

Cover story:

**Heavy Metal & Tubes: Quality, integrity,
and global ambition**

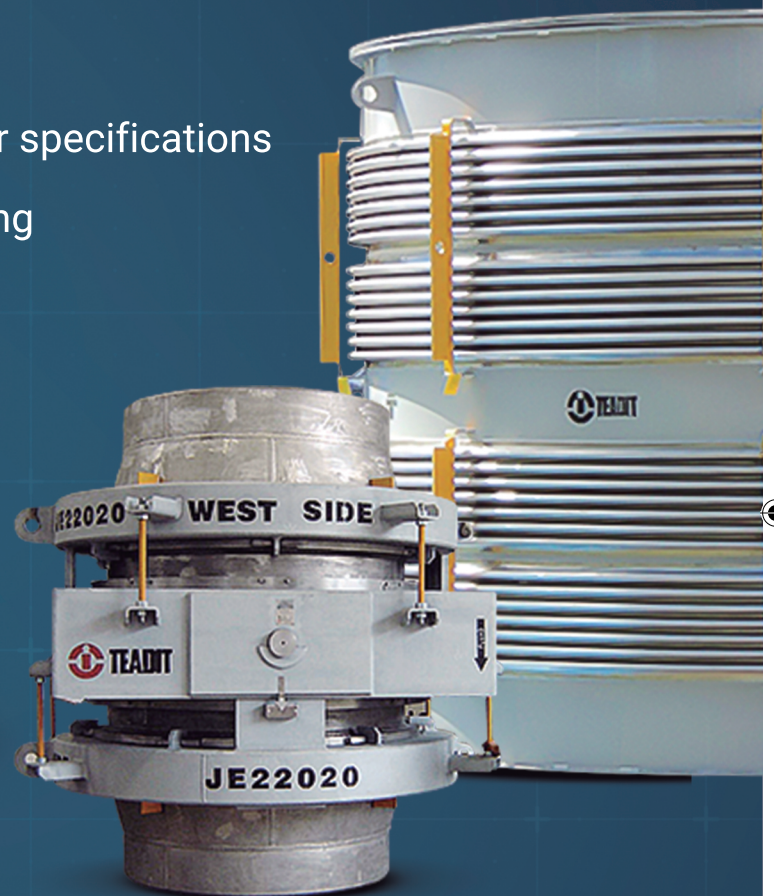


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Heat Exchanger World is the global magazine connecting those working in the heat exchanger supply chain

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Exchanging heat, building futures

This October, our industry turns its focus toward one of the most anticipated events on the heat transfer calendar: the Heat Exchanger World Americas Conference & Expo 2025, taking place on 15–16 October at the NRG Center in Houston, Texas. Over the two days, attendees will have the chance to engage with more than 70 exhibitors, hear from leading experts, and dive deep into the technologies, standards, and strategies shaping our sector. From cutting-edge design enhancements and corrosion-resistant materials to sustainability, fabrication, and maintenance solutions, the program reflects the full breadth of challenges and opportunities we face. Read the Advance Conference Program on page 27.



Fittingly, this issue's stories echo the same themes of innovation, reliability, and global ambition.

Our cover story profiles Heavy Metal & Tubes (India) Pvt. Ltd., a company that embodies resilience and forward momentum. For more than four decades, HMT has built its reputation on producing seamless and welded tubes of the highest quality for critical applications in heat exchangers and boilers. Today, under dynamic leadership, the company is expanding its technological capabilities, introducing advanced machinery, producing record-breaking arbor coil bends, and investing in controlled environment furnaces that raise the bar for product quality. Beyond equipment, what stands out is HMT's commitment to people: retaining expertise across decades while nurturing a new generation of engineers eager to shape the company's future.

Equally compelling is our feature story by Saudi Aramco's Fawaz Al-Khuliawi, which addresses one of the industry's most persistent challenges: fouling. Fouling mitigation and cleaning are far more than maintenance tasks, they are core to ensuring reliability, efficiency, and lifecycle cost control. The article underscores the importance of reliability-centered maintenance, proactive monitoring, and embedding fouling strategies across design, operation, and asset management. Page 16 awaits for you with more insights.

In our technical spotlight on page 20, we highlight a case study from engineers at Petronas that reinforces why standards, testing, and new materials remain the backbone of our industry. While technologies evolve, ensuring compliance, safety, and performance in diverse operating environments requires a meticulous approach to design and inspection. For engineers and operators alike, such insights bridge the gap between innovation and operational excellence.

We look forward to welcoming many of you in Houston this October and to, hopefully, continuing the conversation in the pages of this magazine.

All the best,
Iryna Mukha
Editor
i.mukha@kci-world.com

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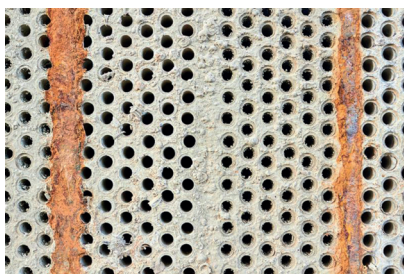
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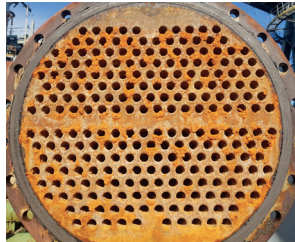
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CALENDAR

15 – 16 October 2025

HEAT EXCHANGER WORLD AMERICAS CONFERENCE & EXPO

» Location: Houston, Texas, USA

Url: <https://heat-exchanger-world-americas.com/>

18 – 20 November 2025

STAINLESS STEEL WORLD CONFERENCE & EXPO

» Location: Maastricht, the Netherlands

Url: <https://stainless-steel-world-event.com/>

6 – 7 May 2026

HEAT EXCHANGER WORLD EUROPE CONFERENCE & EXPO

» Location: Rotterdam, the Netherlands

Url: <https://heat-exchanger-world-europe.com/>

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Community Update

Sharing good news from the heat exchanger community and wider industry...

Elliott Tool Technologies announces leadership changes to drive growth

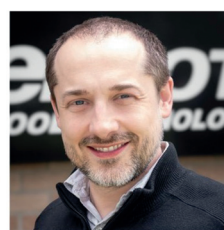
Elliott Tool Technologies has announced a series of leadership promotions designed to strengthen its strategic direction, accelerate product development, and enhance customer support.

Mike Nemeth has been promoted to Chief Executive Officer (CEO), while Nathan Fultz will take on the role of President. Thomas Wagner has been elevated to Vice President of Sales and Marketing, and Zach Bussard has been appointed West Area Sales Manager.

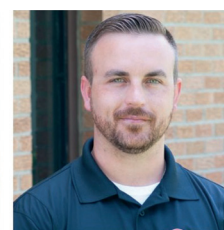
The company stated that these structural changes reflect its ongoing commitment to customer-focused service and continuous improvement. By expanding its leadership team, Elliott Tool Technologies aims to better understand customer needs, streamline processes, and deliver faster, more reliable solutions. Founded on a customer-first approach, Elliott Tool Technologies said the changes will allow it to



MIKE NEMETH
Chief Executive Officer (CEO)



NATHAN FULTZ
President



THOMAS WAGNER
Vice President of Sales
and Marketing

engage more deeply with clients while leveraging resources to provide

exceptional service and product innovation.

Worley appoints former Incitec Pivot CEO to Board



Worley announced the appointment of Jeanne Johns as an independent Non-Executive Director of its Board, effective 1 September 2025. Jeanne brings more than three decades of international leadership experience across refining, petrochemicals, oil and gas, fertilizers, and civil explosives. She served as CEO and Managing Director of Incitec Pivot from 2017 to 2023, and previously spent 30 years with BP in senior roles across the US, Europe, and Asia. Jeanne is also a non-executive director of HF Sinclair. Her appointment adds deep operational, project, and HSE expertise, as well as global perspective in Worley's key markets. Chair of Worley, John Grill AO, welcomed Jeanne's appointment, saying her experience will significantly strengthen the Board's capabilities. Worley also announced the retirement of Non-Executive Director Sharon Warburton, effective 31 August 2025. Sharon joined the Board in 2019, serving as Chair of the Audit and Risk Committee from 2023 to 2024. Grill thanked her for her valued contributions and leadership.

Munters invests in Norway's Capsol to strengthen carbon capture offering

Munters, a global leader in energy-efficient air treatment and climate control, is increasing its ownership in Capsol Technologies ASA and expanding their strategic partnership to include commercial collaboration. Capsol, listed on Euronext Oslo Børs, is a leading provider of carbon capture technology.

After joining Capsol's 2024 investment round, Munters has now agreed to acquire newly issued shares worth EUR 2 million, raising its stake to around 7%. Together, the companies will pursue joint go-to-market opportunities, combining Capsol's carbon capture process with Munters' mass transfer and mist elimination solutions.

"Strengthening our partnership with Capsol enables us to offer more comprehensive solutions for industries looking to cut carbon emissions," says Henrik Teiwik, President of Munters AirTech. "Carbon capture is a key growth area for Munters."



Capsol CEO Wendy Lam added: "Our technologies complement each other. By extending into commercial collaboration, we can support customers in advancing projects with greater speed and confidence."

Danfoss opens largest global facility in China to power green transition

Danfoss, the Danish multinational engineering group, has inaugurated its largest global production facility in Haiyan, China, marking a major step in its commitment to support China's green transition and sustainable growth. Spanning 126,000 sqm, the new Haiyan

Second Campus more than doubles Danfoss' local presence and integrates manufacturing across all three business segments, along with two Application Development Centers. The facility will produce advanced technologies such as

drives, compressors, hydraulic components, and heat exchangers—key solutions for decarbonizing China's buildings, transport, and energy sectors. Built to world-class standards, the campus also demonstrates Danfoss' own sustainability goals, operating with a three-step decarbonization strategy and sourcing 100% green electricity from 2025, cutting carbon emissions by 40,000 tons annually.

The opening ceremony was attended by Danish and Chinese officials, Danfoss executives, and representatives of its founding family. As Danfoss celebrates 30 years in China and 20 years in Haiyan, the new campus underscores its strong partnerships and long-term commitment to the region.

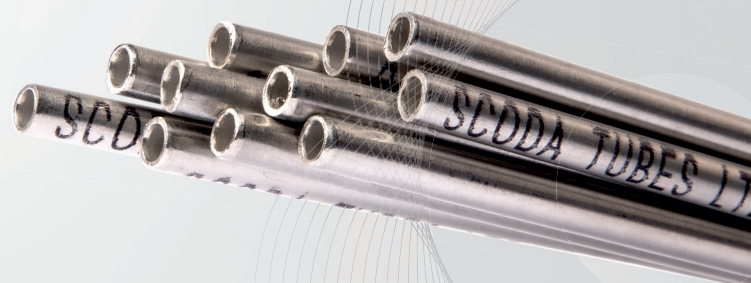




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Heavy Metal & Tubes: Quality,

Heavy Metal & Tubes (India) Pvt. Ltd. (HMT) is a self-sufficient company that manufactures seamless carbon, alloy, and stainless steel tubes/pipes, from round bars to the final product, for heat exchangers and boilers—all under the “HMT” brand. Led by a young and dynamic management team, the company aims to reach new heights. We spoke with Mr. Sandeep Kumar Mathur, General Manager of Marketing, about HMT’s success, production capabilities, and the management’s ambition to expand its role in the heat exchanger and boiler markets.



By Iryna Mukha, Heat Exchanger World

Heavy Metal & Tubes has a clear vision and has invested in cutting-edge technology and top talent to consistently deliver products that exceed customer expectations. The company produces seamless carbon, alloy, and stainless steel tubes and pipes. Starting from round bars, HMT offers tubes and pipes in both hot finish and cold finish, with a wide range of diameters, wall thicknesses, and lengths. With its unique capabilities and strong market position, HMT is a significant player in the domestic market and is steadily gaining recognition internationally.

One key factor behind the company’s remarkable success and its differentiation from competitors is its ability to produce a wide variety of tubes and pipes in different grades, thicknesses, sizes, and lengths—all under one brand. “No one else in India is doing what we do,” says Mr. Mathur. “That’s why we describe ourselves as a perfect blend of quality and integrity.”

Over four decades of excellence

“Heavy Metal & Tubes has a rich history and strong reputation,” says Mr. Sandeep Kumar Mathur. Established in 1978, it was among the pioneers of cold-drawn tube manufacturing in India for carbon and alloy steel. The company started producing commercial-grade

cold-drawn seamless carbon steel tubes in Mumbai during the late 1970s and opened a second plant in Ankleshwar, Gujarat, in 1982. It quickly evolved into a dedicated producer of high-quality products for critical industries like refineries, petrochemicals, power plants, fertilizers, and chemicals. By 1991, firmly established as a reliable producer, HMT invested in two new manufacturing facilities at Chhatral, Gujarat, focused on seamless carbon and alloy steel tubes and stainless steel seamless and welded tubes. These investments positioned the company to meet the surge in demand following the liberalization of the Indian economy in 1991 and capture a significant share of the growing Indian market.

Fuelling growth

In recent developments, Heavy Metal and Tubes further strengthened its technological capabilities by introducing cutting-edge machinery for seamless tube production of both carbon/alloy and stainless. This initiative also ensured the integration of a state-of-the-art piercer machine and the expansion of its pilger machine fleet to 30 units for the stainless steel division. Accompanying these advancements is the incorporation of a heavy-duty draw bench for seamless carbon and alloy steel tubes with heavy wall thickness.

, integrity, and global ambition



≈ Precise temperature control, effective cooling, and manipulation of inert gas atmosphere make it perfect for harsh settings including petrochemical plants, power plants, and refineries.

as no surprise that the choice of tubes is crucial for such machinery, since they are employed globally in crucial industrial sectors like sugar, fertilizer, oil and gas, refineries, chemical and petrochemical, pharmaceutical, and power plants which is a booming sector now specially in domestic market.

One important way that the company sets itself apart from competitors is its ability to produce tubing up to 34 meters long. Few Indian companies are able to accomplish this. Apart from the aforementioned sectors, Heavy Metal & Tubes provides tubes to the automotive industry, locomotives, defence industry, instrumentation, hydraulic and pneumatic systems, and numerous other industries.

In keeping with the company's progress, Heavy Metal recently manufactured arbor coil bends, marking a noteworthy milestone. These bends have remarkable dimensions: 101.4 mm OD x 5.74 mm WT and a bend diameter of 3000 mm (with a radius of 1500 mm). They are constructed from ASTM A335 P9 grade steel. These bends in arbor coil were made for a refinery operated by the state. The company has installed a brand-new, cutting-edge controlled environment bright annealing furnace to improve the quality of its output. By removing the requirement for acid treatment, this furnace ensures improved mechanical qualities and surface finishes while also improving product quality. Precise temperature control, effective cooling, and manipulation of inert gas atmosphere make it perfect for harsh settings including petrochemical plants, power plants, and refineries. These initiatives demonstrate Heavy Metal's dedication to innovation and quality, putting the business in a position to satisfy market demands while upholding its high standards.

