

# PROCESS INDUSTRIES DIVISION

The PID Newsletter

Fall 2004



## Message from the Chair

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

It is my pleasure to welcome the Executive Committee, Technical Committees, ASME staff and other members of the Process Industries Divisions (PID), and offer my services as their Chair.

PID has over 1300 primary members who are very well connected to ASME through the Division which is currently has four Technical Committees active in various disciplines of process industry. During the past year PID has been promoting the Division activities by using several new marketing media such as our effective web site and very attractive expositions by my predecessor Mr. Riyaz Papar and our very active team.

Some major strides have been made in the activity of the PID with sponsorship and participation in the technical sessions at various conferences including IMECE, Heat transfer Conference and others. These activities have resulted in a significant increase of our profile and our financial base. Thanks to the efforts of all my predecessors, this goal has been accomplished to a certain extent and I consider it is my duty to build on these achievements. I would like to take this opportunity to welcome our new Executive Member Dr. Steven Beale who has been very active in the heat transfer Technical Committee and research in fuel cells.

Recently several of our members received prestigious awards. Congratulations to our team headed by Dr. Peter Toma whose accomplishments were recognized by winning the TEC

2004 best presentation. Special congratulation to Dr. Peter Toma and Dr. Michael Ohadi for their accomplishments that were recognized by their election and elevation to the grade Fellow of the ASME and ASHRAE respectively. We are making sincere attempts to nominate deserving candidates for future Fellow promotions.

The Division and its Technical Committees meet twice a year to discuss their activities and to focus our scope on new developments. We welcome suggestions from our members so that all our Technical Committees can be active and suitably streamlined with ASME goals. We would like to introduce to you our newly formed and improved Technical Committee Low Temperature Applications which evolved from the Cryogenic Technical Committee. The focus of this committee is to streamline activities in the area of refrigeration, freezing and ultra temperatures applications. In addition, it is expected that this committee will work and collaborate with other ASME Technical Committees in related fields. Please visit our web site at <http://www.asme.org/divisions/pid/>, review our strategic plan and offer your comments. Your feedback is very vital to us and our progress.

Finally we would like to express our great appreciation to Mr. Riyaz Papar, the outgoing Chair for his active participation during his tenure. We hope to carry on this mission which we take very seriously. We look forward to seeing you at IMECE in Anaheim in November 2004 and to an exciting year to come. ■

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## ASME 1st International Symposium on: Computational Methods for Industrial Heat Exchanger Design sponsored by the ASME Process Industries Division

Heat exchanger manufacturing is a multi-billion dollar engineering activity worldwide. While traditional engineering design methods based on lumped-parameter methods such as LMTD, F-chart, P-NTU, \_ method, as well as other presumed-flow procedures such as the Delaware method are still used in computer softwares advanced computational methods, previously reserved to aeronautical and space applications become in many instances the tool of choice for better design of industrial heat exchangers. Availability and accessibility of high-speed, large memory computers meets novel, and user-friendly software.

The symposium invites software developers, academics and industry to share knowledge and discuss present needs in view of rapid spreading of modern

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## “The Constructal Theory - A Bridge Between Natural World and Man- Made Microsystems”

**Professor A. Bejan, Fellow ASME,  
J. A. Jones Professor of Mechanical Engineering**

This year's Process Industries Division luncheon speaker at IMECE04 is Dr Adrian Bejan, J. A. Jones Professor of Mechanical Engineering at Duke University (North Carolina, USA). Dr. Bejan is one of the top one hundred most cited authors in the area of mechanical engineering, the author of 14 books and more than 350 scientific articles.

Based on the second law of thermodynamics and exergy analysis, Dr Bejan's has developed a practical tool and a framework for design and optimization of energy systems and for observing and understanding the way natural world acts and changes. This is not just an Academic Perspective but also a very practical way to observe, assess and build such systems. This luncheon is open to all and we particularly want to invite nonmembers to join us and learn more about the Process Industries Division.

As stated by Professor Manuel Ferreira Patrício - Rector of the University of Évora, "Adrian Bejan is distinguished as much by the great originality and versatility of his scientific work, widely renowned and praised, as by his exceptional didactic aptitude, repeatedly illustrated in his academic textbooks, several of them serving as primary references texts for engineering studies throughout the world."

