HTRI
The Exchanger
Issue 1 • 2015

STREAM ANALYSIS REVISITED

Proposed changes to STREAM ANALYSIS promise to provide more accurate extrapolation and a more consistent basis for different exchanger configurations.

HTRI
The Exchanger
Issue 1 • 2015

In this issue...

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The **Deep** Bench

Claudette D. Beyer
President & CEO

As all companies do, HTRI experiences the ups and downs of the normal business cycle. Market forces beyond our control impact nearly every aspect of our operations at some point. Dealing with these forces—taking advantage of the ups and weathering the downs—requires that we remain vigilant and that we adopt effective practices and strategies.

A key strategy for us is to work with the most talented people we can find. This is true whether we're engaging a consultant, choosing a vendor, working with member volunteers, or hiring staff. As technology has advanced, we've been able to find these people in more places, not just where our offices happen to be. HTRI has a global workforce, despite its relatively small size, and that is a crucial advantage.

There's a sports term in the United States for teams that have not just a few star players, but a full complement of talented contributors: a deep bench. It's not enough for a team, or a company, to have just one or two key people. To be successful over the long term, to deal with the ups and downs over multiple decades, companies must build a deep bench.

We continue to look to the future–and innovative ways of bringing new talent to the company, new products to market, and ever increasing value to our customers. We are forging alliances, engaging academia, aligning with complementary organizations and, as always, relying on the power of the consortium to further the state of the art in thermal process technology.

I am grateful for our talented and determined staff, academic colleagues, consultants, and volunteers who all contribute so much to HTRI's success. We do indeed enjoy a deep bench.

RTC UPDATE

We are in the midst of a large capital investment to **improve and expand our experimental research program.**

J. Michael Creagor
Associate Vice President,
RTC & Facilities
Operations

Thomas G. Lestina
Vice President,
Research &
Engineering Services

Commissioning the Liquid-Liquid Heat Exchanger test rig, followed by 14 audit and certification tests for The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certification program

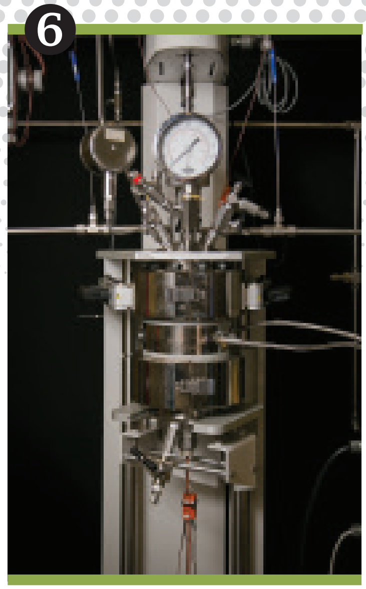
HTRI performs AHRI certification testing for liquid-to-liquid heat exchangers, in accordance with the Standard 400 and Certification Operations Manual

Purchasing and installing a 60-ton chiller, which will expand the test temperature ranges of our current rigs

Installing and commissioning the shellside test section for the Low Pressure Condensation Unit, which has a window for visualization studies

Constructing and commissioning the second High Temperature Fouling Unit to increase the capacity of our crude oil fouling test program

Fabricating and commissioning the Pipe Flow Loop for two-phase flow regimes in thermosiphon piping



Shakedown testing of the new Rotating Fouling Unit, which will provide screening test results for crude oil fouling studies

Installing and shakedown testing of the new thermosiphon reboiler in the Prototype Test Unit

Planning single-phase and boiling tests with the new Tranter shell-and-plate welded heat exchanger

We look forward to all of the research results from these investments.

Changes to

STREAM ANALYSIS

In the 1960s, HTRI introduced our version of stream analysis, which represented a step change in shellside pressure drop and heat transfer prediction accuracy. As **HTRI undertakes refactoring its software code**, we will address the limitations that exist in our current Stream Analysis Method.

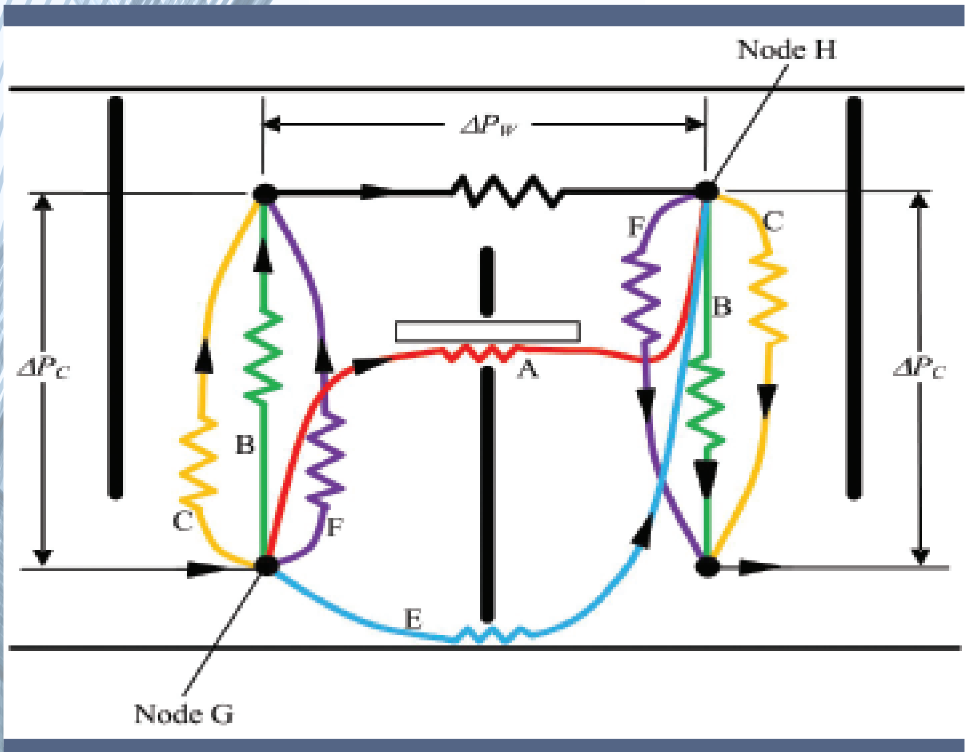


Figure1. Current stream analysis resistance model

Figure 1 illustrates the current stream analysis model. The different flow paths are represented as a resistance network between a point in the window region of a baffle space and a similar point in the window region of the next downstream baffle space. The resistors are the flow resistances for the crossflow, bypass, window, and leakage streams. With the flow resistance correlations tuned to "typical" exchanger configurations, stream analysis is used to predict pressure drop and provide flow velocities for heat transfer correlations. These correlations cover a wide range of fluid conditions and exchanger geometries.