Prioritizing the heat exchanger and boiler market

Heavy Metal & Tubes seamless tubes are utilized in air-fin coolers, boilers, condensers, and shell and tube heat exchangers, among other applications. Seamless tubes are also used in these systems. It should come



≈ Heavy Metal & Tubes provides tubes to the automotive industry, locomotives, defence industry, instrumentation, hydraulic and pneumatic systems, and numerous other industries.



Heavy Metal has successfully manufactured arbor coil bends for the first time in India.

Quality control

Heavy Metal & Tubes must prioritize the quality of its work in order to create a successful route forward. As a result, it has obtained PED and ISO 9001:2015 accreditation. Additionally, the business has put in place a quality assurance system that encompasses every phase of production, from raw materials, cold working, and heat treatment, to packing and shipping. Every component of this system complies with all national and international codes, as well as, if necessary, the specific quality and technical needs of each customer. The company's quality control department works independently of the manufacturing shop. Additional testing facilities that ensure quality include a wide range of air-under-water, eddy current, flaring, flattening, hardness, hydro, reverse bend, tensile, ultrasonic, and laboratory tests with spectrometers and metallurgical investigations by metallurgical microscope to determine grain size, corrosion, and microstructure. These testing facilities are also required by code requirements and mandatory supplementary tests. Each plant has a distinct laboratory setup complete with testing apparatus. Hydro testing is done on every tube. Personnel with the necessary training and qualifications conduct testing in accordance with the organization's stringent "Quality Assurance



The company is capable of providing a wide variety of special coil bends to serve their customers' every requirement.



Dedicated plants

Plant for cold drawn stainless steel seamless tubes and pipes

27,500 m² covered area
1 Piercing Mill
32 pilger mills
4 cold draw benches
3 controlled atmosphere furnaces
1 Solution annealing furnace
3 U-bending machines
3 U-bending SR setups

Plant for hot & cold drawn carbon and alloy steel tubes and pipes

45,000 m² covered area
1 Piercing Mill + Accu-Roll + SRM
11 draw benches
4 Pilger machines
2 U-bend machines
1 U-bend SR furnace
1 U-bend electric resistance heating setup
1 controlled atmosphere furnace
4 roller hearth furnace

Manual." The tests aid in ensuring that, in accordance with the intended use, technical delivery circumstances, and customer specifications, the highest manufacturing standards may be upheld. In addition, the production sites have also been equipped with reliable testing and measuring equipment for destructive and non-destructive testing such as Inter-granular corrosion testing, eddy current testing and ultrasonic testing.

It goes without saying that a number of important inspection organizations, including ABS, Bureau Veritas, DNV, EIL, IBR, LRIS, Intertek, PDIL, SGS, and TÜV, have authorized the mill and its products. A wide range of significant clients and end users, including KNPC, PEMEX, QP, SABIC, BHGE, Alfa Laval, BHEL, BPCL, CPCL, FACT, HPCL, IOCL, KFL, L&T, NFL, NPCIL, NTPC, TECHNIP, Reliance, SAIL, and several more, have also given the organization their approval.

Arbor coils:

- **Grade:** ASTM A335 P9
- **Bend Dia:** 3000mm (Radius 1500mm) with Bevel ends
- **Tests & Inspection:** 100% UT, Hydro, DP, Plane Testing, Ball Pass Test, PWHT
- **Size:** 101.4 mm OD x 5.74 mm WT
- **Size:** 114.3 mm OD x 6.02 mm WT

Investing in people

According to Mr. Mathur, "the high standard of technical competence of our staff is another factor that particularly stands out in our company." "They possess not just technical degrees when necessary but also loyalty and commitment in addition to knowledge and expertise. Some of our staff members have been with us for fifteen or thirty years. The fact that we have managed to retain them speaks volumes about our culture and guarantees that we have a wealth of knowledge and expertise on staff. At a time when many organizations are struggling

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 Mobile No. : +91 90165 49266
 Webpage: www.hmtl.in

to fill technical positions, we have no such problem. Young engineers plead to work with us so they can develop their careers under our leadership. They take great pride in helping to shape our success, and we in turn feel obligated and challenged to do the same." Management is equally concerned for all employee's health and safety along with the environment. The company has been accredited with certification ISO 14001: 2015 and ISO 45001 : 2018 for its sustainability efforts.

Global presence

Roughly 75% of the Heavy Metal & Tubes products are sold within India whereas 25% remaining is exported worldwide. Currently, the company has extended its reach to Middle East, Bahrain, Kuwait, Oman, Saudi Arabia, Qatar, UAE, and the Americas, which include Argentina, Canada, Brazil, Chile, Mexico, USA, and Europe, which includes Belgium, France, Germany, Greece, Italy, the Netherlands, Spain, Turkey, and the United Kingdom. They also have customers in Singapore, Australia, Japan, South Korea, and a number of other nations. "Our clients greatly value the quality and services we offer, as evidenced by the numerous recurring orders we consistently receive," Mr. Mathur explains. With regards to the tubing market for heat exchangers, Heavy Metal & Tubes tend to concentrate its sales to four major regions of the world: India, South Korea in Asia, Italy in Europe, and North America. However, the manufacturers of heat exchanger equipment in the former Eastern Block countries of Europe as well as the Gulf nations remain equally as important.

Looking ahead

Heavy Metal & Tubes is aware that expanding a product line is an easy approach to grow and provide superior customer service.

Last year the company installed two lines of advanced shot peening machines for stainless steel tubes to enhance surface integrity and fatigue life during operation. By implementing this process resistance, stress corrosion cracking can be enhanced in products, which reduces micro cracks and surface imperfections which is helpful in application of aerospace, power and nuclear plants.

The company is now entering into seamless precision coil tubing manufacturing. The world class manufacturing facility is well equipped with seven coil tubing draw benches, bright annealing furnace and in-house testing facility which will be in operation shortly. "Our plan for the future is to keep providing the highest calibre of service to both domestic and international markets, starting with fully Indian-origin material for basic raw materials," Mr. Mathur states. "As a result, we anticipate that business will grow as long as there is a need for tubes and pipes in demanding applications. Specifically, we plan to focus

more on providing support to heat exchanger and boiler makers. To this effect we have expanded our marketing team to aggressively cover this market. We intend to be there for our customers to ensure that their future is also a great success." ■

Milestone Projects/Jobs:**T-91 grade tubes:**

- Supplied 900 MT to BHEL, Trichy for NTPC, Talcher Project (2×660 MW)
- Currently executing an additional 863 MT order for the same Client

T-92 G T-91 grade tubes:

- Successfully supplied 11 MT to NTPC, Gadawara Project

T-12 grade tubes:

- Ongoing execution of 821 MT order to BHEL, Trichy for various NTPC projects

T-22 grade tubes:

- Currently executing a major 3000 MT order to BHEL, Trichy for NTPC applications

GR. A1 / T-22 / T-2 / TP-304H grade tubes:

- Exported 183 MT to a USA-based client
- Order value: USD 1.19 million

Super S30432 (shot peened) grade tubes:

- Booked order of 1150 MT order from BHEL, Trichy for NTPC Plants at Lara, Singrauli, SIPAT, and DVC Koderma (2×800 MW)

TP-347H (shot peened) grade tubes:

- Successfully executed 642 MT order for NTPC projects via BHEL, Trichy

TP-304N grade "U" tubes:

- Supplied 44 MT to BHEL, Bhopal for HP Heater Application
- Supplied more than 70,000 U tubes for Ultra Super Critical Power plants
- Tubes hydro-tested upto 625 Kg/cm² pressure

Heavy wall rifle tubes:

- Supplied SA210 Gr. C Tubes to NTPC, Singrauli. Size: 63.5mm OD × 12.50 mm WT

P-91 grade tubes:

- Supplied to BHEL, Trichy in multiple sizes: 127 × 20 mm, 114.3 × 17.12 mm; 88.9 × 17 mm, 88.9 × 15.24 mm

TP-310 grade tubes:

- Executed 10 MT order for Tata Chemicals

TP-321 grade special shape bend tubes:

- Pig Tails supplied to BPCL up to 5 radius

Long length tubes:

- 27.5 Mtr. straight tubes in SA179 supplied to Brembana & Rolle, Italy

The only NTPC approved manufacturer for the entire range of materials:

- Carbon Steel / Alloy Steel (up to T91 grade) / Stainless Steel (including Super 304)



By implementing this process resistance, Stress Corrosion Cracking can be enhanced in products, which reduces micro cracks and surface imperfections which is helpful in application of aerospace, power and nuclear plants.

Industry News

Pursuit Aerospace acquires Aeromet International



Pursuit Aerospace (Pursuit), a manufacturer of complex aircraft engine components, has announced the strategic acquisition of Aeromet International (Aeromet), a supplier of aluminum and magnesium castings to the global Aerospace & Defense industries, from Privet Capital (Privet). This acquisition expands Pursuit's existing casting capability suite by adding light alloy investment and sand-casting alongside Pursuit's existing super alloy investment

casting offerings. Aeromet further enhances Pursuit's ability to deliver a broad range of components to Aerospace & Defense customers, including castings, closed die and rolled ring forgings, machined components, and fabricated assemblies for aeroengine and other Aerospace & Defense applications. Aeromet is widely recognized for its process and engineering expertise, which enables the company to develop tailored solutions to customer needs.

SPIE acquires Voets & Donkers in the Netherlands



SPIE, the independent European leader in multi-technical services in the areas of energy and communications, has acquired Voets & Donkers Koeltechniek B.V. and VND Technical Services B.V. With this strategic acquisition, SPIE further strengthens its expertise in industrial cooling installations, air treatment systems, heat pumps, industrial automation, and the engineering of process equipment. Founded in 1963, Voets & Donkers employs 69 permanent employees across two locations in Schijndel

and Drachten. This specialist in the development, production, and installation of cooling and air treatment systems generated a turnover of EUR 30M in 2024. Its clients span various sectors, including dairy and food processing, horticulture, the pharmaceutical industry, warehousing, and high-tech machinery. With this acquisition, SPIE takes another step forward in enhancing its specialised industrial services, with a strong focus on innovation and sustainable technology.

Shell EV thermal fluid development paves way for sub-10-minute charging

Shell Lubricants (Shell), has successfully formulated and demonstrated a high-performance EV thermal management fluid with the ability to unlock significant reductions in charging times without compromise to battery safety, thermal stability, or lifespan, aiding the widespread adoption of battery electric vehicles (BEVs). In collaboration with RML Group – one of the leading UK automotive innovation companies – a 34 kWhr battery pack using Shell EV-Plus Thermal Fluid featuring proprietary Shell Gas-to-Liquid (GTL) Technology, has been developed, which is capable of charging from 10% to 80% capacity in under 10 minutes. The thermal

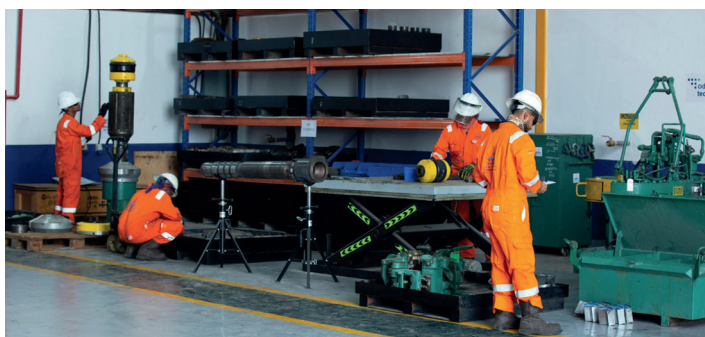
fluid reduces thermal stresses very significantly, allowing much higher cell charging currents to be tolerated. If utilised in a carefully designed lightweight, and aerodynamic car operating with an economy of 10 km/kWhr, a charging rate of 24km per minute spent charging would be achieved – significantly higher than the typical 5km per minute currently attained by many existing BEV designs by optimising performance whilst significantly reducing the number and mass of components. Shell EV-Plus Thermal Fluids are electrically non-conductive fluids, which facilitate excellent heat transfer by filling all of the interstitial spaces within the battery



pack, maximising direct contact between the fluid and each battery cell. They accommodate the very high levels of heat generation associated with rapid charging,

ensuring extraordinary consistency and control of temperatures across the pack whilst offering enhanced protection against adverse thermal events.

Odfjell Technology partners with Vercana



Odfjell Technology, an integrated supplier of well services technology and engineering solutions, has signed a two-year contract with Vercana GmbH, Vulcan Group's drilling subsidiary. Odfjell Technology will provide tubular running services (TRS) to Vulcan Group's Phase One Lionheart Project in Germany, which aims to produce lithium sustainably by combining harnessed geothermal energy with critical mineral extraction.

Odfjell Technology's drilling tool rental and TRS solutions will service the onshore geothermal project, located at Vulcan Group's Phase One project site near Landau in the Upper Rhine Valley. Germany's geothermal energy market is experiencing rapid expansion as part of the country's renewable energy transition, with the sector expected to grow at an annual rate of 1.95% from 2025 to 2029.

Lennox HVAC OEM completes lab validation



Lennox (LII), a leader in energy-efficient climate solutions, has announced that its commercial cold climate heat pump rooftop unit (RTU) was the first to successfully complete the laboratory validation for commercial unitary equipment in the 15-25 tons category in the U.S. Department of Energy's (DOE) Commercial Building HVAC Technology Challenge.

Designed to produce innovative HVAC technology, this accomplishment helps provide customers with access to high-efficiency heat pumps in cold climates, improving performance and solving long-standing defrost limitations for greater comfort and reliability. According to the DOE, commercial building space conditioning accounts for

approximately 40% of commercial energy use in the United States. Led by its Texas Product Development and Research laboratory, Lennox developed a cold climate heat pump RTU that meets and, in many cases, exceeds the stringent performance requirements of the challenge, as validated in an independent lab by the DOE and the National Renewable Energy Laboratory (NREL).

This achievement supports a commitment to sustainable innovation and builds on a 130-year legacy of delivering advanced, energy-efficient solutions at Lennox. It also follows Lennox Residential HVAC's successful participation in DOE's Residential HVAC Challenge, where the company was also the first to complete Phase 1 testing in 2022.

