utilizing unsteady flows has been recognized since the early twentieth century, but neglected as long as substantive improvements could be made to conceptually simple steady-flow or semi-static devices. Also, the inherent non-linearity of large-amplitude wave phenomena in compressible fluids and unusual geometry of unsteady flow devices greatly benefits from detailed calculations, which until recently were too laborious or expensive or imprecise. By understanding and exploiting complex unsteady flows, sometimes a quantum increase in engine performance is possible and/or often hardware can be simplified, made less costly, more responsive, and more. Shock tubes, shock tunnels, pulse combustors, pulse detonation engines, and wave rotors are typical examples of unsteady-flow devices. 1

After first patents appeared between 1906 and 1942, in the mid 1940s the first wave rotor test has been accomplished topping a locomotive gas turbine enhancing its power and efficiency. Figure 2 shows a schematic of a gas turbine cycle using a through-flow four-port wave rotor. Air from the compressor enters the wave rotor (1) and is further compressed inside the wave rotor channels, before it is discharged into the combustion chamber (2). Thus, combustion takes place at a higher pressure and temperature than in the baseline engine. The hot gas leaving the combustion

CONTINUED ON PAGE FIVE

PID Sponsored Sessions in IMECE 2005

(for details see: http://www.asmeconferences.org/congress05/TechnicalProgram Overview.cfm#36)

Program Representative:
Samuel Sami, University of Moncton

Group Representative:
Meherwan P. Boyce, The Boyce Consultancy Group, LLC

PID-1 (*Industrial and Multiphase Transport*)
Session Schedule: Friday, November 11, 2005
07:45 AM-09:15 AM
Session Organizer: Peter Toma, P R Toma Consulting Ltd

PID-2 (*Process Heat Transfer*)
Session Schedule: Friday, November 11, 2005 09:30 AM-11:00 AM
Session Organizer: Peter Toma, P R Toma Consulting Ltd

PID-3 (*Industrial Processing*)
Session Schedule: Friday, November 11, 2005
11:15 AM-12:45 PM

PID-4 A (*Compressor Technology*)
Session Schedule: Friday, November 11, 2005
02:00 PM-03:30 PM
Session Organizer: Peter Toma, P R Toma Consulting Ltd

PID-4B (*Process Control & Fluids*)
Session Schedule: Friday, November 11, 2005
02:00 PM-03:30 PM
Session Organizer: Mike Ohadi, University of Maryland

PID-5 A ENERGY 2020 (*Panel Session*)
Session Description:
Speakers are: Professor Dalton Garris, Petroleum Institute; Dr Duke Duplessis, Senior Advisor, Alberta Energy Department, Canada; Mike Carten, President and CEO - Sustainable Energy Technology; Professor Malcolm Wilson, Program Director for CO2 Management with Energy INet, University of Regina

PID-5 B Current and Future Trends in Compressor Industry and Research (*Panel Session*)
Session Schedule: Friday, November 11, 2005
03:45 PM-05:15 PM
Speakers:
Nicolas Cumpsty, Imperial College, UK
David Japiske, Concepts ETI
Steven Sommer, York International
Charles Garris, George Washington University
Session Organizer: Norbert Mueller
Session Co-Chair: Ahmed Abdelwahab, Praxair Inc.

PID-5 C Industry Networking (*Panel Session*)
Session Schedule: Friday, November 11, 2005
03:45 PM-05:15 PM
Session Organizer: Samuel Sami

Wave Rotor Technology continued from page four

chamber (3) enters the wave rotor and compresses the air received from the compressor (1). While providing the energy for the compression of the air, the burned gas expands and is afterward scavenged toward the turbine (4) for complete expansion. Due to the pre-expansion in the wave rotor, the burned gas enters the turbine with a lower temperature than that of the combustor exit. However, the gas pressure is still higher than the compressor exit pressure by the pressure gain obtained in the wave rotor. Finally, the channels are re-connected to the compressor outlet, allowing fresh pre-compressed air to flow into the wave rotor channels and the cycle repeats.