When engineers design a device or system, they must first understand its purpose. The device must perform a function, subjected to given constraints. The engineer conceives and designs it, optimizes its design, constructs it, makes it work and optimizes its performance. The unique understanding that engineers can offer in the search for the origins and evolution of naturally occurring structures is that many designs for such structures have nearly the same overall performance as the optimal design engineers could conceive, even though they may differ in their details. This engineering insight helps to account for the evolution of naturally occurring systems governed by energy and mass flow and subjected to geometric and size constraints.

In the case of minimizing the overall thermal resistance between a fixed heat-generating volume and one sink point, every subsystem of the given volume can have its shape optimized. This principle is applied first at the smallest volume scale, where a single high-conductivity fiber removes the heat generated by the low-conductivity material from each smallest element. The same geometric-optimization principle applies at larger scales. The next volume is an optimized assembly of optimized volume elements. The process of construction and shape optimization continues stepwise to larger scales until the given volume is fully covered. The high-conductivity paths form a tree, and the low-conductivity paths fill the infinity of points of the given volume.

The steep increase in price of oil and natural gas that we have experienced during the last year is an incentive for a fundamental improving of our engineering models based mainly on a short-term analysis of capital and operation costs. During the last ten years, one of Dr Bejan's main effort was directed towards developing additional tools for assessing the quality and price of our activities and products. The new model is capable of assessing the long-term use and misuse of our limited energy resources as well as the environmental impact of our activities.

Dr Bejan's "constructal theory" is a novel attempt to develop suitable tools for designing macro and micro-systems in view of maximizing the results and minimizing the irreversible components of heat/mass/concentration transport. Let's learn it, adopt it and put it to work! ■

### **A. PID/Water Treatment Group survey and comments (selection/excerpts)**

We would like to thank all participants to this discussion. Every point made is valuable and the PID's Division and ASME did its utmost to create the best conditions during the IMECE 2004 to help, disseminate



## **IMECE Anaheim Join Us and Contribute:**

**Morning: B. Higher Oil Prices and the Opportunity for Alternative Energy**  
**9:30-11:00 AM** Panel Session (PID-6  
Organizers: Michael Ohadi and Arun Muley) see also PID's Sponsored Sessions at IMECE 2004 the full program enclosed

**Lunch: C. The PID Luncheon Event:** “The Constructal Theory - A Bridge Between Natural World and Man- Made Microsystems” Professor A. Bejan, Fellow ASME - will remind us the forgotten “second principle” and offers new and improved tools to cope with:

- ✓ Fuel price,
- ✓ Miniaturization,
- ✓ Environment impact mitigation

### **Process Industry's Today: Focus on Practical Solution The impact of recent increase of fuel (gas and liquids) - Challenges and Opportunities**

**A. The Industrial Water Treatment Committee** (Leo T. Meire, Chair) took the initiative and have recently addressed two salient questions related to the impact of high-energy price. We took the liberty to select a few answers and are expecting to foster a few actions resulting from numerous suggestions.

**E. Promoting “clean” and efficient technologies** for energy transformation such as fuel cells is given a special consideration. A summary of a research work using CFD (computational fluid dynamics) is presented.

**F. Promoting “un-conventional” technologies in combination with chemical additives, insulation and other current practices** for minimizing the negative effect of fouling of heat exchangers.

and further foster and respond to individual and group concerns. There are no immediate solutions, yet we will help to find both general and particular answer to our major energy-related concerns. Due to limited space, we selected just a few of your comments, please join us during November 16th IMECE Sessions and luncheon for further debates.

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### 1. What are you currently doing to prepare for, or adapt to, the high prices of oil and gas?