Geothermal drilling operations break ground in Geiselbullach



Drilling of a geothermal doublet has officially started at the site of the Joint Municipal Company for Waste Management (Gemeinsames Unternehmen für Abfallwirtschaft / GfA) in Geiselbullach in Bavaria, Germany. The project by Amperland Thermalwärme GmbH (ATW) envisions a geothermal heating facility that will serve the existing district heating network, which is currently supplied by a waste incineration facility.

Two geothermal wells will be drilled from a single pad to a depth of approximately 1725 meters, into an Upper Jurassic aquifer hosting thermal waters are approximately 73 °C. Drilling is expected to be completed by December 2025. German drilling company Daldrup &

Söhne Aktiengesellschaft (Daldrup & Söhne) had been awarded the contract for the drilling work. The application for a mining permit for the geothermal heating project was made back in May 2023. Federal funding for the project was confirmed in November 2024, and the approval for the project was granted in June 2025. If drilling is successful, a central heating plant will be built at the site. This will include a heat exchanger, which will serve as the interface between the deep thermal fluids and the circulating fluids of the district heating network. According to the GfA, the drilling site close to the waste incineration plant offers optimal conditions for drilling of the wells, as well as the construction and operations of the heating plant.

GMH Gruppe acquires two business units of Buderus Edelstahl GmbH

GMH Gruppe is acquiring two business units of Buderus Edelstahl GmbH in Wetzlar: the hot rolling mill for large, rolled steel dimensions and the machining and heat treatment facilities for highly complex open-die forged parts. These operations will become part of GMH Gruppe, while the remaining business units will stay under the ownership of Mutares SE & Co. KGaA. The purchase price remains confidential. The transaction is subject to various closing conditions, which are

expected to be fulfilled in the fourth quarter, thus enabling the legal completion of the acquisition. With the integration of Buderus Edelstahl, GMH Gruppe continues to pursue its strategic growth agenda: strengthening existing production capabilities, expanding into new market segments, and enhancing service quality for its customers. The integration of Buderus Edelstahl's business units into GMH Gruppe is planned for the fourth quarter.



Accelera delivers its largest electrolyzer system

Accelera™ by Cummins, the zero-emissions business segment of Cummins Inc. [CMI], has supplied a 35-megawatt (MW) proton exchange membrane (PEM) electrolyzer system, its largest to date, to support hydrogen production at Linde's facility in Niagara Falls, New York. Powered by renewable hydroelectric energy, the system will generate

green hydrogen to help decarbonize industrial operations and accelerate the clean energy transition in the U.S. "The successful delivery of this 35MW electrolyzer system is a significant milestone for Accelera and for the advancement of clean hydrogen technology in North America," said Des McMenamin, General Manager – Electrolyzers for

Accelera. "This project demonstrates our ability to deliver large-scale, reliable solutions that enable our customers to produce green hydrogen on a commercial scale." Electrolyzers that leverage renewable energy sources produce green hydrogen, which is vital for accelerating the clean energy transition. Accelera is a

leader in large-scale hydrogen production using PEM electrolysis and has deployed more than 600 electrolyzer units worldwide, powering some of the most advanced PEM electrolyzer systems operating globally. This includes a 20MW facility in Quebec, Canada, and a 25MW system in Florida, U.S.

QHeat & Exel Composites develop a solution for energy plant

QHeat has completed its co-created product innovation together with Exel Composites, a publicly listed Finnish company serving global industries with advanced composite solutions. The partners developed and installed custom-made composite collector pipes in one of QHeat's geothermal wells at the Lounavoima site. Having previously worked with Lounavoima, QHeat was familiar with the plant's requirements. It needed a cost-effective and sustainable solution to improve energy efficiency while meeting regulations. Exel designed and manufactured the collector pipes, which QHeat installed using specialized tools. As a pioneer in bespoke composite solutions and with a growing focus on energy applications and circularity, Exel was a natural fit for the collaboration.

While QHeat owns the solution and patent for the geothermal well technology, Exel's R&D team and decades of composites expertise played a crucial part in the co-creation project. Both parties were equally impressed by each other's expertise. The collector pipes needed to withstand their own weight two kilometers underground, while also insulating heat to ensure energy isn't lost during transfer. Exel's composite solution rose to the occasion, being metal-free, light-weight, optimized for flow and insulation, and recyclable. The pipes are made of fiberglass utilizing a continuous manufacturing process called pultrusion. This material might seem unconventional compared to acid-resistant steel or plastics. However, traditional materials weren't a good fit for this case: metals conduct heat, and plastic lacks the mechanical strength required at such depths.



QHeat and Exel Composites have created composite pipes that improve the energy efficiency of the Lounavoima waste-to-energy plant. The tailored composite collector pipes were developed to meet the plant's specific needs, with a focus on durability, sustainability, and recyclability.

Enwave commissions its new Enwave Green Heat™ plant

Enwave Energy Corporation (Enwave) commissioned its new Enwave Green Heat™ Plant during a ceremony at the Pearl Street Energy Centre in Toronto. This announcement is a monumental step in further enabling Enwave to provide low-carbon heating through its Enwave Green Heat™ program to Toronto's world-renowned district energy system. In an effort to provide decarbonization at scale, the plant

will leverage waste heat from Enwave's Deep Lake Water Cooling (DLWC) system customers – including data centres, hospitals, scientific research facilities, and lab spaces – which is then upgraded through the electrified heat pump into hot water. This allows the plant to provide heat to other district-connected customers, while potentially reducing new electricity peak generation, distribution, and

transmission infrastructure that would otherwise be required if heating were provided by stand-alone electrified solutions. Enwave's award-winning DLWC system and its Enwave Green Heat™ Plant directly support Ontario's first Integrated Energy Plan, which aims to ensure that the Province of Ontario has the energy it needs to power homes and industries, today and in the decades to come.

The new plant will have a total electricity demand of approximately 6MW when it is serving its full thermal load and has been designed with the potential to reduce its peak electricity demand by up to 6MW – supporting the reliability of Ontario's electricity system while continuing to meet the heating and cooling needs of Enwave's thermal energy customers.

SÄKAPHEN and Donelli joining forces for heat exchanger protection



SÄKAPHEN and Donelli Alexo, part of Gruppo Donelli (Legnano, Italy), have been partners for over 20 years now: the former as a manufacturer of industrial anti-corrosion and protective coatings and linings, and the latter as an authorized applicator of high-performance solutions for safeguarding assets. Together, they have decades of expertise in the most diverse industries, including heat exchangers, tanks, pipelines, and high-voltage insulators, across various environments, from marine areas to refineries, worldwide. As part of an important public project in a waste-to-energy plant with strict requirements in terms of both performance and documentation, the task involved refurbishing and reapplying a protective coating on 6 finned-tube air coolers. The systems were 6 m long, 1 m high, and 0.5 m wide. As they were

used for cooling down fumes at an operating temperature of 140 °C (230 °C Tmax), their surfaces were contaminated with oils and grease, which posed a risk of clogging their finned tubes and, therefore, causing a loss of performance or even plant stoppages. Donelli Alexo was thus required to clean and re-coat them to restore their original functionality and extend their service life. Donelli Alexo started with a chemical cleaning phase of the air coolers to remove oil, grease, and any other contaminants. "The specific surface preparation process implemented is the result of years of experience and extensive testing with a specialist partner to define the best possible treatment protocol," pointed out Vanacore. Simultaneously, casings and manifolds underwent dry cleaning with micro glass beads. "Finally, we applied a protective coating from SÄKAPHEN in 3 layers, performing the necessary intermediate and final polymerization stages to achieve the required dry film thickness (DFT) of 75 µm." "The protective coating chosen for this high-stakes project was Si 14 E, one of our flagship products," noted Christoph Fischer-Zernin, Commercial Director at SÄKAPHEN.

Conflux Joins Honeywell-Led TheMa4HERA consortium



Conflux Technology has joined the Honeywell-led TheMa4HERA consortium (Thermal Management for Hybrid Electric Regional Aircraft), a Clean Aviation project aimed at developing advanced thermal management systems and architectures for next-generation hybrid-electric regional aircraft, with scaling activities for the short-medium range aircraft. The consortium, comprising 28 partners across 10 European countries, is coordinated from Honeywell's international development centre in Brno, Czech Republic. Conflux will apply its thermal management expertise to accelerate the development of innovative, lightweight, additive-manufactured heat exchangers for next-generation aircraft. This includes contributions to multiple projects focused on both Air Cycle Systems (ACS) and Vapour Cycle Systems (VCS) – specifically an air-to-air heat exchanger for ACS, as well as air-to-liquid heat exchangers for VCS evaporator and condenser. Joining TheMa4HERA aligns with Conflux Technology's commitment

to delivering high-performance thermal solutions that enable energy-efficient, low-emission aviation," said Michael Fuller, CEO of Conflux Technology. "Our additive manufacturing capabilities will help the consortium push the boundaries of thermal management design to meet the demands of hybrid-electric propulsion systems." The TheMa4HERA project addresses the growing complexity of thermal management in hybrid-electric aircraft, driven by the increasing integration of heat-generating components such as batteries, fuel cells, and power electronics. The initiative will explore and validate advanced thermal architectures and systems to improve energy efficiency, reduce carbon emissions, and meet evolving sustainability regulations. The program targets the advancement of heat exchanger technologies up to Technology Readiness Level (TRL) 5 through component-level development and system testing.



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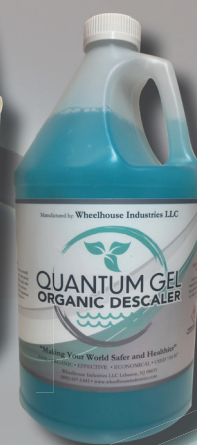
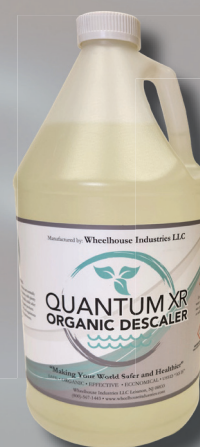
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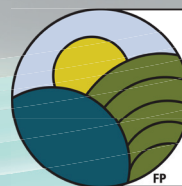
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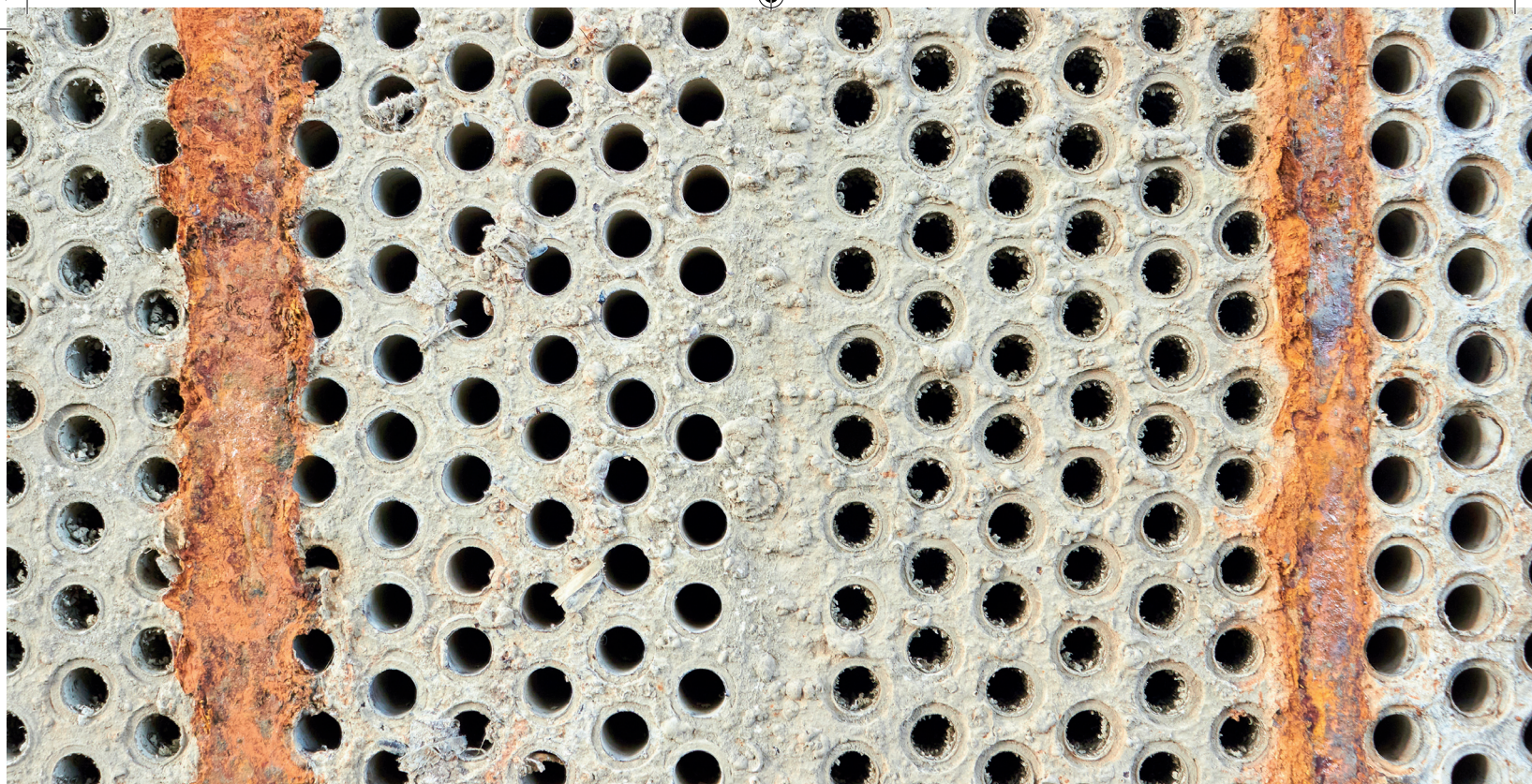
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Enhancing heat exchanger reliability through proactive fouling mitigation and cleaning

The reliable operation of heat exchangers is essential to ensure uninterrupted production, maintain energy efficiency, and prevent costly unplanned shutdowns. Reliability, in the context of heat exchangers, refers not only to mechanical integrity but also to sustained performance over time. One of the most persistent threats to heat exchanger reliability is fouling, the accumulation of unwanted materials on internal surfaces, such as corrosion products, particulates, biological growth, and chemical residues.

By Fawaz Al-Khuliawi, Corporate Maintenance Engineering Consultant, Saudi Aramco

Impact of fouling on reliability

Fouling impairs the ability of heat exchangers to efficiently transfer heat, leading to increased energy consumption, elevated pressure drop, and potential process bottlenecks. If left unaddressed, it contributes to under-deposit corrosion, vibration-induced fatigue, and ultimately, mechanical failure. From a reliability-centered maintenance (RCM) perspective, fouling control and effective cleaning practices are essential elements in extending equipment life, minimizing risk, and ensuring process stability. In highly integrated facilities, the loss of a single exchanger due to fouling can cascade into system-wide inefficiencies or production losses. Hence, proactive fouling management aligns directly with organizational goals of asset performance and operational excellence.