Soon after the first gas turbine test the focus switched to using the wave rotor for supercharging internal combustion engines, which are highly dynamic machines. First supercharging tests are known in the late 1940s. The biggest commercial success have been about 150,000 Mazda Capella 626 cars that have been supercharged by the Comprex® developed by BBC in Schwitzerland, and which have been sold between 1987-1995. The IC engine supercharging wave rotor has been further developed with the help of ETH Zurich and is now available as Hyprex® by Wenko in Schwitzerland. Also developments have be seen for air refrigeration cycles, and superheating air for a hypersonic wind tunnel test facility at Cornell Aeronautical Laboratory (CAL). Today a major focus is underway on maturing the wave rotor technology for the commercial successful use as pressure gain combustor or for topping gas turbines for generation or propulsion. This effort is now conducted mainly by NASA, AADC, Indiana University Purdue University Indianapolis, Michigan State University, Warsaw University, and Tokyo University. The last three universities also pursue the miniaturization of the wave rotor technology. 2 Recently new embodiments have been published like the radial wave rotor and the condensing wave rotor for the use in phase change compression refrigeration cycles like those using only water (R718) as refrigerant.[3]

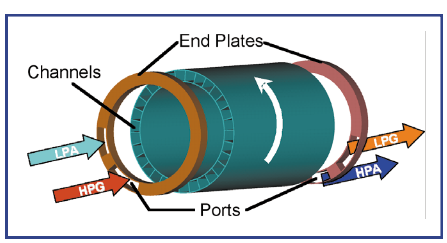
More applications in industry are conceivable everywhere there is a high pressure fluid available that can be expanded for compressing a low pressure fluid, while allowing some contact between them. It has been shown that the energy exchange is much faster than mixing and that mixing can be kept to a minimum. Advantages of this technology are simple geometries, only one moving part, relative low rotational speed, the opportunity for minimum frictional loses, inherent self cooling feature since the channels are exposed alternatively to higher and lower temperature fluid, and fast response due to the utilization of shock waves. ■

References:

[1] Akbari, P., Nalim, M. R., Müller, N. "A Review of Wave Rotor Technology and its Applications", 2004 International Mechanical Engineering Conference, ASME Paper IMECE2004-60082, USA, Nov 2004.

[2] Iancu F., Müller, N. "Efficiency of Shock Wave Compression in a Microchannel", Journal of Microfluidics and Nanofluidics, DOI 10.1007/s10404-005-0054-7, 2005.

[3] Akbari, P., Müller, N. "Wave Rotor Research Program at Michigan State University", 41st AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, AIAA Paper 2005-3844, USA, Jul 2005.



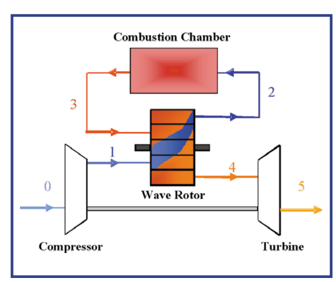


Figure 1: Four-port axial wave rotor. The flow and shock wave through the axial channels are controlled by the opening and closing the channel ends to ports in the stationary endplates through rotation of the drum. Low Pressure Air (LPA) is compressed by High Pressure Gas (HPG) to High Pressure Air (HPA), while HPG expands to Low Pressure Gas (LPG).

Figure 2: Schematic of a gas turbine topped by a through-flow four-port wave rotor. 1: LPA, 2: HPA, 3: HPG, 4: LPG.

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Executive Committee

Message from the Chair

continued from page one

committee to help us achieve ASME goals and objectives. We believe that these activities will result in a significant increase in our financial base and our membership.

The PID is also launching a new initiative in response to the current energy crisis in collaboration with other divisions to assess its impact on the process industry operations. Areas to be discussed through open sessions at IMECE 2005 include conversion technologies, thermal energy transport, smart energy systems, and development of new class of energy drivers that take advantage of high rates of heat and mass transfer as well as superconductivity.

On a final note I have enjoyed serving as PID chair and look forward to greeting you at the PID luncheon on Thursday November 9 during IMECE 2005. If you have any suggestions, or you want to become more involved in our PID activities, please contact me or chair persons of our various technical committees. I also invite you to visit our web site for further information. ■