HTRI shellside flow methods currently require three separate stream analysis models to handle segmental, double-segmental, and NTIW arrangements. Tubes removed under nozzles are accounted for; however, the methods have shortcomings, especially if the tube removal is asymmetric. Furthermore, current HTRI resistance correlations are interrelated and empirical. It is difficult to modify and improve local resistance methods without the risk of disturbing the overall model.

Joseph E. Schroeder
Consultant

M. Kyle Ross
Senior Project Engineer,
Engineering Services

The proposed method promises more accurate extrapolation for different exchanger configurations.

The existing limitations to our current Stream Analysis Method are the result of simplifications used when devising the original model. For example, the model in **Figure 1** assumes that all shellside flow passes through an upstream window (with a pressure equal to Node G) and divides among parallel paths that converge in the next window (at a pressure equal to Node H). In reality, there is leakage flow from the baffle to the left of Node G. Furthermore, the A- and E-streams do not flow upstream to Node H after passing across the baffle.

Today, our CFD and flow visualization tools offer great insight into defining local resistances and mixing effects. The proposed Stream Analysis Method will be better equipped to incorporate the insights learned with these tools. Additionally, the proposed method promises to provide more accurate extrapolation and a more consistent basis for different exchanger configurations.

EXTENDING THE REACH OF HTRI TRAINING

Shannon F. Iverson
Coordinator, Training

When you think of training and HTRI, you probably think about workshops, short courses, and webinars–content that we have developed to help you use our products more effectively and understand our research more thoroughly. HTRI often receives requests for training on basic heat exchanger design to assist with onboarding of recent graduates. We are often challenged by a wide variation of engineering and HTRI experience within a group of attendees in a single workshop. HTRI training reaches a broad audience throughout the HTRI membership. As we continue to expand our offerings, we determined a way to provide additional content to the HTRI membership while reaching beyond to a wider group. To help level the field and broaden our audience, we are introducing two new training products at HTRI:

online, video-based tutorials and the **HTRI Heat Transfer Academy.**

We have posted a series of short, video-based tutorials to the HTRI website: ***X****changer Suite* Basics, ***X****changer Suite* Power Users, ***X****ist* Getting Started, and ***X****ace* Getting Started. These tutorials are approximately one to three minutes in length and are focused on how to efficiently use ***X****changer Suite*.

The **HTRI Heat Transfer Academy** is an online portal to house informational reports, tutorials, and practical explanations for how thermal process research is applied in the field. To date, we have posted a paper on surface roughness, simple rules-of-thumb for heat exchanger cost comparisons, and a review, with 3D animation, of incrementation analysis. We are developing infographics for reading lists to help engineers learn more about heat transfer and HTRI. The Heat Transfer Academy will help bridge the gap between college and industry. In spring 2015, we will host live webinars to give engineering students a real-world perspective of how engineering research and theory can be practically applied in the workforce. These webinars are meant to complement the materials that heat transfer professors provide in the undergraduate university curriculum.

All of these materials are meant to be timely and relevant, and are developed by HTRI subject matter experts with decades of HTRI and engineering experience, incorporating insight, expertise, and best-in-class quality that only HTRI can provide.

DISTRIBUTING and COLLECTING

Kevin J. Farrell
Director, Computational Simulation & Optical Anemometry

Probably the most fundamental relationship in process heat transfer is that duty equals the product of the overall heat transfer coefficient, *U*; the area for heat exchange, *A*; and the temperature difference. Generally, the process conditions determine the required duty and temperature difference. We use engineering skills to design an affordable, reliable exchanger that provides the required *U A* product.

The laws of physics always limit the magnitude of the heat transfer coefficient. Therefore, to meet the required duty with this limitation on *U*, we add surface area. For the heat exchanger area to become effective, fluid parcels of each stream must come in thermal contact across the boundary that divides them.

Essentially, hot and cold streams must be distributed uniformly when entering the exchanger and then collected afterwards for transport to the next operation in the process, all while minimizing the pressure drop and cost. Unfortunately, each tube or tube gap does not generally contain an equal share of the flow, so this nonuniformity, or *maldistribution*, is a potential problem in almost all heat exchangers with multiple parallel flow paths.

Flow maldistribution can be exacerbated by

- **operating conditions (viscosity- or buoyancy-induced stratifications, multiphase flow, or fouling)**

  For example, in a vaporizer, a retarded flow in one tube may increase the vapor generation rate leading to a higher pressure drop and further reducing the flow. Maldistribution can be particularly problematic when most of the pressure drop occurs in a two-phase region.

- **geometry (configuration, manufacturing variations, or tolerances)**

  For example, in a header, the high dynamic pressure of the nozzle flow often produces nonuniform pressure and thus nonuniform flow distribution. In a manifold of uniform cross section discharging to the atmosphere, there is static pressure recovery along the length as flow is extracted from each branch. The last branch then receives the greatest flow rate.

Minimizing maldistribution is an important enabling technology for efficient process heat transfer and will continue to garner the attention of HTRI research activities.

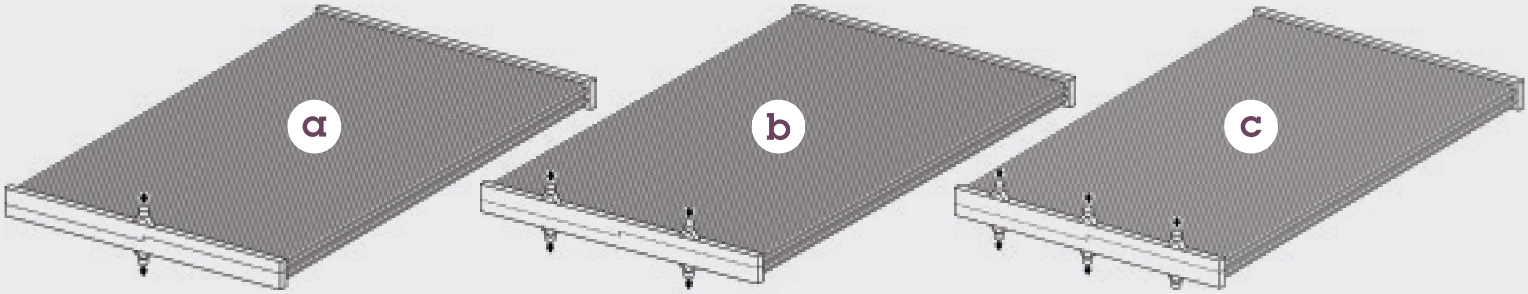


Figure 1. Headers with (**a**) one inlet and exit nozzle, (**b**) two inlet and exit nozzles, and (**c**) three inlet and exit nozzles