Understanding fouling mechanisms

Fouling mechanisms are multifaceted and depend on the operating environment. Key fouling types include:

- Particulate fouling: sedimentation of suspended solids



Figure 1. Coke fouling accumulation.

- Crystallization fouling: scale formation due to solubility changes
- Biofouling: microbial and algae growth, especially in seawater systems
- Corrosion fouling: accumulation of corrosion byproducts
- Chemical fouling: due to polymerization and reactions

Each fouling type affects heat exchanger performance differently and requires specific mitigation or cleaning strategies. For example, biofouling and corrosion fouling dominate in seawater coolers, while process units may experience coke or catalyst dust fouling.

Reliability-centered approaches

To improve reliability, heat exchanger maintenance should be proactive, data-driven, and risk-based. Key approaches include:

- Design for cleanability
- Performance monitoring



Figure 2. Clogged tubes by severe fouling.



Figure 3. Fouling accumulation on shell side.



Figure 4. Under deposit corrosion.



Figure 5. Biological fouling (algae and microbial slimes).

- Maintenance planning
- Material selection
- Integrated data and inspection management

Operational and process integration

Heat exchanger reliability should be embedded in day-to-day operations through better integration with process control systems. Advanced control loops can automatically adjust flow rates or temperatures to reduce fouling potential. Operators play a crucial role in monitoring equipment behavior, identifying early signs of fouling, and coordinating with maintenance for timely intervention. Incorporating fouling mitigation strategies into operating procedures ensures alignment between production and reliability goals.

Lifecycle reliability and asset management

Reliability practices must extend throughout the entire lifecycle of heat exchangers—from design and procurement to operation and retirement. Risk-based inspection (RBI) approaches prioritize exchangers based on failure probability and consequence. Asset Performance Management (APM) systems can help integrate reliability metrics, inspection records, cleaning history, and risk models into a single platform to optimize decision-making. This holistic view of asset health supports better capital planning, spare parts strategy, and lifecycle cost control.

Standards and best practices

Various international standards guide the design and maintenance of heat exchangers, including API 660 (Shell-and-Tube Exchangers for Petroleum Services), ASME Section VIII (Pressure Vessels), and TEMA (Tubular Exchanger Manufacturers Association) classifications. These standards often include fouling resistance allowances and cleaning recommendations. Benchmarking reliability KPIs — such as Mean Time Between Cleaning (MTBC), fouling factor trends, or exchanger uptime — can provide valuable insight into organizational performance and drive continuous improvement.

Organizational and cultural aspects

Achieving sustained heat exchanger reliability depends on organizational culture and workforce capability. Cross-functional collaboration between operations, inspection, engineering, and maintenance teams is vital to ensure proper monitoring, diagnostics, and response to fouling. Training programs should emphasize the reliability

implications of poor heat exchanger performance and promote ownership of preventive strategies. Leadership must reinforce the importance of proactive reliability and ensure that teams are empowered with tools and authority to act.

Industrial cleaning practices

Cleaning practices are divided into on-line mitigation and off-line cleaning methods. Selection depends on exchanger configuration, fouling type, and plant constraints.

- Mechanical cleaning
- Hydraulic (hydrojetting) cleaning
- Chemical cleaning
- On-Line cleaning techniques

Cost considerations

Cleaning methods are considered cost-effective when compared to the potential for process disruption or asset damage. Embedding cleaning into a broader reliability strategy reduces long-term costs, avoids emergency maintenance, and supports optimal energy usage.

Conclusion

Heat exchanger reliability is a cornerstone of operational excellence in thermal systems. Effective fouling management and cleaning are not merely maintenance tasks, they are integral reliability practices that protect asset integrity, enhance safety, and optimize energy use. From improved uptime to reduced environmental impact, reliability-focused mitigation strategies yield measurable benefits. Organizations must embed these strategies across design, operation, and maintenance disciplines. By leveraging field data, predictive analytics, and innovations in design and materials, industries can ensure their heat exchangers perform reliably, economically, and sustainably throughout their lifecycle. ■

About the author

Fawaz Al-Khuliawi is a Corporate Maintenance Engineering Consultant at Saudi Aramco with extensive experience in project management, plant maintenance, and vendor engagement. He holds a Mechanical Engineering degree from KFUPM and an MBA. He is a Chartered Engineer (IMechE), a CMRP, an AVS-certified specialist, and a registered Consultant Engineer with the Saudi Council of Engineers.



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100 years strong: TC Wilson's legacy of innovation and leadership

Reaching 100 years in business is no small feat. For Thomas C. Wilson, Inc. (TC Wilson), it's more than a milestone, it's a testament to resilience, ingenuity, and a steadfast commitment to solving real-world problems in the boiler industry.

By Iryna Mukha, Heat Exchanger World

Led today by CEO Stephen Hanley, the third generation of family leadership, TC Wilson has evolved from a small New York operation into a global provider of specialized tools, trusted in more than 40 countries. Its century-long success is built on innovation, precision, and a people-first culture.

Built to last: Purpose-driven innovation

What sets TC Wilson apart is its focus on purpose-built products. Instead of pushing off-the-shelf solutions, the company works directly with customers to design tools that withstand demanding industrial environments.

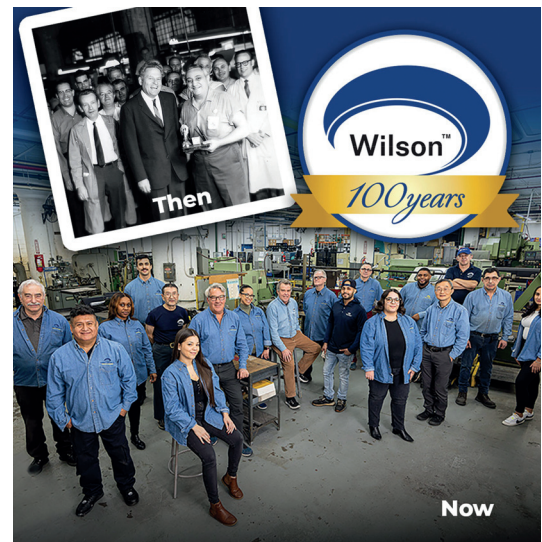
This customer-first approach has fueled many industry breakthroughs, including:

- **Expandable tube cleaning brushes** that transformed maintenance efficiency.
- **Combination beading expanders** that drastically reduced noise during installation.
- **Hydraulic tube cutters** for in-place cutting and beading.
- **Venturi-effect vacuum leak detectors**, still widely relied upon today.

Many of these tools remain in use decades after their introduction, underscoring TC Wilson's reputation for reliability and relevance.

Listening first: Customer as co-engineer

The development process begins in the field. Customers present problems, and TC Wilson responds with prototypes tested under real working conditions until the solution is perfected. This iterative design loop ensures products not only meet theoretical standards but also solve tangible challenges. The company's partnerships with leading



boiler manufacturers such as Cleaver-Brooks and Victory Energy demonstrate its ability to adapt to industry shifts, including the rise of rifled and stainless steel tubes.

Precision manufacturing and purposeful innovation

At TC Wilson, every critical step of production, such as cutting, milling, grinding, and heat treatment, happens under one roof in Long Island City, ensuring quality control, rapid prototyping, and durable finishes. Skilled machinists, many with decades of experience, carry forward a tradition of craftsmanship that sets the company apart. This foundation supports TC Wilson's forward-looking approach as the boiler industry evolves with new materials, efficiency demands, and digital expectations. Recent innovations include tools for rifled and stainless steel tubes, along with a 2024 e-commerce launch that gives customers easier access to ordering and support. By blending precision manufacturing with purposeful innovation, TC Wilson remains closely connected to manufacturers and end users, positioning itself to meet tomorrow's challenges with confidence. ■



▲ TC Wilson's century-long success is built on innovation, precision, and a people-first culture.

HEAT EXCHANGE PACKAGE SUPPLY

CSM owned 25 years of experience supplying heat exchange tubes including titanium & titanium alloy, nickel alloy, stainless steel, duplex & super duplex. In order to make the clients procurement more easily, CSM started to offer package supply including tube, tubesheet (solid or clad, machined available), baffle, dished heads, flange, ring, nozzle, tie rod, etc. You are welcome to ask about packaging inquiries for titanium to nickel alloy.

Material Available:

Titanium

Nickel

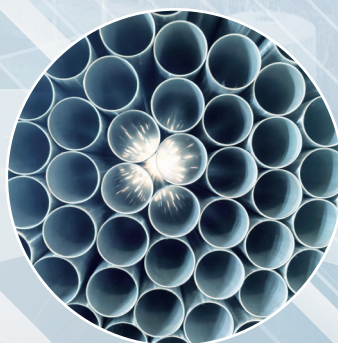
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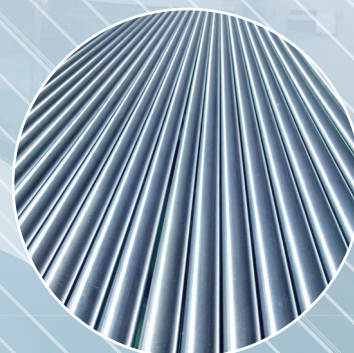
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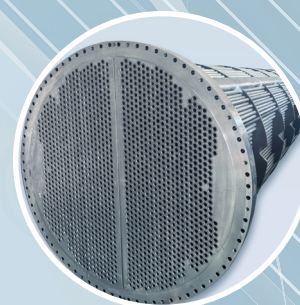
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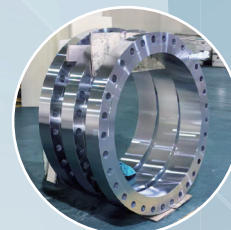
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Preventing weld cracks in BFW preheaters for high-temp hydrogen service

In a high-pressure, high-temperature hydrogen service, the integrity of pressure equipment is critical to the safe and efficient operation of the plant. This is especially true in facilities where long-term exposure, material selections, and demanding operation converge to challenge design assumptions and inspection practices.

By M Norhisyam Awang, Principal Mechanical Engineer, and Nur Athirah Ishar, Staff Mechanical Engineer, PETRONAS

This paper presents a case study from an ammonia complex that has been operational since the late 1990s, focusing on recurrent cracks found in its Boiler Feed Water (BFW) Preheaters. These preheaters, constructed from 2 1/4Cr-1Mo low alloy material, are operating in high-temperature and high-pressure hydrogen service. Despite adhering strictly to the material selection and specifications outlined in API RP 934 and API RP 941, which align with the Nelson Curve operating limits, these units have consistently exhibited cracks in their thick-walled circumferential weldments. The cracks originated from the internal surface and, in some cases, propagated through the full thickness of the material. These recurring incidents have necessitated the removal of the affected equipment, underscoring the severity of the issue and the irreparable nature of the damage.

In response to the incidents, enhanced replacement strategies were developed with stricter fabrication and heat treatment protocols aligned with API RP 934-A standards. Advanced inspection techniques such as 100% Phased Array Ultrasonic Testing (PAUT) at all circumferential welds were implemented. This case highlights the importance of proactive assessments and stringent fabrication requirement and quality controls in maintaining plant reliability and efficiency.

Background

A high-pressure, high-temperature hydrogen production facility operates with multiple heat exchanger systems, including a set of three vertically stacked Boiler Feed Water (BFW) Preheaters in the ammonia synthesis section. These units, shown in Figure 1 — referred to as E-02A, E-02B and E-02C — are designed to transfer heat from synthesis gas to boiler feed water, significantly improving thermal efficiency of the process.

On the tube side, synthesis gas containing hydrogen enters at a temperature of 340°C and pressure of 190 barG. Simultaneously, boiler feed water enters the shell side at around 216°C and 130 barG. The exchangers' function is to recover heat from the hot synthesis gas stream to preheat the feedwater for a boiler, thus recovering thermal energy and optimising process efficiency.



Figure 1. E-02A/B/C installation at site.

Each of these heat exchangers is constructed using low alloy material SA-336 F-22 Cl. 3 (2¼% Chromium, 1% Molybdenum) for the tube side, while the shell side is fabricated from low alloy of same specifications at the front and carbon steel SA-516 Gr. 70 towards the rear side. The tubesheet is also made from SA-336 F-22 Cl. 3 with an Inconel 600 overlay of 6 mm thickness for enhanced resistance against High Temperature Hydrogen Attack (HTHA). The detailed construction is illustrated in Figure 2.

The circumferential weldments discussed for the heat exchangers are as follows:

- CS-01 refers to the weldment between the channel's flat head (item 1) to the channel head's barrel (item 2), both fabricated from low alloy material.
- CS-02 refers to the weldment between the channel head's barrel (item 2) and the tubesheet (item 3), also of the same low alloy.
- CS-03 refers to the weldment between the tubesheet (item 3) and the shell (item 4), which are also of the same low alloy.
- CS-04 refers to weldments between the shell courses (item 4 and 5), and are of different materials—low alloy steel and carbon steel, respectively—requiring careful consideration of dissimilar metal welding.
- CS-05 pertains to the weldments between the shell (item 5) to the rear head (item 6), both

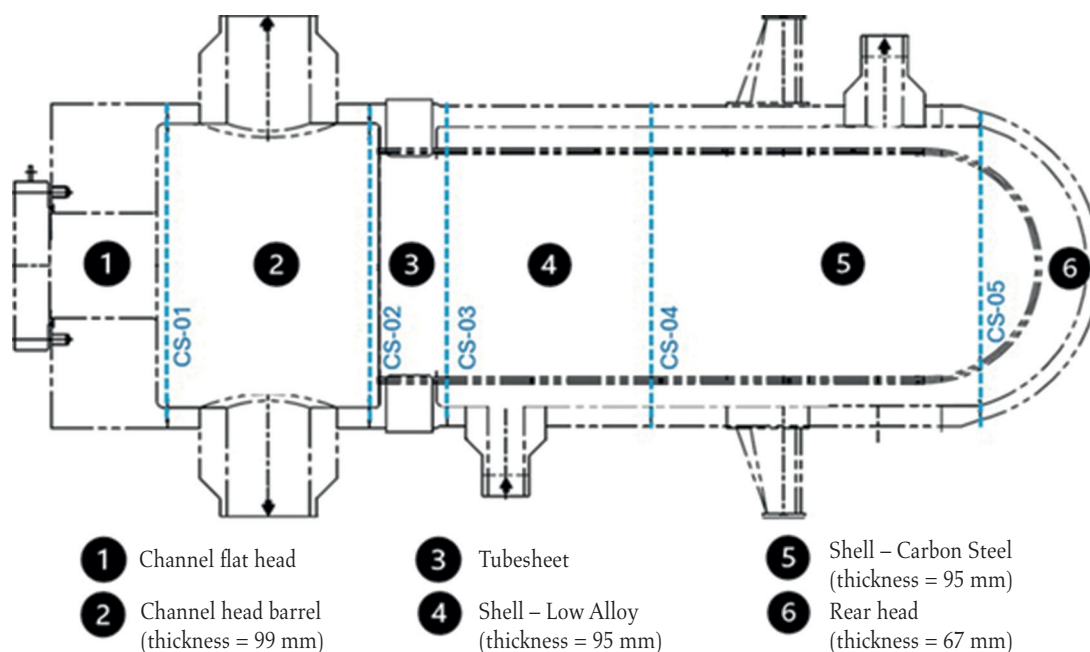


Figure 2. Components and circumferential weldments in E-02A/B/C.

made of carbon steel, which is a relatively lower complexity compared to dissimilar metal and low alloy material joints.