- ✓ We are currently not doing anything in this facility.
- ✓ From a personal standpoint, my wife and I are currently in the market for a new car. Fuel economy has definitely become one of the highest priorities in our selection process (A.E. - COS)
- ✓ Cheering, drinking Champaign and buying shares in Syncrude (I.R. - RTC)  
PID note: the comment is probably offered by an associate of one of the big oil producer -
- ✓ Buy more Hummers (I.R. - RTC)
- ✓ Our heating and air conditioning equipment are extensively using the heat pump principle and this contributes in a great extent to compensate the negative effect of higher energy prices. (G.L.)
- ✓ For the longer term, we need to encourage greater use of coal, and again review the options for nuclear energy for power generation (G.L.)
- ✓ Hybrid cars and trucks appear to offer great promise for energy conservation and as consumers we should show greater interest in such prospects (G.L.)
- ✓ My only responsibility is to up date the projected energy costs in every project I do (W.E.B.)
- ✓ The high oil prices are due to indiscriminate use of (non-renewable) energy sources (oil & Gas). We are presently developing several renewable energy systems (solar) to recover the acid (HCl) from spent liquor (pulp & paper industry) using the made in USA Energy Technologies solar glasses with electronic grade iron oxide (N.P)
- ✓ Use of recuperators in furnaces Kilns to save up to 30% fuel and use of hot air burners for further saving (N.P)
- ✓ From a business standpoint, my company, an engineering contractor, is going through a major diversification process from downstream (petro-chemical) markets to upstream (oil and gas production and LNG) markets (E.C.-ABB)
- ✓ We don't have enough vehicles that this makes a big impact. I'm sure our service branches are doing something (A.E. - COS)

### 2. What can PID do to assist you in this area?

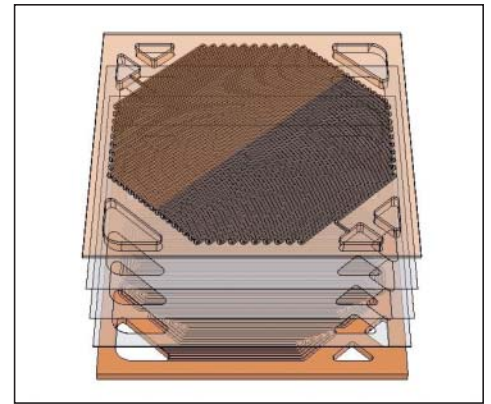
- ✓ It is extremely important to support government officials in favor of exploring and developing new sources of oil and gas production in North America and decrease the dependence on foreign oil (E.C. - ABB) -

**PID note:** see also the 2003 PID's Newsletter and web sites : <http://www.cepmagazine.org/pdf/120140.pdf> and [http://www.osti.gov/bridge/product.biblio.jsp?osti\\_id=824856](http://www.osti.gov/bridge/product.biblio.jsp?osti_id=824856) (HIVAC) and consult Industrial Technologies Program Office of Energy Efficiency and Renewable Energy - U.S. Department of Energy at <http://www.ceeformt.org/ind/oit-pubs.pdf> also <http://www.oit.doe.gov/bestpractices/>

- ✓ I don't Know (A.E. - COS)
- ✓ One suggestion is for PID to report on the progress of alternative power Sources (E.C.-ABB)
- ✓ The need for evaluating efficiency becomes more critical in designing, building, and operating process plants (E.C).
- ✓ It would be interesting to do a study on the impact of oil and gas prices on plant operating costs (E.C.)
- ✓ How does the efficiency of the equipment affect operating cost today compared to years past? (E.C.-ABB)
- ✓ Create more emphasis on the alternatives mentioned above by encouraging articles and technical presentations (G.L.)
- ✓ My only thought here is to publish energy related items and cost projections (W.E.B.)
- ✓ PID should create a data bank of manufacturers of energy saving / renewable energy solutions and a list of users of bulk fuel who would like to reduce fuel consumption - "N.P" is prepared to help (N.P)

### E. Promoting "clean" and efficient technologies - Today: The Fuel Cell

By: Steven Beale PID  
(E-mail: [steven.beale@nrc.ca](mailto:steven.beale@nrc.ca))  
Chair, Heat Exchangers Technical Committee Group leader, Institute for Chemical Process and Environmental Technology, NRC - Canada



### Ballard Mark V PEMFC

Fuel cells have become the subject of much interest as a potential low-carbon-fuel substitute for conventional heat engines. Researchers at the Institute of Chemical Process and Environmental Technology at the National Research Council (NRC) in Ottawa, Canada have been using commercial CFD, and writing in-house codes to model fuel cells for more than 5 years. A fuel cell is an electrochemical device, which converts hydrogen-rich fuel and oxygen to electricity and heat. Similar-to, yet-different from a battery in that a fuel cell does not require re-charging, fuel cells are operated in stacks to increase the operating voltage. NRC/ICPET research is primarily directed towards both high-temperature solid oxide fuel cells (SOFC's) and low temperature proton exchange membrane fuel cells (PEMFC's). In both cases, the temperature distribution is critical to successful operation