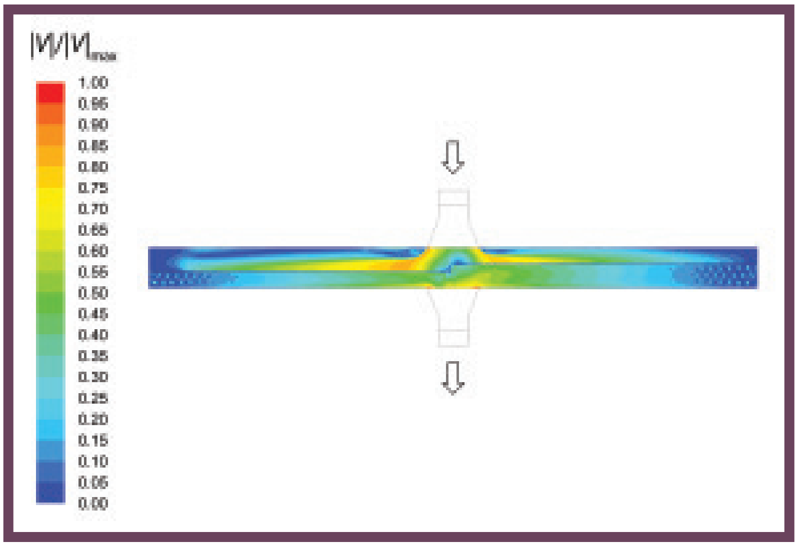


Figure 2. Contours of velocity magnitude in the combined inlet/outlet header

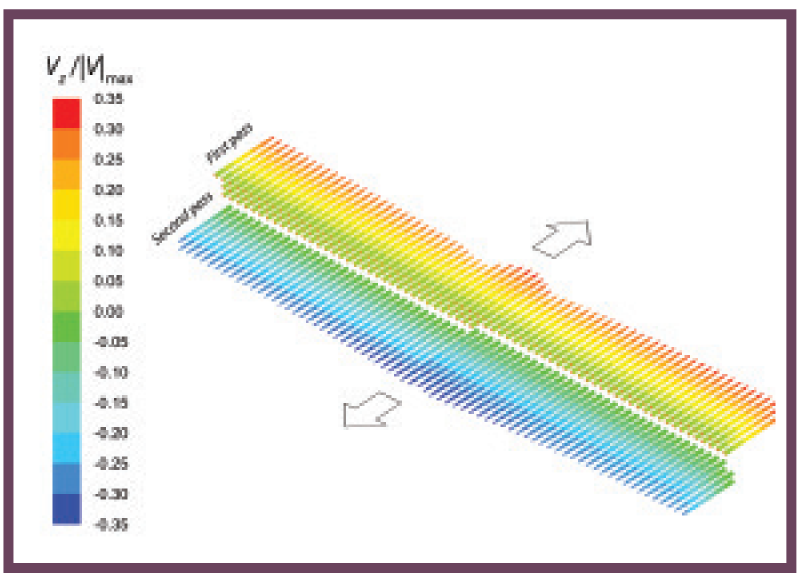


Figure 3. Profile contours illustrate the axial velocity in each tube of each pass in the middle of the bundle shown in Figure 1a

Over the last decade or so, we have used computational fluid dynamics (CFD) simulations to study flow distribution issues within various regions and types of shell-and-tube exchangers (*see publications list*). HTRI is also very interested in studying the flow distribution in other types of exchangers, like API air coolers and plate-and-frame exchangers.

With that objective, HTRI contracted with the Institute of Process and Environmental Engineering at the Brno University of Technology, Czech Republic, to provide CFD simulations of the tubeside flow in a two-pass air cooler with several nozzle arrangements (as shown in **Figure 1**).

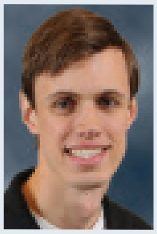
The simulations provide the pressure and velocity distribution in the inlet and outlet headers (**Figure 2**) as well as in each tube. The tubes in the middle of the bundle, where the pressure gradient is greater, have larger flow rates than those at the end (**Figure 3**). A careful review of the CFD simulations of each of the header configurations in **Figure 1** provides valuable insight on header configurations that satisfy design objectives and constraints.

HTRI STUDIES OF FLOW DISTRIBUTION

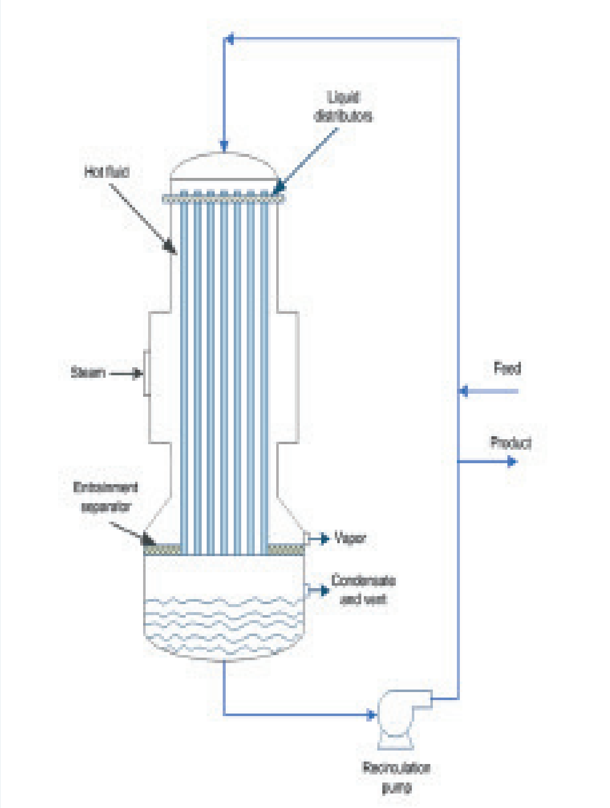
***Q* 10-1**	The benefits of numerical design optimization (2006)
STG-13	Computational fluid dynamics study of impingement plates (2002)
STG-17	Annular distributors: A parametric design study (2005)
STG-18	Using perforated plates to improve flow distribution in X shells (2013)
STG-19	Design guidance for impingement rods (2014)
S-SS-3-14	CFD study of NTIW bundles (2004)
S-SS-3-16	CFD study of flow distribution in TEMA X shells (2004)
S-SS-3-18	CFD simulations of single-phase turbulent shellside flow (2008)
S-SS-3-21	Disk-and-doughnut baffled heat exchangers: CFD simulations and methods (2010)
S-SS-3-22	Stream analysis in a single-segmentally baffled exchanger: CFD vs. *Xist* (2011)
S-SS-3-25	Analysis of NTIW shellside performance using CFD and *Xist* (2013)

Keeping Up with the Times: Falling Film Evaporators

Falling film evaporators (FFEs) are typically used to concentrate products that are sensitive to heat from an evaporating liquid. The evaporation occurs on the surface of the film, not the surface of the tube. Due to the presence of a thin liquid film, FFEs can maintain a low temperature difference along with a high heat transfer rate.