These exchangers are designed in accordance with ASME BPVC Section VIII Division 2 (1995 Addendum) and follow TEMA Class R standards with a DEU-type configuration — characterised by a high-pressure closure and a one-pass U-tube bundle arrangement.

Problem statement

E-02A, at the top of configuration as shown in Figure 3, was the first unit to exhibit signs of degradation in 2010, after more than a decade in service. A leak was observed at CS02 circumferential weldment, indicating that a crack had propagated through the wall thickness. Based on the operational margin of the system and confirmation from Operations and Process teams, the unit was taken out of service while maintaining plant performance with the remaining two units, E-02B (middle) and E-02C (bottom).

Following the installation of the replacement unit for E-02A in 2012 (tagged as E-02A-01), all three heat exchangers continued operating without any incidents until the scheduled plant shutdown in 2018, during which, a proactive internal inspection was carried out on all CS01, CS02 and CS03 circumferential welds of the three units. During the inspection of E-02B, a transverse crack approximately 5 mm in length was identified near the 1 o'clock position at CS02. Additional cracks were also observed in the weldments connecting the pass-partition plate support to both the tubesheet and the channel head. Similar to the E-02A, unit E-02B was removed from service, and operations continued with the remaining two units until the next scheduled shutdown.

Based on the recurrent findings, proactive inspection by means of PAUT was planned during shutdown in

2021. Again, similar findings were observed on the new E-02A-01 and E-02C. The findings revealed a total of two cracks on the weldments of CS01 and CS03 in E-02A-01 and four cracks on the weldments of E-02C – two at CS01 and one each at CS02 and CS03.

Similar failures have been reported in other ammonia plants internationally, where comparable Boiler Feed Water (BFW) Preheaters experienced early-life cracking. In several documented cases, equipment failures occurred within one to four years of service. A published article in the Ammonia Technical Manual (2005) highlighted instances of similar failures of similar heat exchangers characterised by significant transverse cracks after four years of operation. In many

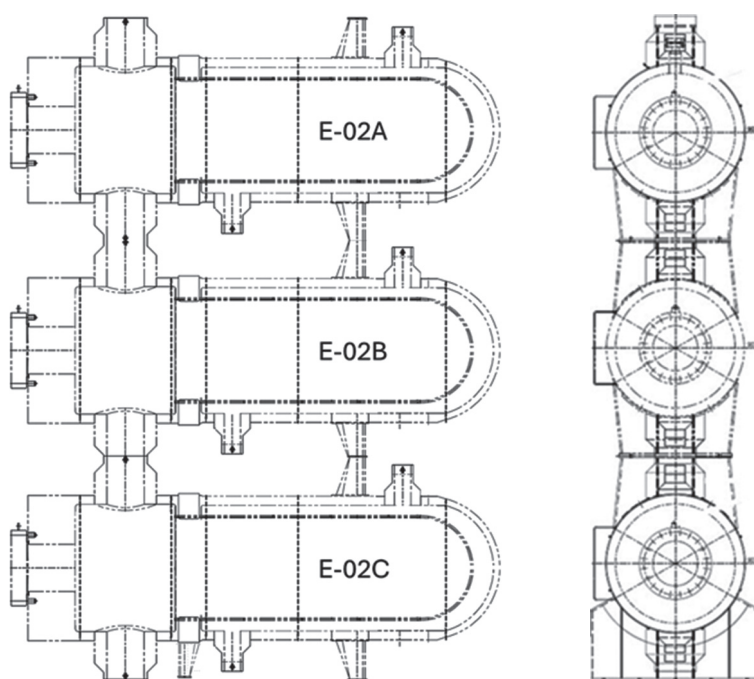


Figure 3. Configuration of E-02A/B/C at site.

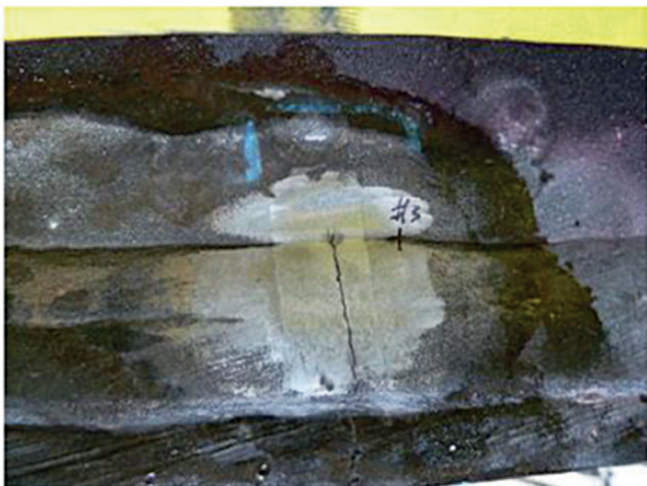


Figure 4. General view of E-02A tubesheet cross section after cutting at CS02.



of these cases, the affected units were removed from service while operations continued with the remaining two exchangers.

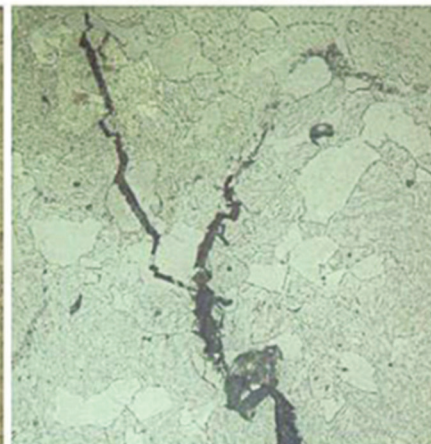
The heat exchangers in these reports shared common characteristics: they were fabricated in accordance with recognised design codes such as ASME Section VIII, BS PD5500, constructed using 2¼Cr-1Mo low alloy materials and operating in high-temperature, high-pressure hydrogen environments.



Examined location #4 OD



Open



Replicated micrographs at 50X (left) and 200X (right)

Figure 5. Cross section view of crack through the thickness (top). Replica test image at magnification of 50x (bottom left) and 200x (bottom right) showing crack propagation in intergranular manner.

These repeated observations suggest that the issue is not plant-specific but rather a systemic concern associated with this type of equipment design, fabrication and service condition.

Findings

E-02A was transported to a fabrication shop, where it was fully sectioned through its CS02 weld joint to expose the cracks and facilitate a comprehensive examination, as shown in Figure 4.

Hardness testing was conducted on the weld and base metal from both the internal and external surfaces of E-02A. The results showed elevated hardness values on the internal areas of weld, ranging from 241 to 345 HB, exceeding the recommended maximum of 225 HB as outlined in API 934-A. In contrast, the base metal exhibited normal hardness readings of 150 to 168 HB on the external surface and 132 to 192 HB internally.

Replica metallography and other NDE confirmed that the cracks propagated in an intergranular pattern across the weld region, with some progressing through the full wall thickness as shown in Figure 5. The cracked areas at the weld joint of the tubesheet also revealed numerous intergranular fissures in the vicinity of the identified cracks especially at the weld and heat affected zone (HAZ) regions.

The findings indicate that high hardness remained in the weld region due to insufficient post-weld heat treatment (PWHT) during fabrication. Specifically, local PWHT was applied externally using heating pads, but no internal thermocouples were used to verify adequacy to the required temperature and holding time. Given the substantial wall thickness, and the vicinity to heavy components such as the tubesheet, heat sinking likely occurred, reducing the effectiveness of PWHT. The high hardness, coupled with residual stresses and other factors such as elevated pressure, temperature gradients, complex geometry, and hydrogen exposure, likely initiated and propagated the cracks observed during inspection.



Figure 6. Thermocouples were installed at internal and external surfaces prior to furnace PWHT.

Improvements

To address the recurrence issues, several critical improvements were implemented in the fabrication process of the new unit of Boiler Feed Water Preheater. These improvements were implemented to enhance the structural integrity, welding quality, and long-term reliability of the equipment, with a particular focus on the challenges associated with high-temperature, high-pressure hydrogen service.

The improvements began with a thorough review of international standards, particularly API RP-934, especially API RP 934-A for pressure vessels made of 2-1/4 Chrome-1 Molybdenum Steel, and API 941 for materials in hydrogen service. Based on these guidelines, a meticulous and comprehensive approach was adopted, addressing key technical aspects such as material and consumable testing, welding techniques, heat treatment methods, and advanced inspection procedures.

One significant improvement was the elimination of local PWHT. Instead, furnace PWHT was mandated for all weldments. Thermocouples were placed on both the internal and external surfaces to ensure uniform temperature distribution and effective stress relief and restoring toughness throughout the weldment and heat affected zone (HAZ), as shown in Figure 6 below. This method mitigates the high hardness and residual stress that can lead to crack formation and growth.

As for welding procedure, it was mandated that Intermediate Stress Relief (ISR) be used instead of allowing the alternative Dehydrogenation Heat Treatment (DHT), even though DHT in lieu of ISR can be considered for non-restrained joints of conventional or advanced low alloy steel grades, and is commonly allowed for conventional steels on non-restrained welds, as per API RP-934-A. Although a DHT will reduce hydrogen, it will not sufficiently restore

toughness, as would an ISR, especially for advanced materials which remain very brittle during pre-PWHT handling. Due to the repetitive crack incidents, even though the material of E-02A/B/C is of only conventional steel grades and the affected joints are not considered as restrained, the authors deemed the ISR would be really contributing and therefore had specified it as a compulsory requirement.

The inspection methods were also significantly upgraded to enhance defect detection in the circumferential welds. While methods like radiography and colour contrast dye penetrant testing (DPT) would normally be effective, their limitations in detecting subtle defects in low alloy steels prompted the inclusion of PAUT, and fluorescent penetrant test. PAUT provides high-resolution, real-time imaging, enabling the detection of cracks with greater sensitivity.



Figure 7. Hardness testing was performed pre and post heat treatment.

This method ensures that even small defects are identified during fabrication, improving the defect-free delivery of the equipment and reliability of the equipment.

In addition to PAUT, hardness testing was emphasised pre- and post-heat treatment, to validate material strength and toughness, ensure compliance with specifications, and detect any defects or anomalies that might have resulted from improper heat treatment as shown in Figure 7. Replica testing was also introduced to detect any microscopic and metallurgical issues that visual inspection might have missed, ensuring comprehensive weld quality evaluation.

These improvements—ranging from enhanced material and consumable requirements, and advanced welding techniques to state-of-the-art inspection methods—are all aimed at improving the long-term reliability and operational safety of the equipment. By doing rigorous root cause analysis and adhering to its findings, API 934 guidelines, integrating industry best practices, these changes ensured that the equipment can reliably perform under demanding operating conditions, minimising risks of failure and maximising operational efficiency.

Moving forward

While several fabrication and inspection improvements have been made to the new units, the possibility of cracks still developing at the weldments in the near or far future of service persists. Therefore, a suitable replacement strategy and permanent resolution must be further developed. This will include proposing a fail-proof design improvement, along with properly engineered heat treatment protocols that can reduce material susceptibility to cracking while enduring the severe high-temperature, high-pressure hydrogen service conditions.

Looking ahead, the next step would involve leveraging on advanced Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD) simulations to further investigate any potential design shortcomings and refine it based on findings from a detailed thermo-mechanical stress analysis. These advanced simulations will enable a deeper understanding of how the equipment responds under actual operating conditions, transient or steady state, highlighting any areas that could benefit from incremental improvements.

Moreover, continuous improvement remains a key focus, aiming not only to address current issues but also to eliminate their root causes permanently. Through ongoing optimisation of design, materials and consumables selection, fabrication processes, and inspection protocols, it will be possible to achieve a higher standard of equipment integrity and reliability.

Conclusion

In conclusion, the comprehensive approach taken in addressing the issues related to the

Boiler Feed Water Preheater Heat Exchanger has successfully incorporated some fabrication improvements, focusing on enhancing material testing, welding practices, heat treatment processes, and inspection methodologies. These actions were driven by a commitment to resolving the root causes of previous failures and improving the long-term reliability of the equipment in high-temperature, high-pressure hydrogen service. The implementation of post weld heat treatment (PWHT) of the whole equipment inside a furnace, making obligatory the Intermediate Stress Relief (ISR) instead of Dehydrogenation Heat Treatment (DHT), and the adoption of advanced inspection techniques such as Phased Array Ultrasonic Testing (PAUT), etc. all served to significantly improve the structural integrity and operational safety of the equipment. The commitment to continuous improvement ensures that the equipment will perform at its highest potential, minimising risks, and enhancing plant operational performance for years to come. ■

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Ir. Ts. Nur Athirah Bt Ishar is a Staff Engineer with 13 years of experience in mechanical static equipment within the ammonia-urea fertiliser industry. Starting her career in Maintenance, she managed reliability programmes and major repairs of pressure vessels, tanks, and heat exchangers. Now a Technical Authority at PETRONAS plant, she leads solutions for static equipment integrity and compliance. She holds a mechanical engineering degree and Graduate Certificate from Stevens Institute of Technology, NJ. A passionate advocate for continuous improvement, she actively contributes to training, seminars, and technical publications. Outside of work, she enjoys reading, gardening, and traveling.



Ir. Mohd. Norhisyam Awang is a Principal Mechanical Engineer with 28 years of experience in the petrochemical industry holding engineering roles at PETRONAS plants including Manager, Reliability, Project and Maintenance Engineer. He specialises in static unfired equipment but also has exposure to rotating, fired, and bulk handling systems. He holds a Bachelor of Science in Mechanical Engineering & Applied Mechanics from University of Pennsylvania, Philadelphia, USA, Master of Business Administration (Muamalah) from Selangor Islamic University and a Grade I Steam Engineer certification. Currently serving as Principal Static Unfired in PETRONAS, he provides vital consultations and solutions for mechanical static issues, leading improvements and establishing best practices for plant equipment, work processes, and technical standards. Off-duty, he enjoys off-roading, scuba diving, and camping.