The main problem with conventional CFD approaches is the enormous mesh sizes required to perform flow-field calculations within the numerous passages of the fuel cell and especially in stacks of fuel cells. What makes the fuel cell interesting to model developer is the interaction between transport and electro-chemical phenomena. NRC scientists and are using volume averaging techniques, originally developed to model fluid flow and heat and mass transfer in shell-and-tube heat exchangers, to perform calculations for fuel cells.

However, hydrogen fuel cells are more complex than heat exchangers. Electric field potential is affected by three main factors; (i) charge transfer also known as activation potential/overpotential, ie kinetic losses, which occur at low current densities, (ii) Losses associated with Joule heating in the ionic and electronic conductors at intermediate currents, and (iii) mass transfer limitations in the gas passages and

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porous diffusion layers which can be very important at high current densities. Thus it is necessary to include iterative computations for the electric field and current density which are non-linear functions of temperature and mass fraction of fuel and oxidant, as part of the overall calculation procedure.

Results for the NRC-developed models have been carefully validated against detailed simulations using very fine meshes. In addition, a comprehensive combined experimental/numerical capability; employing fuel cell designs in the public domain to provide benchmarks for the development of future numerical tools is now used to construct virtual prototypes for this exciting new process-technology industry.

### F. Promoting and researching for "un-conventional" effective technologies Today: The Magnetic Devices

The influence of a continuous (DC) or alternating (AC) magnetic field on the rate of transport (momentum, concentration, and mass) is a subject of controversial debates and challenging scientific proof. There are vast oil reserves at our doorstep (Gulf of Mexico), reserves almost impossi-

ble to be produced due to high content of paraffin creating congealing conditions, well above the seabed temperature. In addition, the mixture of water, carbon dioxide at seabed temperature-pressure condition creates solid hydrates, another plague of the off-shore oil industry. The injection of chemical additives (to reduce the congealing temperature conditions for crystallized paraffin) and methanol, to dissolve hydrates plugs costs the oil industry many cents for each barrel of oil (e.g. frequent pigging and additives presently used for a pipeline transporting paraffin oil in Sudan totalizes approximately \$us16 Millions/year or more than 16c/barrel of crude). In addition, a day of flow interruption is evaluated at a few \$us millions. The excess of chemical additives and their impact on refining and environment is rarely considered in the balance of operation costs and risk.

Similar fouling problems described for upstream section of the oil industry are equally impacting the downstream, refinery industry segment. They include both refinery equipment and water purification equipment reaching thousands of cubic meters an hour in some remote locations. Re-injection of water resulting after separation of water is not anymore an option in many land or off-shore locations.

Here the end users, manufacturers of magnetic devices (such as : <http://www.magnetizer.com/>), energy (oil and gas) companies and academic and applied research organizations can find a vast territory open to new ideas and improvement. Recently, PID, during the Annual IMECE and regional or dedicated meetings, has presented research results indicating that permanent magnets may improve the efficiency of a refrigeration cycle. While the optimal placement of a magnetic field and its threshold intensity can be relatively easy adjusted and pinpointed for a refrigeration cycle, in such a way that nucleation and evaporation heat transfer can be positively influenced, this is sometimes complicated when dealing with complexity and variability encountered in the oil industry.

Yet, a recent research work completed at the Alberta Research Council, in Edmonton Canada and published (Chow, R., Sawatzky, R., Henry, D. , Babchin, A , Wang, Y. Cherney, L. and Humhreys, R. - Precipitation of Wax From Crude Oil Under the Influence of a Magnetic Field, JCPT, June 200, v.39, No.6, pp. 56-61), as well as yet un-published but very promising research performed by a group of scientists at ICP-ECOPETROL, Columbia, Bucaramanga, suggests that the magnetic field properly applied can have a measurable effect on precipitation (of waxy crude). According to the ARC's research team: The key concept motivating the work presented in this paper is that the presence of a magnetic field can alter the kinetics of precipitation of wax crystals from crude oil. According to this hypothesis, it is only precipitation kinetics that are involved; equilibrium thermodynamic properties such as the wax out temperature and the solubility of wax in the oil are not affected by the presence of a magnetic field. Two major implications arise from this concept:

1. the presence of the magnetic field does not cause wax to precipitate from solution in the oil;
2. in order to have an effect on wax precipitation, the magnetic field must be applied while the crude oil is saturated or super-saturated with wax

Fundamental and practical implications resulting from these conclusions may be extended to a large class of fouling under magnetic field and generate a new class of application designs. ■

## PID - Serving Mechanical Engineers Around The World

In the New-Old Process Industries Areas - An open platform of communication exchange (7880 Members in 2003)

### Vision:

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

1. Compressor Applications
2. Heat Exchangers
3. Industrial Water Technologies
4. Low Temperature 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 Associates Industries,
4. Foster and encourage cross-fertilization through partnerships and group discussions - achieve individual and group pre-eminence,
5. Wise and prudent management of PID's human and monetary resources needed to stimulate these goals.



## PID Sponsored Sessions in IMECE 2004

(for details see: <http://www.asmeconferences.org/Congress04/TechnicalProgramOverview.cfm#31>)

Program Co-Representative: Arun Muley, *Honeywell International*

Group Representative: Michael Ohadi

Innovations in process, design, manufacture and operations of wide spectrum of cryogenics equipment

Innovative heat exchanger design and thermal systems for automotive, aerospace, power, fuel cell, chemical process, among several others

Topic Organizer: Ahmad Fakheri, *Bradley University*

Topic Co-Organizer: Steven Beale, *National Research Council of Canada*

### PID-6 Higher Oil Prices and the Opportunity for Alternative Energy (Panel Session)

**Session Description:** This panel includes presentations from recognized speakers in the fields of energy, oil & gas industries. There will be short presentations by the five participants, followed by questions and discussions.

**Session Schedule:** Tuesday, November 16, 2004 **09:30 AM-11:00 AM**

**Session Organizer:** Michael Ohadi

**IMECE2004-62745** Energy Conservation via Enhanced Heat Transfer • Panel

**IMECE2004-62746** Oil Price Increases and The Energy Industry: What Role for the Majors? • Panel

**IMECE2004-62747** High-Temperature Heat Exchangers For Energy Savings • Panel

**IMECE2004-62748** Improving Energy Utilization in Industrial Facilities Through the Use of New Technologies and Heat Recovery • Panel

### PID-7 Heat Transfer in Heat Exchangers III (Technical Session)

**Session Schedule:** Tuesday, November 16, 2004 **11:15 AM-12:45 PM**

**Session Organizer:** Arun Muley, *Honeywell International*

**Session Co-Chair:** Ahmad Fakheri, *Bradley University*

Novel compressor design and performance evaluation methods including experimental investigation and numerical simulation; mechanical and aero/gasdynamical aspects of all industrial compressors, pipeline compressors and wave rotors

Topic Organizer: Norbert Mueller, *Michigan State University*

### PID-1 Compressor Application I: CFD (Technical Session)

**Session Schedule:** Sunday, November 14, 2004 **02:00 PM-03:30 PM**

### PID-2 Compressor Application II: Design & Performance (Technical Session)

**Session Schedule:** Sunday, November 14, 2004 **03:45 PM-05:15 PM**

**Session Sponsors:**

**Session Organizer:** Ahmed Abdelwahab, *Praxair Inc.*

**Session Co-Chair:** Abraham Engeda, *Michigan State University*

### PID-3 Wave Rotor Technology I: Review & CFD (Technical Session)

**Session Schedule:** Monday, November 15, 2004 **07:45 AM-09:15 AM**

### PID-4 Wave Rotor Technology II: Design (Technical Session)

**Session Schedule:** Monday, November 15, 2004 **02:00 PM-03:30 PM**

### PID-5 Wave Rotor Technology III: Application (Technical Session)

**Session Schedule:** Monday, November 15, 2004 **03:45 PM-05:15 PM**

## Solution to Fall 03 Mental Exercises

A. Fakheri, [ahmad@bradley.edu](mailto:ahmad@bradley.edu)

Thanks for all the correct answers. Although we received correct responses from across the country and even a few from South America, Middle East, and Europe, unfortunately, we did not get 50 correct answers to either of the problems, and regrettably no winners.