Matt Lane
Engineer,
Research



Simplified drawing of a falling film evaporator

Common processes performed by FFEs include

- desalinization of sea water
- recovery of small amounts of product from high boiling tars
- concentration of urea and ammonium nitrate
- black liquor evaporation when converting wood to wood pulp
- concentration of fruit juice

***X**changer Suite* 7.1 includes a heat transfer model for vertical intube FFEs, mostly based on a method developed at Lehigh University in the 1990s.

To update ***X**changer Suite*, HTRI has compiled experimental data from the literature and is investigating additional correlations for heat transfer and pressure drop in vertical FFEs. We also plan to

- investigate new features (Convective Only and Convective + Nucleate options) for FFE modeling in our software
- collect pressure drop data
- provide an option for liquid-vapor countercurrent flow
- improve predictions of liquid film breakdown
- improve heat transfer for wide boiling range mixtures

FOR FURTHER READING

J. C. Chen, T. Palmer, and K. Tuzla, **Falling film evaporation of ultra-viscous fluids,** BT-16, Heat Transfer Research, Inc., College Station, TX (1999).

P. E. Minton, ***Handbook of Evaporation Technology,*** 1st ed., Noyes, Park Ridge, NJ (1986).

A. C. Mueller, **Falling film vaporizers,** BT-5, Heat Transfer Research, Inc., College Station, TX (1980).

M. Johansson, I. Leifer, L. Vamling, and L. Olausson, **Falling film hydrodynamics of black liquor under evaporative conditions,** *Intl. J. Heat Mass Transfer* **52**(11 – 12), 2769 – 2778 (2009).

J. S. Prost, M. T. González, and M. J. Urbicain, **Determination and correlation of heat transfer coefficients in a falling film evaporator**, *J. Food Eng.* **73**(4), 320 – 326 (2006).

WHY VISCOSITY IS IMPORTANT in HEAT TRANSFER

Siddharth Talapatra
Engineer, Research

Viscosity is the measure of a fluid's resistance to flow. Water is about 100 times more viscous than air, so wading through knee-deep water is much more difficult than walking on a dry surface.

This resistance to motion is quantified through the viscosity coefficient, μ. It is defined as the ratio of the shear stress over the shear strain rate: $\tau = \mu Y$. For a Newtonian fluid, μ is a material property just like density; for a non-Newtonian fluid, μ may depend on the applied shear strain (shear thickening/thinning) or the time duration that the stress has been applied. One example of a shear thickening fluid is corn starch mixed in water. When stirred slowly, the mixture has a milky texture, but when stirred vigorously, it becomes very viscous. Fortunately for engineers, a majority of applications involve Newtonian fluids, allowing us to consider μ simply as a material property.

Why is viscosity important to heat transfer?

First, viscosity impacts the velocity distribution and rate of momentum diffusion (a measure of how well mixed a flow is). As a result, viscosity affects convective heat transfer, often the dominant heat transfer mechanism for fluids.

Correlations for convective heat transfer are expressed in terms of the Nusselt number, Nu, which is a function of the flow geometry, entrance length, process conditions, and three dimensionless numbers: Re, Pr, and Gr. All of these numbers have a viscosity dependence: $Re \sim \mu^{-1}$, $Pr \sim \mu$, and $Gr \sim \mu^{-2}$.

Under conditions of forced convection, Nu depends only on Re and Pr; when natural convection becomes important, Nu also depends on Gr. The ratio of convective and buoyancy forces, defined as Gr/Re^2, dictates whether or not natural convection plays a significant role. If this ratio is less than 10, natural convection becomes important. Interestingly, Gr/Re^2 is independent of μ, so that the transition criterion from forced to mixed convection has no viscosity dependence.

Second, μ varies due to heating and cooling, which impacts the velocity profile of the flow. Heating usually makes the fluid near a wall less viscous, so the flow profile can become more plug-like. Cooling has the opposite effect, increasing the viscosity near the wall and impeding heat transfer. The effect is most pronounced for viscous flows with large wall-bulk temperature differences. To incorporate these effects, the common approach is to apply a correction factor to the expression for Nu, which for liquids is $(\mu / \mu_{wall})^m$, where m is 0.11 for heating and 0.167 for cooling.

Isolating the effects of viscosity on heat transfer isn't easily done. Compared to a thin liquid (like water), a thick liquid (like honey) has a higher viscosity and most likely a different density, thermal conductivity, and heat capacity, each of which impacts heat transfer in different ways.

But we can make some qualitative assertions about the impact viscosity has on heat transfer.

- A very viscous fluid offers higher resistance to forces that drive the flow. Such fluids are likely to be more sluggish, resulting in laminar flow, less mixing, and thus less convective heat transfer.
- A high μ also implies a high Pr, which indicates that momentum diffusion is more effective than thermal diffusion (conduction) for heat transfer. So for two fluids with the same conductivity, the one with a higher Pr has a higher heat transfer coefficient.
- When natural convection becomes important, a correction factor is applied to expressions for Nu, which have been predominantly developed based on forced convection mechanisms alone. Typically, this factor is dependent on Gr ($\sim \mu^{-2}$) or on Gr/Re^2 ($\sim \mu^0$). In the first case, a high μ usually reduces Nu, while for the latter, viscosity does not play a role.
- For liquids, the stronger the dependence of μ on temperature, the higher the difference between heat transfer coefficients for cooling and heating services.

HTRI commonly studies fluids with a wide range of viscosities. Recent experiments concern highly viscous fluids, both for tubeside and shellside flows. Some common consequences of high viscosity are laminar flow and flow stratification, which can adversely affect the rate of heat transfer. HTRI plans to continue such research and to study newer topics such as non-Newtonian heat transfer.