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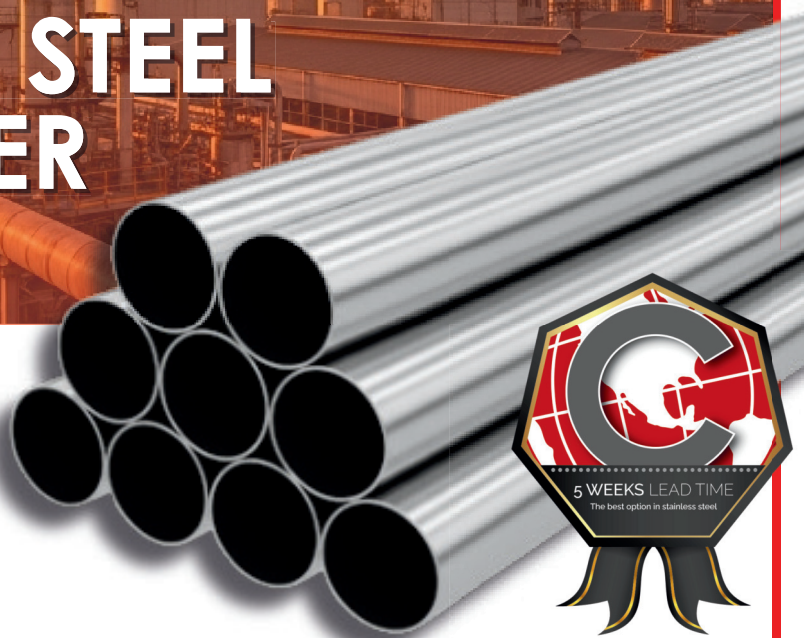
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Conference and Exhibition Information

DATES AND VENUE

The two-day Heat Exchanger World Americas Conference & Expo 2025 is being held on Wednesday, October 15th, and Thursday, October 16th, 2025, at the NRG Center in Houston, Texas. The venue is fully accessible.



The NRG Center

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HEAT EXCHANGER WORLD CONFERENCE 2025

The Heat Exchanger World Americas Conference will be held in conference rooms located in the back of the exhibition floor. Conference delegates are required to collect their badges from the main registration counter and proceed to the conference sessions.



Conference Hours

WEDNESDAY, **October 15th** › 9:45 a.m. – 4:00 p.m.

THURSDAY, **October 16th** › 9:45 a.m. – 4:00 p.m.

SOCIAL PROGRAMS

To make the Heat Exchanger World Expo & Conference 2025 a complete experience, we will also host a special evening networking event.



Post-Event Reception with Local Live Entertainment

WEDNESDAY, **October 15th** › 4:30 p.m. – 6:30 p.m.

All conference delegates and visitors are invited to our post-event reception in the exhibition area. Enjoy live music from The Royal Dukes Band, drinks, and a selection of food in a relaxed setting designed to encourage networking and socializing among industry professionals.

CONFERENCE AND EXHIBITION HOURS

The Conference and Exhibition Registration Counter is located at the main entrance of the Expo Hall. All registrations and collections from Exhibitor Passes, Conference Delegate Badges, and Information will be processed from this counter.



Registration Counter Hours

TUESDAY, **October 14th** › 2:00 p.m. – 5:00 p.m.

WEDNESDAY, **October 15th** › 8:30 a.m. – 4:00 p.m.

THURSDAY, **October 16th** › 8:30 a.m. – 4:00 p.m.

HEAT EXCHANGER WORLD EXPO 2025

More than 70 exhibitors are set to welcome you to their displays, where experienced technical and sales representatives will be on-hand to answer any questions, provide information, and showcase their company, products, and services.



Exhibition Hours

WEDNESDAY, **October 15th** › 9:00 a.m. – 4:00 p.m.

THURSDAY, **October 16th** › 9:00 a.m. – 4:00 p.m.



EXPOFLOOR



CONFERENCE

Welcome To The Heat Exchanger World Americas Conference & Expo 2025!



MESSAGE FROM THE CHAIRMAN

It is my great pleasure and honor, as the Chairman of the Heat Exchanger World Americas Conference and Expo 2025, to WELCOME YOU ALL with enthusiasm and excitement.

The Gulf Coast—Texas and Louisiana—are recognized as major players in the U.S. energy sector, with Houston serving as the energy capital of the world. Houston's vibrant economy and surrounding areas host a high concentration of major EPC companies, heat exchanger fabricators supporting leading Oil & Gas companies, refineries, petrochemical and chemical plants, midstream and pipeline operations, LNG export terminals, offshore production, and more.

This is the only conference devoted specifically to heat exchangers and related cleaning and maintenance industries. It provides a unique platform for individuals to connect, share knowledge and expertise, and learn about new and emerging technologies and products.

The conference includes expert panels and sessions with presentations, discussions, and workshops that highlight the most relevant topics in the heat exchanger industry. The Expo will showcase sponsors' and manufacturers' products, along with service providers, suppliers of raw materials, and tooling. You will also have the opportunity to enjoy interactive discussions with experts as you walk the floor.

I assure you that attending this conference will provide a unique opportunity to learn from exhibits featuring specialized heat exchanger technologies, troubleshoot equipment, and explore ways to increase operating efficiency. I look forward to meeting all of you at the conference over the next two days.

Sincerely,

Jack Piparia,
Engineering Consultant
retired Technip Energies



MESSAGE FROM THE VICE CHAIRMAN

I am looking forward to being the Vice Chairman of the Heat Exchanger World Americas Conference & Expo 2025. This wonderful event provides endless opportunities to allow the heat transfer community to come together, partake in new ways of thinking through extensive knowledge transfer, learning of the latest innovations in heat transfer equipment, cost-saving initiatives, practical solutions, and technical demonstrations. This event will serve as a stage for networking opportunities with some of the most talented individuals in this diverse industry.

Throughout my career, I have gained a wealth of knowledge and expertise in sealing, bolting, training, and technical support. My position at TEADIT in Pasadena, TX has allowed me to oversee its Commercial Team and Application Engineers here in North America. As one of the nation's leading SMEs in Bolted Flange Joints subject matter, I have authored and maintained standards for the assembly of bolted-flanged connections and valve packing installations. During my career, I have had the opportunity to assist end users and OEMs in providing the necessary training to understand bolted flange joints, sealings and gaskets, which is necessary for understanding their connection to heat transfer equipment. Having the opportunity to educate and train is vital to ensuring your heat transfer equipment meets maximum performance; this way, users extend the life expectancy of their assets, improving processes and mitigating common challenges.

As we anticipate meeting one another this October, we invite you to join us at the NRG Center, with your ideas and topics focused on heat exchanger costs, design, performance, maintenance and efficiency in the oil and gas industry. I am confident that there is something for every professional from all levels of expertise at the Heat Exchanger World Americas Conference and Expo 2025. I am looking forward to seeing you all there!

Mark Ruffin,
Vice President of Sales
Teadit North America



October 15th & 16th 2025

NRG Center
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October 15th | Day 1

WEDNESDAY

ROOM 1

9:00 AM	Exhibition floor opens
9:45 AM	Welcome by Conference Chairman Jack Piparia
10:00 AM – 10:30 AM	Keynote 1: U.S. energy outlook and heat transfer market,, <i>Naomi Jabbari</i> , S&B Engineers & Constructors
10:30 AM – 11:00 AM	Keynote 2: Artificial intelligence in petrochemical plant design, operation & maintenance, <i>Bill Ashenhart</i> , Engineering consultant
11:00 AM - 11:30 AM	COFFEE AND NETWORKING ON THE EXHIBITION FLOOR

ROOM 1

11:30 PM – 1:00 PM SESSION:
Heat exchanger design

- Performance enhancement in heat exchanger with various type of tube inserts, *Jack Piparia*, **Engineering consultant**, **retired Technip Energies**
- Changes in ASME Section VIII, div 1 requirements in 2025 edition for HX design, *Ramesh Tiwari*, **CoDesign Engineering**
- The science of vapor infusion nanobubbles and their application in heat exchanger foul elimination, *Michael Radicone*, **HTRI**

ROOM 2

11:30 PM – 1:00 PM SESSION:
Corrosion & materials

- Decoding corrosion: Understanding and controlling iron oxides in closed-loop systems, *Logan Manaranche*, **ODYSSEE USA INC.**
- Alloy 59® and its applications in the oil & gas industry, *Cristian Degano*, **A.D. Tubi Inossidabili SpA**, *Dr. Bill MacDonald*, **VDM Metals USA**
- Introduction of 316A: A unique cost effective grade to replace 316L, *Audrey Allion*, **Aperam Stainless France**

1:00 PM – 2:30 PM **LUNCH BREAK AND NETWORKING ON THE EXHIBITION FLOOR**

ROOM 1

2:30 PM – 4:00 PM SESSION:
Sustainability & emerging technology

- Replacement of old MWK bayonet boiler with latest generation vertical floating head boiler in ammonia plants, *Uma Sankar Khan*, **KBR**
- Feedback on using a bio-sourced product for anti-scaling treatment in cooling tower water, compared to conventional products, *Logan Manaranche*, **ODYSSEE USA INC.**
- Advancements in direct steam injection technology for industrial process heating, *Alex Kolb*, **Pick Heaters**

ROOM 2

2:30 PM – 4:00 PM SESSION:
Fabrication & testing

- How tube-to-tube sheet welds impact wall reduction, *Brandon Fultz*, **Elliott Tool Technologies**
- Supplier quality surveillance process for shell and tube heat exchangers, *David Gonzalez*, **Aramco Americas**
- Understanding reaction forces in hinged and gimbal expansion joints, *Ibere Souza*, **Teadit**



October 16th | Day 2

THURSDAY

ROOM 1

8:30 AM Exhibition floor opens

9:30 AM – 10:00 AM Keynote 3: Vice Chair's Welcome, *Mark Ruffin, Teadit*

10:00 AM – 11:00 AM Panel discussion:
Heat exchanger design & specification: TEMA, API 660 & 661, PIP, ASME, ISO, PCC-1, and end user specs
Panel moderator: *Dinesh Bakshi, Brask*
Panelists: *Mark Ruffin, Teadit; Ramesh Tiwari, CoDesign Engineering; Bill Ashenhart, Engineering Consultant*

11:00 AM - 11:30 AM **COFFEE AND NETWORKING ON THE EXHIBITION FLOOR**

ROOM 1

11:30 PM – 1:30 PM SESSION:
Heat exchanger design

- Enabling high-aspect ratios, thin walls, and production scalability for critical microchannel heat exchangers via pulsed electrochemical machining (PECM), *Daniel Herrington, Voxel Innovations*
- Heat recovery with twisted tube® technology upgrade of feed/effluent heat exchanger at Saraland, *Prashant Jadhav, Metalforms Heat Transfer*
- Case studies in applying dual enhanced finned tubes to improve shell and tube heat exchanger efficiency, *Craig Thomas, Neotiss*
- Hybrid plate heat exchangers transform sugar evaporation, *Osama Olabi, VAU Thermotech*

ROOM 2

11:30 PM – 1:30 PM SESSION:
Design & leak prevention

- Advancing tube plugging: Digital solution to improve reliability, conformance, and traceability, *Danko Kobziar, Curtiss-Wright – EST Group*
- Modernizing bolted joint performance in new and aging heat exchanger systems, *Noah Detjens, A.W. Chesterton Company*
- Sealing performance of various pass bar rib gasket styles, *Robert Taylor, 3S Superior Sealing Services LLC*

1:30 PM – 3:00 PM **LUNCH BREAK AND NETWORKING ON THE EXHIBITION FLOOR**

ROOM 1

3:00 PM – 4:00 PM SESSION:
Maintenance & cleaning

- Addressing the limitations of HEX maintenance with safe and cost-effective organic descaling solutions, *Ken Marko, Wheelhouse Industries LLC*
- Continuous online cleaning of heat exchangers, condensers and evaporators, *John Panarese, Taprogge*

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Floorplan



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Staying competitive with smart inspection

In industrial systems where safety, uptime, and precision matter most, identifying damage before it escalates is critical. Regulations such as the German Ordinance on Industrial Safety and Health (BetrSichV) require proactive strategies to prevent hazardous situations. Acoustic Emission Testing offers an innovative, real-time solution for monitoring asset integrity, helping to streamline maintenance and extend inspection intervals. TÜV SÜD demonstrates how this advanced testing method can also lead to significant cost savings while supporting smooth production processes.

*By Rainer Semmler, Head of Process Safety Management,
Hermann Schubert, Head of Digital and Continuous
Inspection, TÜV SÜD Industrie Service*

As industries face increasing demands for modularity, adaptability, and continuous output, traditional inspection approaches are reaching their limits. These methods — often cyclical and invasive — cannot easily accommodate the fluctuating stress profiles modern systems endure. Acoustic Emission Testing (AT) presents a viable alternative. It is a sensor-based technique that captures acoustic signals emitted by structural changes in materials, such as crack propagation or corrosion onset. AT sensors detect transient elastic waves that originate from subtle vibrations or displacements in structural integrity, even if they are mounted externally on equipment surfaces. Normally, a piezoelectric measuring principle is used for these



➤ A flat-bottom storage tank is inspected using Acoustic Emission Testing.

sensors. Once activated, they continuously monitor the system and feed data into specialised software. This allows for both high-resolution monitoring and pinpoint localisation of anomalies, all “without” halting operations. By avoiding shutdowns, operators maintain throughput and eliminate many risks associated with opening systems. Additionally, components are not exposed to cleaning agents, humidity, or potential contaminants. Moreover, AT can be adapted to various component geometries and materials, making it ideal for stainless steel piping systems, pressurised equipment, and integrated machines such as pumps, mixers, and compressors.

Monitoring materials and mechanisms in demanding environments

In industrial facilities that handle aggressive media, high pressures, or extreme temperatures, corrosion-resistant alloys (CRAs) — such as austenitic stainless steels, duplex grades, and nickel-based alloys — are fundamental to ensuring long-term structural integrity. These materials are chosen for their ability to withstand harsh chemicals, mechanical stress, and thermal cycling. As a result, CRAs are widely used in pressurised equipment, piping systems, and rotating equipment across sectors like chemical processing, energy, and water treatment.



➤ Acoustic Emission Testing: Sensors on a process vessel.



⚠ Hazardous conditions or events must be avoided. For this purpose, recurring inspections must be carried out in process engineering plants in accordance with the BetrSichV (Ordinance on Industrial Safety and Health).