1. List all three digit numbers which are equal to the sum of the cubes of their three digits.

**Solution-** 153, 370, 371, 407, (0 may also be considered a solution)

These numbers are called narcissistic numbers, or Armstrong numbers or perfect digital invariant. (<http://mathworld.wolfram.com/NarcissisticNumber.html>)

2. A large water tank has two inlet pipes (a large one and a small one) and one outlet pipe. It takes one hour to fill the tank with the large inlet pipe, and 5 hours to fill the tank with the small inlet pipe. The outlet pipe allows the full tank to be emptied in 6 hours. If all three pipes are in operation how long (in minutes) will it take for the tank (initially empty) to become half full.

**Solution-** If represent the mass flow rates and the amount mass in the tank when full, then from the law of conservation of mass, the rate of increase of mass in the tank is given by

$$\frac{dm}{dt} = m_1 + m_2 - m_3$$

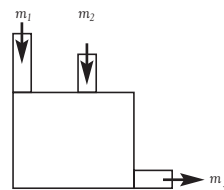
$$m_f = m_1 = 5m_2 = 6m_3$$

$$\frac{dm}{dt} = 5m_2 + m_2 - \frac{5}{6}m_2 = \frac{31}{6}m_2$$

$$m_f = \frac{31}{6}m_2 t$$

$$m_f = 5m_2 = \frac{31}{6}m_2 t$$

$$t = \frac{30}{31} \text{ hrs} = 58.06 \text{ min}$$



The time for the tank to become half full is half this much or 29.03 minutes. This assumes that the exit mass flow rate is constant, which probably is not accurate as changes with changing fluid level in the tank.

### The First and Second Principles of Thermodynamics and Daily Life

Mental Exercises (reference: Thermodynamics - An Engineering Approach by Y. Cengel and M. Boles - Ed. 3rd - McGraw-Hill, 1998/ chapter 7 - Exergy: A Measure of Work Potential)

Two refrigeration machines are offered to two different clients, both requiring the same cooling load: 1 MJ/h; both locations have similar air cooling conditions (for condenser) say +35 C.

- one client needs the cooling for a chemical process to be maintained at -20 C,
- the other needs crushed ice.

Q1. Let's assume a refrigeration system using reciprocating compressors and an electrical motor as a mover is offered, which client will need more power? "a" or "b"? - and why?

Q2. Before signing the contract, the client "a" indicates that he has a sizable amount of waste steam available and asks for an absorption refrigeration (water-ammonia) system to be considered and priced. The salesman indicates that the coefficient of performance (ratio between the electrical power expressed in kJ/h and refrigeration load - indicated above) is 0.3 for its very efficient compressor machine, while the same ratio (expressed as the ratio between the heat used for the stripper and the refrigeration load) is almost 1.1 for the absorption unit - a difference of almost three times in favor of the compression unit; he suggests the buyer to find a better use for his "waste steam".

Where is the fallacy? (Help: We need to use the second-principle and exergy balance to discover it).

# PROCESS INDUSTRIES DIVISION

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## International Symposium continued from page one

numerical methods for daily use of industry in the area of heat exchangers.

Active participation of industry, academics and of numerical program developers is required to discuss needs, trends and problems in the area of numerical simulation applied to conventional and to new heat exchangers applications.

These include but are not limited to:

- Multi-phase flow and phase change issues
- Characterization[PRT2] of free-stream, low Reynolds number turbulence and transition
- Conjugate heat transfer and enhanced surfaces
- Transient and periodic flows
- Meshing complex enhanced surface geometries
- Computer memory/size/speed limitations and algorithm optimization

User-friendly new software for heat exchangers - advantages and limitations Fouling

- Fluid-structural interactions
- Experimental validation

We invite participation in the 1st ASME International Symposium on Computational Methods for Heat Exchanger Design:

Who should attend?

- Engineers and designers of process equipment
- Software development companies
- Heat exchanger equipment manufacturers
- Vendors of heat exchanger and CFD software
- Research engineers and students

For further information: Contact: [steven.beale@nrc.ca](mailto:steven.beale@nrc.ca) ■