RECENTLY PUBLISHED

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TECHNICAL REPORTS

BX-15	Boiling Outside Low-finned Tubes
BX-16	Crossflow Boiling of Fluids with Noncondensable Gas
CT-36	Horizontal Intube Condensation Heat Transfer and Pressure Drop of Propane
F-23	A Review of Predictive Models for Crude Oil Fouling
S-SS-3-26	Crossflow Mixed Convection Heat Transfer for Horizontal Tube Banks
S-SS-3-27	A Review of the A-stream Model of the Stream Analysis Method
STG-19	Design Guidance for Impingement Rods
TE-6	Correlations for Heat Transfer and Pressure Drop of Tube Inserts in Single-phase Turbulent Swirl Flow
TPF-10	Intube Pressure Drop Across Changes in Cross-sectional Area
TPF-11	Pressure Drop in Bends: A Reappraisal

WEBINAR RECORDINGS

- Getting Started: Building Your First Case in *Xpfe*
- Research Update: Modeling Flow Distribution in Manifolds and Headers
- Research Update: Maldistribution in Shellside Laminar Viscous Flow
- Research Update: Crossflow Mixed Convection Heat Transfer for Horizontal Tube Banks
- Research Update: Two-phase Pressure Drop Across Changes in Cross-sectional Area
- Research Update: Condensation Heat Transfer and Pressure Drop Measurement for Pure Hydrocarbons and Mixtures in Plain Tubes
- TechTip: Effectively Selecting Physical Properties in *Xchanger Suite*
- TechTip: Using the HTRI Parametric Study Tool

And others!

UPCOMING EVENTS

TRADESHOWS/EXPOS
WEBINARS
TRAINING
CONFERENCES

TRAINING

HTRI Training – Europe
March 10 – 12, 2015
The Westin Valencia • Valencia, Spain

HTRI Training – Europe
November 24 – 26, 2015
Crowne Plaza Amsterdam City Centre • Amsterdam, The Netherlands

TRADESHOW/EXPO

China International Petroleum & Petrochemical Technology and Equipment Exhibition (CIPPE 2015)
March 26 – 28, 2015
New China International Exhibition Center • Beijing, China
HTRI will exhibit in booth W1552 (Hall W1)

CONFERENCE

HTRI 2015 Global Conference and Annual Meeting of Stockholders
September 21 – 25, 2015
The Ritz-Carlton, St. Louis • St. Louis, Missouri, USA

Visit www.htri.net for more event information.

WORD SEARCH

Say What?

Our puzzle computer made this word search from a list of heat transfer terms, but the voice recognition system misheard all of the clues. See if you can find the real terms.

P	J	F	C	R	I	F	L	T	D	N	A	R	P	T	R
R	A	L	O	A	M	I	T	A	E	L	C	U	N	N	A
A	C	U	N	N	N	J	A	C	K	E	T	E	D	E	D
B	K	X	V	I	T	U	C	E	A	C	R	C	C	L	I
O	E	E	E	M	U	B	C	C	N	N	O	O	T	U	A
I	T	L	C	A	R	L	O	L	O	H	N	N	P	B	T
L	A	U	T	L	B	N	S	I	E	D	A	V	D	R	I
I	S	B	I	H	D	P	T	G	E	A	G	E	C	U	C
N	N	R	O	E	I	A	E	N	E	N	T	S	D	T	O
G	E	U	N	R	I	N	S	L	I	A	I	I	T	J	N
O	D	T	A	D	H	A	C	L	R	V	P	F	O	U	D
I	N	L	A	A	T	U	U	C	N	A	H	N	E	N	U
D	O	R	N	I	N	O	U	T	U	B	E	M	A	L	C
A	C	C	O	P	F	A	C	O	N	V	E	C	T	I	K
R	E	N	H	S	C	O	N	D	U	C	T	I	O	N	I
D	P	K	C	A	J	Y	T	I	S	O	C	S	I	V	B

BOWLING
CONDEMNATION
OBSTRUCTION
CONVOCATION
ENTRANCED TUBES
HEAT **FLEX**
RUDE OWL **GROWLING**
JACKET AND PIPE
LAMINATED FLOW
NEW CREATION POINT
PRANCER NUMBER
RAIDED NATION
SPIROGRAPH EXCHANGER
TURBOCHARGED FLOW
YOUTUBE
DISCO CITY

See solution on page 19

David J. Evans
Manager, Technical Support

LESSONS LEARNED from ENGINEERING SERVICES

From inquiries submitted to HTRI Technical Support about ***X****changer Suite*, we typically select a few topics to discuss in detail at the Global Conference. At the 2014 conference, our presentation covered self-venting nozzles in condensers and modeling one-fan-off operation in air coolers.

SELF-VENTING NOZZLES IN CONDENSERS

The most common problems with condensers are improper venting, inadequate drainage, or significant fouling. Correctly sizing the outlet nozzle reduces the possibility that the level of condensate in the condenser builds up and covers some of the heat transfer surface.

Consider a condenser with a large nozzle. Condensate flows over the mouth of the nozzle, similar to flow over a weir. (Self-venting nozzles are often described as exhibiting weir flow, much like water flowing over Niagara Falls.) The important thing to consider is that a vapor core exists in the center of the nozzle (see **Figure 1**).

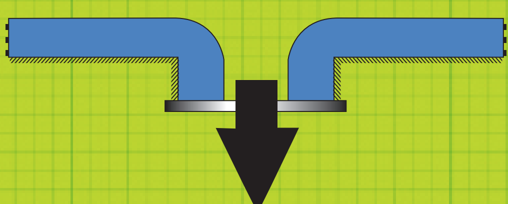


Figure 1. Flow through a self-venting nozzle

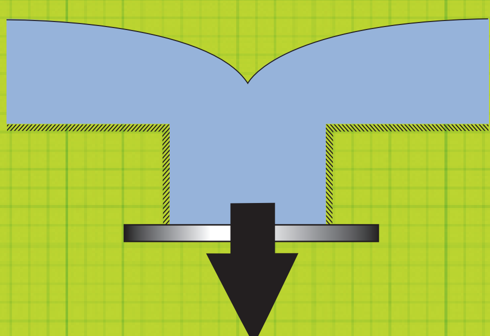


Figure 2. Flow through a flooded nozzle

Gradually increasing the flow rate of condensate or reducing the nozzle diameter decreases the size of the vapor core. Eventually, when the core disappears altogether, the nozzle is no longer self-venting (see **Figure 2**). Any further increase in condensate flow or reduction in the size of the nozzle significantly increases the level of condensate.

Sometimes having condensate build up in a condenser is necessary, for instance, when you want to provide some subcooling of the condensate or perhaps reduce the effective heat transfer area for turndown conditions. However, you should never rely on a flooded nozzle to determine the condensate level. Using an adjustable external loop seal is a much better alternative.

Currently, only ***X****ist* can calculate the condensate level, but the calculations will be included for ***X****ace* in ***X****changer Suite* 7.2. The next version may also include changes to the default nozzle sizing calculations so that the programs calculate the size of condensate outlet nozzles to be self-venting instead of basing nozzle size on a percentage of the pressure drop.

MODELING ONE-FAN-OFF OPERATION IN AIR COOLERS

Air-cooled heat exchangers often have to operate in "off design" conditions such as during winter (or summer), turndown, etc. Under these circumstances, operating with one or more fans turned off could prevent overcooling of the process (tubeside) stream. On occasion, normal operation may mean one fan is generally turned off and to be turned on only during very hot days to achieve the required cooling.