⚠ Pressure gas containers for the transport and storage of hydrogen, for example, are also subjected to inspections using Acoustic Emission Testing.

However, while CRAs offer high performance, they are not immune to damage. Welds, flanges, and load-bearing zones can experience fatigue, stress corrosion cracking, or microstructural deterioration — often in ways that are difficult to detect visually. AT provides an ideal monitoring solution by capturing high-frequency signals generated by material distress. AT sensors are mounted externally on equipment surfaces and detect even subtle discontinuities or shifts in structural integrity. Additionally, inspections can be performed without disrupting operations or exposing sensitive surfaces to contaminants that could compromise the passive oxide layers critical to CRA performance.

Within these same operational environments, heat exchangers present a complementary challenge. Though they may be constructed from the same corrosion-resistant materials, they function as thermal control systems used to condense vapours, recover waste heat, or cool process fluids. Exchangers are often subjected to intense thermal cycling, high flow velocities, and chemically reactive conditions. This makes them susceptible to tube cracking, joint fatigue, and erosion, especially in designs like shell-and-tube or plate exchangers, where internal access is limited.

Here, too, AT offers a significant advantage. It allows operators to monitor the structural health of exchanger units in real time, identifying subtle signs of internal failure long before they escalate into system outages or compromised thermal performance. Because AT works without dismantling the equipment, it supports a shift toward condition-based maintenance, reduces unnecessary downtime, and extends service intervals for these critical subsystems.

While CRA-based infrastructure and heat exchanger assemblies differ in function, they often operate side by side — subjected to similar environmental stressors and degradation mechanisms. AT enables both to be assessed under a single, non-invasive methodology, offering a unified approach to asset integrity in demanding process conditions.

Real-world example: Cost reduction in practice

A typical polymer resin production facility can provide a compelling case for the benefits of AT. Traditionally, such a plant conducted annual hydrostatic testing at a cost of approximately €1 million. By transitioning to AT, the operator would achieve measurable savings across several categories.

Breakdown of annual savings:

- Avoided two-day production stoppage: EUR 160,000
- Eliminated fluid-based inspection process: EUR 200,000
- Avoided gasket and seal replacements post-inspection: EUR 25,000
- Reduced unplanned maintenance by 80%: EUR 40,000
- Enabled simultaneous testing of multiple pressure circuits: EUR 100,000
- Limited follow-up inspections to high-risk areas: EUR 50,000
- Extended lifespan of key components: EUR 10,000

Total potential savings: EUR 585,000 annually

Conservative implementation (70%): EUR 410,000 annually

The switch to AT not only cut direct inspection costs but also allowed for smarter allocation of maintenance resources. Labour and material use were reduced, and the asset health insights gained from AT enabled better long-term investment planning.

Optimising inspection cycles

The value of Acoustic Emission Testing extends beyond fault detection. By capturing real-time

operational data, AT allows engineers to build an evidence-based view of how components degrade over time. This supports condition-based maintenance, enabling inspection intervals to be shortened or extended based on actual equipment status rather than fixed cycles.

When anomalies such as sudden changes in acoustic signal patterns are detected, engineers can interpret these with intelligent, AI-supported software tools. Depending on severity and localisation, decisions are made to either repair the defect, monitor it further, or plan replacement. All actions are documented and must be reviewed with inspection institutions, such as TÜV SÜD, to ensure compliance with national and international inspection standards.

Enhancing integration and reducing strain

One of the strongest features of AT is its compatibility with other non-destructive testing methods. It can complement radiographic or ultrasonic inspections and, because of its live-monitoring capability, guide the timing and scope of these supplementary methods. Rather than inspecting every weld or tube, operators can use AT data to focus on areas showing acoustic anomalies — saving time and inspection effort. Moreover, AT can be performed using the present fluid, eliminating the need for drying processes and preventing issues like residual moisture-induced corrosion and contamination.

Conclusion

Acoustic Emission Testing represents a pivotal advancement in industrial inspection. By combining real-time data collection with non-invasive procedures, it delivers a holistic view of equipment health while reducing costs and downtime. Its application is particularly beneficial in stainless steel and heat exchanger systems, where early damage detection, protective layer preservation, and inspection flexibility are essential. With proven success in operational environments and compliance with regulatory frameworks, AT offers a practical path forward for industries seeking more efficient ways to manage asset integrity. ■

About the authors

Rainer Semmler is the Head of Process Safety Management at TÜV SÜD Industrie Service, a branch of TÜV SÜD specialised in the inspection and testing of plants, infrastructure facilities and buildings. With a degree in process engineering, Semmler has worked in the process industry since 1991 and was declared an expert according to Section 29 a/b of the German Federal Immission Control Act in 1998. He has been with TÜV SÜD since 2011.



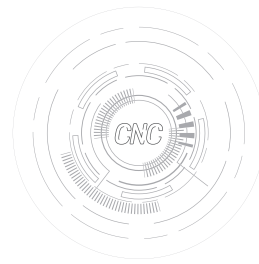
Hermann Schubert is Head of Digital and Continuous Inspection at TÜV SÜD Industrie Service. With a degree in metallurgical engineering, Schubert specialised in damage mechanisms and advanced non-destructive testing (NDT). Certified Level 3 in Acoustic Emission and Ultrasonic Testing, Schubert has been instrumental in developing smart inspection solutions and asset health monitoring strategies. He joined TÜV SÜD in 2020.



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♣ Coconuts are highly versatile, capable of producing food, fuel, cosmetics, building materials, growing media and cosmetic compounds.

Multiple roles for heat exchangers in coconut processing

The coconut tree (*Cocos nucifera*) is one of the world's most versatile and valuable plant species. Capable of producing food, fuel, cosmetics, building materials, growing media and cosmetic compounds, it's no wonder that in the Philippines, the coconut is known as the Tree of Life. The global market for coconut products is predicted to reach \$53.4 billion by 2033¹, thanks to annual growth rates of around ten per cent.

By Francisco Hernández Ortiz, Global Food Projects Director at HRS Heat Exchangers

The increasing demand for coconut products is driven by a number of factors, including the sheer versatility of the coconut palm itself. Consumers are more and more aware of the health benefits of coconut milk and water, while products such as cocopeat (coir) and coconut oil are more sustainable inputs for industries such as horticulture and cosmetics.

Increasing demand is not only boosting coconut production in traditional areas such as India, Sri Lanka, and Southeast Asia, but also accounts for new areas of production such as Latin America

and Africa. At the same time, the development of local processing facilities is helping to increase production and export potential, while also ensuring that valuable revenues are kept in the local market.

Coconut's multiple uses

Coconut oil accounts for the largest value of coconut-derived products (around 55%²), followed by coconut water (the fastest growing product), coconut milk, desiccated coconut and other products and co-products (such as coir). As an edible oil, not only does coconut oil have a unique fatty acid composition including the presence of healthy medium-chain triglycerides (MCTs), but it also has a high smoke point and distinct flavor. As interest in plant-based alternatives to dairy products has increased, so has the demand for coconut products, with coconut milk being used in place of similar products such as cream. Coconut water is a natural electrolyte-rich drink, and a diverse range of varieties has evolved, such as flavored coconut water, coconut milk blends, and desiccated coconut. In addition, coconut flour and

desiccated coconut are increasingly being used as gluten-free alternatives to wheat products in baking and other food applications.

A burgeoning demand for coconut products in the cosmetics, personal care and pharmaceutical sectors is being driven by the natural moisturizing properties of ingredients like coconut oil, which is recognized for its skin-friendly attributes. As if this wasn't enough, the fibers from the coconut husk are useful as a renewable growing media for gardeners and in professional horticulture; coconut sap can be used to make a range of products from vinegar and sugars to vegan nectar and honey alternatives; while palm fronds are often used locally for construction, making everything from baskets to boats.

Thermal processing considerations for coconut products

Coconut water

The wide range of coconut products means that many different processes are employed in their production. However, in many areas heat plays an important role. For example, coconut water (which is taken from fresh coconuts) reacts quickly once the coconut has been opened, meaning that aseptic processing and packaging are required. The HRS AF Series of aseptic fillers is ideally suited to coconut water, with a range of nozzle sizes and the ability to work with pre-formed and pre-sterilized bags of between 5 and 1,000 liters capacity.

At the same time, being 92-95% water, coconut water can be expensive to transport, so evaporation is often used to reduce volumes before shipping and further processing. A special version of the HRS Unicus Series is available for evaporation

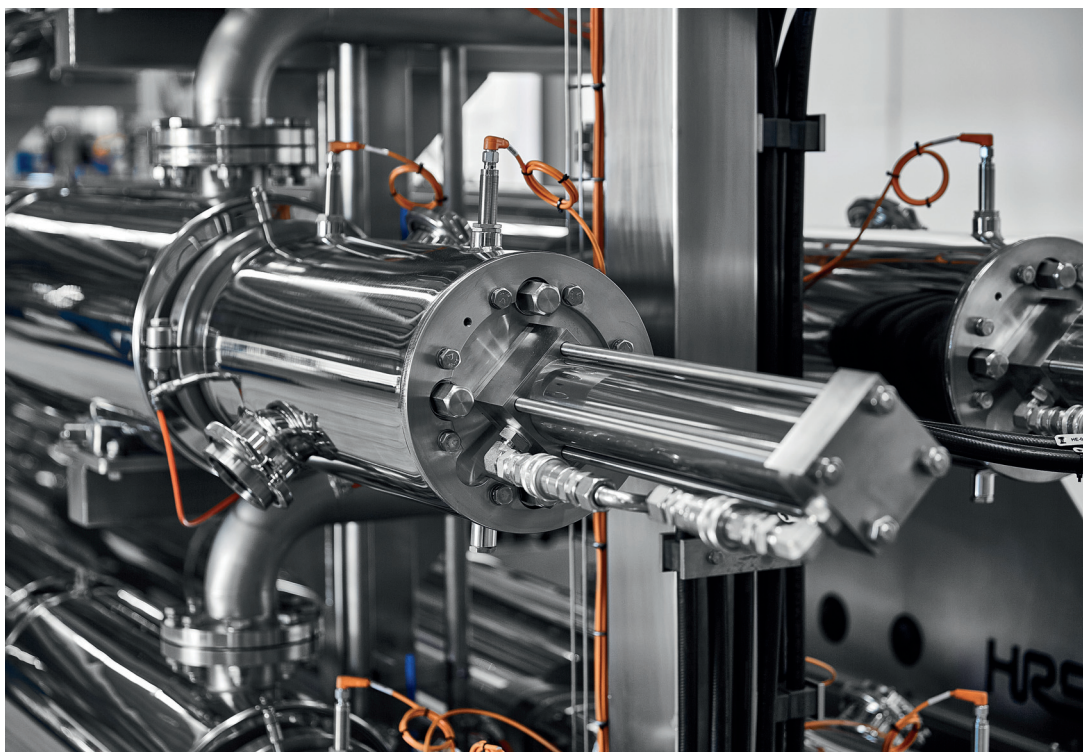


➤ The HRS AF Series of aseptic fillers is ideally suited to coconut water.

applications, utilizing a shell and tube heat exchanger with scraping rods in the interior tubes.

Coconut milk

Coconut milk and cream are produced from mature coconuts and as such, different products (light milk, milk, cream and cream concentrate) have different properties. They also react in different ways, meaning the correct choice of processing is crucial, particularly in terms of pasteurization. As with other plant-based milk alternatives, the HRS DSI Sterilizer, which uses direct steam injection to sterilize the product, brings a number of benefits. The system works by rapidly injecting steam into the product, instantly heating it to the ultra-high temperature. This is immediately followed by condensation in around 0.1



➤ The HRS Unicus Series has a characteristic reciprocal action ideal for processing coconut milk.



~ The HRS DSI Steriliser uses direct steam injection to sterilize products such as coconut milk.

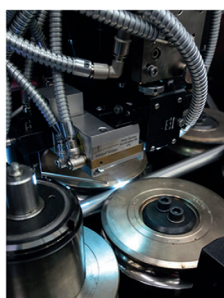
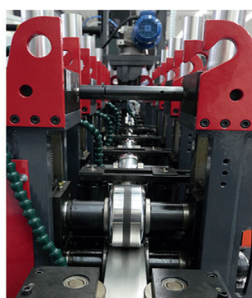
second, equalizing the temperature. Short heating time and high sterilization temperature ensures that product taste and colour are not damaged while microorganisms and spores are neutralized. Another consideration when processing coconut milk is that its fouling potential increases with

treatment temperature³. Because coconut milk is a homogenized mixture of water and coconut flesh, it is also important that physical stresses do not result in shearing or separation of the product. This can mean that many scraped surface heat exchangers are too aggressive to be used. Conversely, corrugated



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tube heat exchangers, such as the HRS MI Series, or a gentle scraped surface heat exchange like the HRS Unicus Series (with its characteristic reciprocal action) are ideal for processing coconut milk.

Coconut oil

Coconut oil is extracted from the dried coconut kernels known as copra. Pre-treatment heating to between 40-60°C has been shown to not only improve oil yields, but also to deactivate some

of the enzymes in the oil, which could otherwise affect the final quality. Depending on the end use, it may be subject to a wide range of subsequent processing including hydrogenating, degumming, deacidification, decolorization, and deodorization – all of which need accurate temperature control at a range of different temperatures.

Because many of these processes also generate large quantities of steam, there is significant scope to install heat exchangers to condense this steam for reuse, and many systems will be designed to maximize energy recovery (energy regeneration) to improve overall energy efficiency and reduce costs. With more than forty years' experience in the thermal processing of vegetable oils and coconut products, HRS Heat Exchangers has a wide selection of both standalone heat exchangers and integrated systems for use in coconut processing. Contact us today so we can help you find the optimal solution for your requirements. ■

About the author

After graduating as an industrial technical engineer from the Universidad Politécnica de Cartagena (in Murcia, Spain) in 1990, Francisco worked in the refrigeration, air conditioning and food machinery manufacturing sectors. He joined HRS Heat Exchangers in 1994 as a Design Engineer and played a crucial role in developing the Engineering Office in the rapidly expanding company. In 2010 Francisco was appointed as the global Food Business Director for HRS. In this role he supports the various HRS Group sales offices around the world. His extensive technical knowledge, acquired during his years as a design engineer, along with his ability to understand the needs of the client, have made Francisco one of the top experts in the food processing industry.