HTRI realized some years ago that members were using different but inconsistent workarounds to model one-fan-off operation. In 2008 we published a TechTip (TT-3), followed in 2010 by a *Q* article (*Q* 14-3), to try to provide a consistent workaround for modeling one-fan-off operation until the software included an option to model this directly.

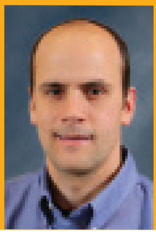
Engineering judgment is required both to determine what the actual flow distribution is likely to be and also to interpret the results. While the HTRI workaround focused on thermal and hydraulic performance, it did not address the effect on values used for fan selection.

In particular, ***X****changer Suite* assumes that the air flow is distributed over all fans (whether operating or not). Because the fan power is displayed per fan, the correct fan power is calculated only when all fans are operating. Further details are given in the conference presentation.

It is advisable to use the HTRI workaround for "what-if" type scenarios rather than for designing equipment for one-fan-off operation. The method assumes that the part of the bundle where fans are not operating acts like a natural convection bundle and that there is no interaction between this area and the area where fans are operating normally. CFD studies suggest that warm air from operating fans can back-circulate through the bundle. More work is needed to verify this behavior. HTRI is evaluating the possibility of designing a new experimental test unit to perform additional research on this topic.

2014 Global Conference Materials Available for Purchase

To purchase a copy of the presentation slides and summaries, send an email to **registration@htri.net** with Conference Materials in the subject line (do not include credit card information). HTRI will contact you about the details.



Aaron Smith
Engineer, Research & Engineering Services

Crude Oil Fouling Task Force News

The Crude Oil Fouling Task Force (COFTF) has supported HTRI's crude oil fouling research program for more than 15 years.

As we expand our research endeavors, we will be relying on their valuable advice even more. At our meeting at the 2014 Global Conference, the following topics were discussed:

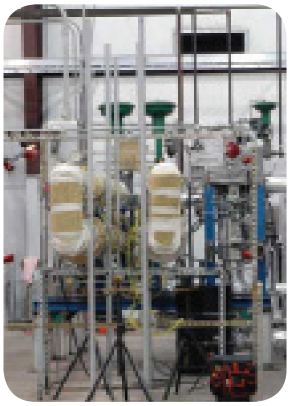
- Status of shakedown of Rotating Fouling Unit (RFU)
- Status of construction of a second High Temperature Fouling Unit (HTFU2)
- Fouling specific chemical characterization methods with discussion of benefits and caveats
- Summary of Crude 19 testing to date
- Impact of subcooled boiling on fouling
- Options to flash crude prior to fouling tests
- Plans for predictive fouling model development

The discussion on the options to flash crude highlights the value the COFTF brings to HTRI's fouling program. Samples of crude donated by COFTF member companies are typically desalted unflashed crude. However, the conditions that the COFTF has advised HTRI to focus on studying are at the hottest end of the crude preheat train. At this point in the preheat train, it is common for the crude to have been flashed. Thus, without the ability to flash the crude, the fluid provided and the test conditions HTRI wants to study do not align. The COFTF provided excellent feedback on design conditions and relative frequency of flash drums in preheat trains. This industry input is what we rely on to ensure our research is relevant to our members.

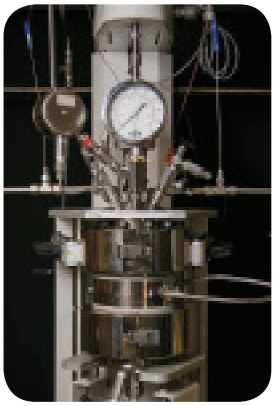
This coming year we are bringing a new fouling test unit online. The second HTFU is under construction, and a full system test starts soon. The advances we have implemented in the design of the new HTFU allow for improved precision in test measurements. The RFU shakedown testing is nearing completion, and we will evaluate how well the RFU data compares to the HTFU data; we also plan to use the RFU to identify threshold fouling temperatures. We will continue to use the HTFU in our contract testing program to obtain the best-in-class fouling test data.

As HTRI expands its crude oil fouling program, the COFTF will continue to play a critical role in guiding our research to outcomes that are applicable to the goals of our members.

High Temperature Fouling Unit (HTFU): *The HTFU is the original HTRI fouling unit. It has two intube flow test sections. The unit requires a 30-L charge of crude.*



Rotating Fouling Unit (RFU): *The RFU is a small fouling rig operating on 2.5 L of crude. The design is a heated probe with a spinning cup around the probe to induce flow. The unit has lower shear stress resulting in faster fouling rates (i.e., shorter run times), making it ideal as a screening tool.*



High Temperature Fouling Unit 2 (HTFU2): *The HTFU2 is a second intube fouling unit. In concept, it is similar to the HTFU but incorporates many improvements in test section design, controls, and instrumentation. The most notable difference is that the unit has six test sections, allowing for collection of three times the data from a single run.*

WHY STUDY CRUDE OIL FOULING?

Crude oil fouling is a costly and challenging problem for oil refiners. Deposition of oil components on crude preheat exchangers results in increased heating costs due to loss of thermal efficiency and increased pumping costs and/or reduced throughput due to increased pressure drop.

ABOUT THE COFTF

The COFTF is a group of 27 individuals representing companies from around the world, most of which operate oil refineries. The COFTF provides input, guidance, and priority on crude oil fouling research conducted at HTRI. Additionally, the COFTF provides samples of crude for testing. If you are interested in participating in the COFTF, contact us at htri@htri.net.

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ENCYCLOPEDIA OF TWO-PHASE HEAT TRANSFER AND FLOW

Set I : Fundamentals and Methods
Set II: Special Topics and Applications

edited by **John R Thome**
(Laboratory of Heat and Mass Transfer (LTCM), Switzerland & Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland)

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HTRI WELCOMES
NEW MEMBERS OF THE BOARD OF DIRECTORS AND TECHNICAL COMMITTEE

Several new members joined the Board of Directors and Technical Committee; their distinct skills bring a fresh perspective and their complementary experiences add new dimensions to these volunteer groups.

FY 2015 BOARD OF DIRECTORS

Sam E. Chapple
Hudson Products Corporation, Beasley, Texas, USA

Chapple has over 37 years of experience in heat transfer design and business development. He joined Hudson in 1992 after six years as General Manager with Hudson Northern Industries Inc. As the Chief Technical/Business Development Officer, he has led several company acquisitions, has established joint ventures/technical licensees in multiple countries, and has spearheaded product and engineering development for the Hudson companies. His previous positions with Hudson have included Global Sales and Marketing Vice President, Regional Sales Director for Asia/Europe/Canada, and Manager of Fans, Parts & Field Services. Chapple has also been an active member on the American Petroleum Institute and Cooling Technologies Institute standards committees. He is a licensed Professional Engineer (P.Eng.) in several Canadian provinces.

Chapple earned his BS in Mechanical Engineering from the University of Alberta, Edmonton, Alberta, Canada. He was the founder and a charter member of Communication Committee–Canada and served as its Chair from 2002 – 2005. Since 2012, he has been an active member of the re-named Communication Committee–Western Canada. Chapple is also the Stockholder Representative for Hudson Products Corporation.

George A. Denavit
URS Energy & Construction, Inc., Denver, Colorado, USA

Denavit is a recognized specialist in heat transfer engineering. As the Manager, Heat Transfer Specialty, he coordinates engineering requirements with other engineering disciplines within URS. With over 35 years' experience in the design and purchase of mechanical equipment for the process industry, Denavit has served as a technical consultant on numerous engineering projects throughout the United States and Canada, as well as in Asia and the Middle East. In this role, he has worked with major clients and subcontractors to ensure quality products and services from initial specification through fabrication and field checkout.

Denavit graduated with a BS in Mechanical Engineering from the University of Illinois at Urbana–Champaign, Urbana, Illinois, USA. He is a licensed Professional Engineer (PE) in Alaska, Colorado, and Texas, as well as a licensed Professional Engineer (P.Eng.) in Alberta and British Columbia, Canada. He has served as the Technical Advisory Committee representative for URS since 2007 and was a member of the Exchanger Design Margin Task Force (EDMTF). Denavit has been attending HTRI meetings for nearly 30 years.

FY 2015 TECHNICAL COMMITTEE

Steven A. Barnett
Marathon Petroleum Company LP, Ashland, Kentucky, USA

As Advanced Senior Refining Engineer and Heat Transfer Technologist, Barnett provides technical support on performance issues and evaluates new technologies and software for flares, heat exchangers, and fired heaters in all Marathon refineries. For 30 years prior to his current assignment, Barnett was a lead process design engineer working on major new unit designs and existing unit revamps. He also served as a process design group leader and process design manager.

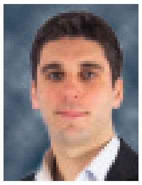
Barnett holds a BS in Chemical Engineering from the University of Cincinnati, Cincinnati, Ohio, USA. He currently serves as the company's TAC representative.

Ray G. Broussard
INVISTA S.à r.l., Houston, Texas, USA

Broussard has over four decades of experience in engineering technology. He currently serves as the heat transfer and mechanical specialist for all of INVISTA's chemical plants. In this role, he is responsible for sizing all heat transfer equipment and mechanical and pressure vessel designs, as well as thermal performance and mechanical reliability studies and optimization. Broussard is also highly involved with day-to-day plant process performance and mechanical issues. Prior to joining INVISTA, Broussard held multiple senior-level engineering positions with DuPont Engineering Technology and worked at other HTRI member companies. He is a licensed Professional Engineer (PE) in Texas.

Broussard graduated with a BS in Mechanical Engineering from Texas A&M University in College Station, TX. Broussard is a charter member of Communication Committee–Houston, TX

(USA), serving as its Chair from 2008 – 2011. He has been an active participant in HTRI meetings/conferences and training events for many years; he also currently serves as the company's TAC representative.



Florian Picard

Fives Cryo, Golbey, France

As the Business Development Officer of the Research & Development Department, Picard is responsible for the promotion and market launch of new compact heat exchanger technologies and services. In addition, he serves as the product manager of new types of enhanced heat transfer solutions and coordinates technical and commercial developments. Picard is also involved in technical support and best practice initiatives especially in transient conditions (start-up, shutdown, trip cases, etc.). His prior assignments focused on software development, especially for the design and simulation of brazed aluminum plate-fin heat exchangers.

Picard is a Graduate Engineer, who earned his PhD in Chemical Engineering from the Institut National Polytechnique de Toulouse in Toulouse, France.

Carolyn E. Schmit

BP Products North America, Inc., Naperville, Illinois, USA

After joining BP in 2001, Schmit initially worked on research and development teams charged with implementing plant process improvements and developing new technology options to implement. In her current position as Principal Engineer–Energy, Refining & Logistics Technology, she develops energy efficiency strategies and refinery-wide improvement programs, conducts energy workshops focused on identifying opportunities to improve energy performance, as well as troubleshoots, models, and evaluates heat exchanger performance. Schmit is highly experienced in evaluating process improvements in refining and petrochemicals, including applying rigorous heat exchanger and process simulation modeling tools. In addition, she also serves as a corporate trainer and coach to process engineers.

Schmit graduated with a BS in Chemical Engineering from Case Western Reserve University in Cleveland, Ohio, USA and an MS and PhD in Chemical Engineering from the University of Texas, Austin, Texas, USA. She is a member of the Crude Oil Fouling Task Force (COFTF) and was a member of the Exchanger Design Margin Task Force (EDMTF).

Ray E. Tucker

UOP LLC, Tonawanda, New York, USA

As the Principal Design Engineer in the UOP Process Equipment Skill Center, Tucker leads the engineering group which designs exchangers based on UOP's suite of heat transfer technologies (High Flux and High Cond Tubing). He has also served as the head for UOP's ISO-9000 audit team. He joined UOP (formerly Union Carbide) in 1986. His career has focused on heat transfer design and equipment for the refining and petrochemical industries in 47 countries. In addition, Tucker has worked within the tray and tube equipment areas on product development, field installations, process and detailed thermal design, operation of data collection units, troubleshooting, and new product commercialization.

Tucker earned a BS in Chemical Engineering from the University at Buffalo, The State University of New York, Buffalo, NY. He is an active participant in HTRI conferences and training events. He also is recognized as an expert user of HTRI software.

Our thanks to...

HTRI acknowledges the service of **Bernd Rumpf**, who as the Research Manager, Distillation/Heat Transfer of BASF SE, Ludwigshafen a. Rhein, Germany, served on the Technical Committee (TC) from 2005 through 2014. Both the TC and Communication Committee–Germany benefited from his expertise in process and equipment design.

ELECTION RESULTS
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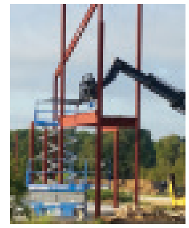

HTRI IS EXPANDING

In the last edition of *The Exchanger*, you may have read about our plans to locate all Texas-based staff in one place at our global headquarters location in Navasota, Texas. We are excited to share the construction progress of the new office building. At this time, the steel structure has been erected, and we have poured concrete for the second floor of the two-story building. The building will consist of 34,335 square feet, allowing for future expansion. As HTRI continues to grow, that will be an important benefit.

The building was designed with energy efficiency in mind. The intent was to keep operating and maintenance costs at a minimum. LED lighting will be used throughout, to reduce the heat load and cooling system requirements. Construction is expected to be completed in late summer of 2015. Look for more photos of the building in the next issue of *The Exchanger*.

Construction is moving along at the newest office building at the HTRI global headquarters in Navasota, Texas, USA. The new building will allow all Texas-based HTRI staff to work out of the same location for the first time.

NEW HTRI STAFF WELCOME

WILLIAM J. DEMKE, Instructional Design Specialist
CHERYL L. GARCIA, Senior Marketing Communications Specialist
FELIPE GONZALEZ, Desktop Support Specialist
MARCIE GREENBAUM, Administrative Assistant (Marketing)
SHRIPAD JUMDE, Software Quality Assurance Specialist
GREG L. PATTERSON, Research Technician
JENNA L. ROSIER, Administrative Assistant (Human Resources)
CLEMENT J. SOFKA, Research Physicist

PROMOTIONS/TITLE CHANGES CONGRATULATIONS

VENIA R. BALDOBINO, Membership Associate II
AGNES M. BONIFACE, Sales & Administrative Assistant, EMEA
KENDRA B. COCEK, Administrative Assistant II
ELIZABETH H. DUFF, Administrative Assistant II
JUNE ELLIOTT HARDY, Coordinator, Corporate Conferences & Travel
MICHAEL B. GARRETT, Senior Software Support Specialist
FLOYD "TODY" HOLMES, Lead Research Technician
KIMBERLY T. KITCHENS, Membership Associate II
LAUREN V. MORAN, Lead Technical Support Engineer
KENNETH P. SCHOLZ, Administrative Assistant II
CAROL A. STRUKEL, Manager, Human Resources

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January through October 2014

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Antumec Ingenieria y Servicios Ltda.
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Seoul, Korea

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Singapore

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Changwon, Gyeongsangnam-do, Korea

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Harsco Industrial Air-X-Changers
Catoosa, Oklahoma, USA

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Gijón, Asturias, Spain

Inelectra Colombia S.A.S.
Bogotá, Colombia

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Jiangyin, Jiangsu, China

Kolon Process Systems Co., Ltd.
Gwacheon-si, Gyeonggi-do, Korea

Kopetz Manufacturing, LLC
Decatur, Illinois, USA

McKay Design Group, Inc.
Calgary, Alberta, Canada

Nantong Cellulose Fibers Co., Ltd.
Nantong, Jiangsu, China

Nisso Engineering Co., Ltd.
Chiyoda-ku, Tokyo, Japan

OFMECO Pressure Components S.r.l.
Marmirolo (MN), Italy

Pentech
Caracas, Venezuela

Perry Products Corporation
Hainesport, New Jersey, USA

Petrojet Kattamia Central Workshop
Cairo, Egypt

POSCO Energy Co., Ltd.
Pohang, Gyeongsangbuk-do, Korea

Pöyry Deutschland GmbH
Mainz, Germany

PT. Asahimas Chemical
Cilegon, Banten, Indonesia

PT. Erraenersi Konstruksindo
Jakarta Selatan, DKI Jakarta, Indonesia

Quality Infra Projects International Pvt. Ltd.
Mumbai, Maharashtra, India

SABIC Americas, Inc.
Sugar Land, Texas, USA

Sadara Chemical Company
Dhahran, Saudi Arabia

Sep-pro Systems, Inc.
Houston, Texas, USA

Shanghai Electric Power Generation Equipment Co., Ltd.
Shanghai, China

SHICSA
Vila-Seca, Tarragona, Spain

Teralba Industries Pty Ltd
Campbelltown, New South Wales, Australia

Titanium Equipment and Anode Manufacturing Company Limited
Chennai, Tamil Nadu, India

Tounichi Kikai Co., Ltd.
Ayase, Kanagawa, Japan

Universal Solution Pte Ltd
Singapore

W. R. Grace & Co.-Conn.
Columbia, Maryland, USA

Wuxi Dingbang Heat Exchange Equipment Co., Ltd.
Wuxi, Jiangsu, China

New Participating Affiliates
January through October 2014

Alfa Laval (Thailand) Ltd
Bangkok, Thailand

Alfa Laval EOOD
Sofia, Bulgaria

ANA Prozesstechnik GmbH
Merseburg, Germany

BASF Advanced Chemicals Co. Ltd.
Shanghai, China

BASF Personal Care and Nutrition GmbH
Monheim, Germany

Bohorquez Ingenieria Bilsa, S.A.S.
Bogota, D.C., Colombia

BP Exploration (Angola) Limited
Luanda, Angola

Cincinnati Renewable Fuels LLC
Cincinnati, Ohio, USA

Dow MF Produktions GmbH & Co. OHG
Rheinmünster, Germany

Fluor Engineering N.V.
Antwerpen, Belgium

GEA Ecoflex China Co., Ltd.
Shanghai, China

GS Engineering & Construction Mumbai Private Limited
Mumbai, Maharashtra, India

INVISTA Management (Shanghai) Co., Ltd.
Shanghai, China

JGC America, Inc.
Houston, Texas, USA

Jord International s.a.r.l.
Lille, France

Jord (OHQ) Sdn Bhd
Kuala Lumpur, Malaysia

Mitsubishi Hitachi Power Systems, Ltd.
Yokohama, Kanagawa, Japan

Saipem Services Mexico, S.A. de C.V.
Mexico, D.F., Mexico

Sarawak Shell Berhad
Lutong, Miri, Sarawak, Malaysia

Tecnicas Reunidas Chile, Ltda.
Santiago, Chile

ThyssenKrupp Electrolysis GmbH
Dortmund, Germany

ThyssenKrupp Industries and Services Qatar LLC
Doha, Qatar

Total Austral S.A.
Buenos Aires, Argentina

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Calgary, Alberta, Canada

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Bogota, D.C., Colombia

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For more than 50 years, HTRI's innovative and extensive research into thermal process technologies has developed an equally impressive training program.

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- **webinars to demonstrate software procedures, technical tips, or design guidance**

Conducted around the globe, our onsite training can be customized to provide an affordable and timely option for our customers.

Courses are continually updated to represent the most current HTRI software and recommendations. Our instructors—subject matter experts with decades of experience—can help you use our products more effectively and understand our research more thoroughly.

Webinars are available only to HTRI members, but other training sessions are open to all industry professionals.

We update our training calendar often. Bookmark this link to view the latest schedule: www.htri.net/events.

Contact HTRI

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