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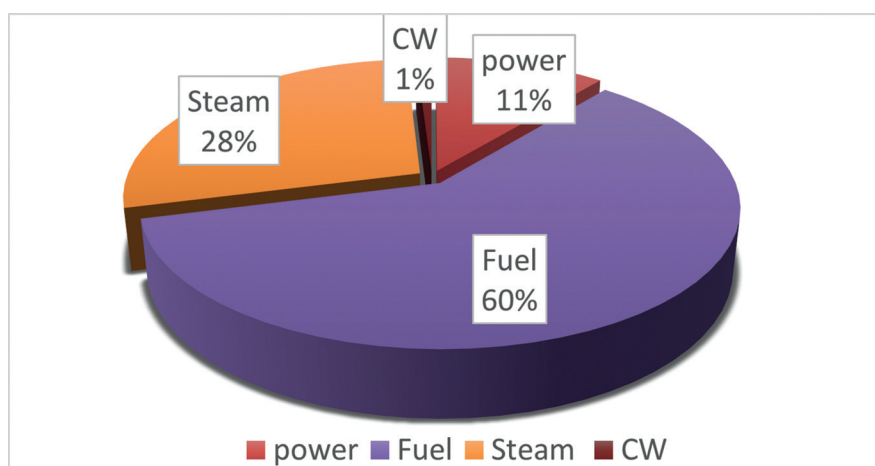
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Energy optimization with VSD in air coolers

Variable Speed Drives (VSDs) are emerging as one of the most effective solutions for optimizing energy use in refinery air coolers. By precisely matching fan speed to process and environmental conditions, VSDs minimize unnecessary power consumption, improve efficiency, and reduce noise. This article examines their advantages over traditional control methods and highlights the potential savings achievable through their application in ACHE systems.

By Uma Sankar Khan, Technical Professional Leader, KBR

Refineries are designed to handle a wide range of crudes to have greater operational flexibility. These crudes usually differ widely in their characteristic, resulting in quite different yield patterns. As final product destination conditions are broadly outlined, equipment is specified and designed catering to various operating conditions. The Air-Cooled Heat Exchangers (ACHE) are no exceptions. ACHEs are typically designed and optimized to cater to a variety of operating conditions usually under various stringent scenarios (i.e., maximum process duty while encountering maximum ambient temperature) because of the seasonal variations in the ambient temperature during the year and the change in type of crude processed. ACHEs without proper control of airflow will supply too much cooling air most times of the year, leading to higher power consumption. ACHEs are extensively employed in refineries to reduce the temperature of process streams to about 60-65 °C, which is then followed by a water cooler to cool the process streams to their respective desired temperature. ACHEs typically account for about 10-15% of the total power required in primary distillation units, which translates to approximately 2-3% of the total energy required in these units.



▲ Figure 1. Energy usage profile in CDU/VDU.

As air coolers are predominantly operated at lower heat duty and ambient temperature than their design conditions, there exists extensive potential for energy saving. In this paper, energy conservation opportunities in refinery ACHEs are addressed using variable speed drives/variable frequency drives (VSD).

Regulation of air flow

A fan without a flow controller supplies too much cooling air most of the year and thus often leads to unwanted sub-cooling of the products. Furthermore, the power consumption of the fan supplying the full air volume is unnecessarily high. Reducing airflow as conditions permit can result in substantial power saving and reduced noise level, since former goes with the third power of the airflow requirement. To match the system requirements with the fan output, one of two basic approaches may be adopted. One approach is to change the system curve and the other is to change the fan performance curve. Some of the most commonly employed approaches are described below along with their advantages and disadvantages.

- **By placing damper:** For flow throttling, a damper is placed upstream or downstream of the fan, and the system curve is modulated to give the desired airflow rate. This mode of controlling fan capacity is energy inefficient, noisy, and may also lead to flow instabilities.
- **By shut down of individual fan:** This is achieved by shutting off one of the two fans in each bay. On-off fan control is simple, but it can cause problems in ACHEs such as water hammering, tube-to-header leakage, nozzle-flange leakage and so forth. Power saving depends solely on operators' judgement, and greater operator interventions are also required in this case. Moreover, shutting off a fan causes step change leading to instabilities in the process. Due to its very nature, it does not permit savings of full potential.
- **By controlling pitch of the fan:** For energy-efficient control of fan capacity, it is always preferred to change the system curves. The fan's blade angle or rotational speed may be changed to adjust the fan's performance curve. To change the blade angle, thereby controlling the fan capacity, either manually adjustable or auto-variable fans are adopted. However, energy conservation for manually adjustable fans depends solely on the efficiency of the operator; for manual adjustment of the pitch, a temporary shutdown of the fan may be

required. Therefore, auto-variable fans are preferred over manually adjustable fans. These fans automatically adjust pitch in response to a preset operating variable (mainly, product outlet temperature). The most frequent complaints about variable pitch involve its reliability. Many instances of the fan blade getting stuck due to various reasons have been reported. Furthermore, with variable pitch fans, the motors run with the same speed but at lower load, adversely affecting its efficiency.

- **By changing speed of the fan:** Changing the fan's rotational speed also changes the fan's characteristics and reduces airflow with substantial power savings and reduction in noise level. Variable voltage DC motors, using transformers and rectifiers may be used for controlling the fan's rotational speed. However, such DC motors require frequent maintenance, and their part load efficiency is very poor. By changing the number of poles of the fan's induction motor rotational speed, operating with pole changing motors may be controlled with only a few discrete values and may cause system control problems. Therefore, full potential of power saving is not realized in actual practice by the above measures.

Inherent characteristics of fan-motor system

The energy-saving potential of different air flow controls mechanisms, discussed above, are limited due to their inherent characteristics, briefly discussed below.

- **Fan efficiency:** Efficiency for a fan of particular design is a function of the fan's geometry (such as diameter, hub diameter and tip seal) and airflow (i.e., pitch). For auto-variable fans, the blade angle at clevis is changed to adjust the pitch. At or near full load, a fan's efficiency is changed very little. Reducing the velocity by reducing the blade angle results in a change in efficiency because velocity is reduced while the RPM remains constant.
- **Motor efficiency:** Three-phase induction motors are used mainly to drive the fans. As the air flow requirement decreases due to reduction in ambient temperature, the motor operates at part-load conditions. Efficiency and power-factor of an induction change with the loading of an induction motor. Until 50% loading, variation in motor efficiency and power factor is negligible. However, the efficiency and the power factors are significantly lower than their full load values for induction motors operating with 40% of the design load or less. This results in lower efficiency for fixed blade and auto-variable fan-motor systems. Typical electrical motor efficiency under different load condition is shown in Figure 2. It is evident from the above that the total efficiency of the motor and fan system decreases significantly at lower than design load.

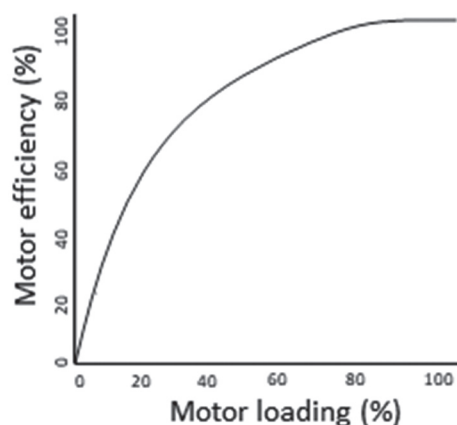


Figure 2. Variation of electric motor efficiency under different loading for constant speed-motors.

VSDs as energy-saving devices

VSDs provide the best way to control air flow, in terms of energy efficiency and operational flexibility. Variable frequency drive technology has been underutilized and its potential not yet realized to convert power in refineries. Optimum system performance can be achieved if the fan, the VSD-motor unit, and the accessories are selected with adequate precaution. Use of VSD allows power savings on account of the following:

- Change in process duty due to change in throughput and/or type of crude being processed
- Seasonal and daily variations in ambient temperature

The power saving potential is fully exploited by maintaining motor efficiency at reduced load. Most of the saving will occur when the variation in type of crude and seasonal temperature variation are accounted for. As mentioned above, the ACHes are typically designed for maximum ambient temperature encountered in the geographical area. Even in the middle of the summer, ambient temperature varies significantly between day and night. Hence, power saving is possible daily. The typical power requirement for fixed blade fans, auto-variable pitch fans, and fans with VSD at different ambient temperatures is shown in Figure 3A.

Case study

An air temperature of 39 °C is considered where ACHes are followed by water coolers. When the ambient temperatures rise to 45 °C, the ACHes will underperform. But downstream water cooler is designed to take care of additional duty under such an eventuality.

Approach: Based on the site average climatological data presented in Figures 3A and 3B, the whole year is divided into four temperature zones by combining those months where the maximum and minimum temperatures are similar. In addition to seasonal temperature changes, daily temperature variation also takes place and is accounted for.

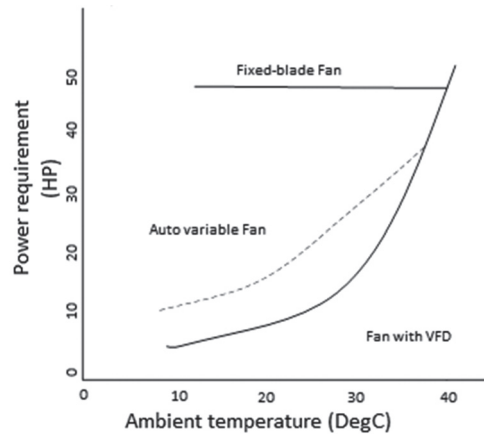


Figure 3A. Variation of electric power requirement for the fan-motor system under different ambient temperatures.

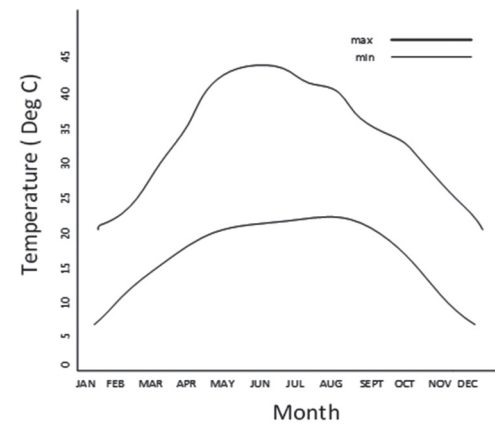


Figure 3B. Month wise variations in ambient temperatures.

Evaluation:

- **Airflow requirement:** Required airflow and static pressure are obtained from different ambient temperatures from detailed simulation of the ACHE's design using actual design software. Typical results are shown in Figure 4.
- **Power requirement:** For fans with fixed blade angle air flow, rotational velocity of the fans is not changed to control the air flow, but the air flow is throttled to reduce it. This is the most energy-inefficient operation of the fan motor system and practically results in no savings.

For auto-variable fans, the blade angle at clevis is changed to match the required airflow and static pressure for different ambient conditions, keeping the original speed of the fan same. Performance equation of motor fans have been used to calculate the power requirement by an auto-variable fan operating under different ambient conditions.

The rpm of a fan operating with VSD is changed to match the required airflow and static pressure with variable ambient temperature, keeping the original blade angle at clevis of the fan the same. Reducing velocity using a variable frequency drive does not result in a change in efficiency since the velocity and the rotational speed are reduced by the same proportions. The pitch, therefore, remains constant.

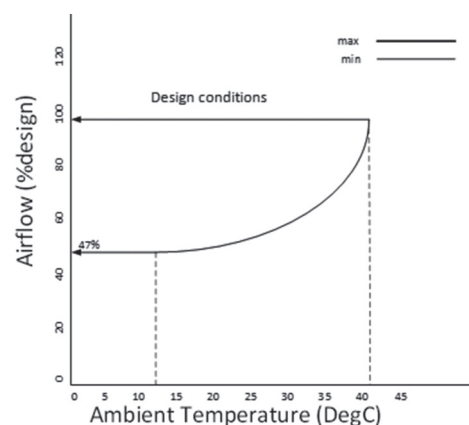


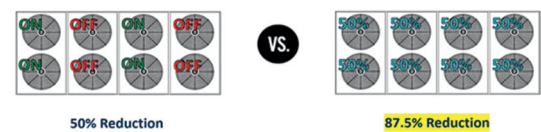
Figure 4. Required airflow and static pressure under different ambient temperatures.

Saving in power due to change in rpm is estimated using the characteristic and performance equations of Moore Fan.

$$\frac{GPM_1}{GPM_2} = \frac{RPM_1}{RPM_2} \rightarrow GPM_2 = GPM_1 \left(\frac{RPM_2}{RPM_1} \right)$$

$$\frac{TDH_1}{TDH_2} = \left(\frac{RPM_1}{RPM_2} \right)^2 \rightarrow TDH_2 = TDH_1 \left(\frac{RPM_2}{RPM_1} \right)^2$$

$$\frac{BHP_1}{BHP_2} = \left(\frac{RPM_1}{RPM_2} \right)^3 \rightarrow BHP_2 = BHP_1 \left(\frac{RPM_2}{RPM_1} \right)^3$$



Energy savings potential:

Refineries can reduce fan speed by 20-30% using VSDs, leading to 25-35% energy reduction.

- Example: Speed control vs on/off cycling;
Demand = 50%
 $Power_2 = (1/2) Power_1$

Motor Configuration:

- Typically, 50% of fan motors are manual on/off and 50% are variable speed.
- If needed, 100% of motors can be variable speed for enhanced efficiency.

Conclusion

A rated capacity saving of at least 20% could be realized on account of seasonal temperature variation and duty variation owing to different processed crude. In case of units not operating normally at a rated capacity throughout the year, power saving will still work out to be higher.

The payback period for other refineries (capacity and location) may vary depending on site-specific conditions such as seasonal temperature variations and the varying types of crude being handled. In addition to energy saving as a result of reductions in speed, tremendous reduction in the ACHE's noise level is also of great advantage. ■



How to prepare your carbon data for CBAM compliance

The EU's Carbon Border Adjustment Mechanism (CBAM) is reshaping international trade by requiring importers of carbon-intensive goods to account for their embedded emissions. With reporting obligations already in force and full compliance due by 2026, businesses must prepare robust systems for data collection, verification, and supplier engagement. This guide outlines practical steps to help organisations meet CBAM requirements and strengthen their role in global decarbonisation.

By Dr Alejandra Zazueta Lopez, Biodiversity Scientist, BSc, PhD, Tunley Environmental

The Carbon Border Adjustment Mechanism (CBAM) is the European Union's landmark policy to prevent carbon leakage and promote global decarbonisation. As the EU tightens its climate goals under the European Green Deal, CBAM aims to ensuring that imported goods are subject to the same carbon costs as those produced within the EU. If you're a business importing certain carbon intensive goods into the EU such as iron and steel, aluminium, cement, fertilisers, hydrogen, or electricity, you are now subject to CBAM reporting requirements. The transitional phase of CBAM began in October 2023, requiring importers to submit quarterly reports on the embedded emissions of covered goods. By 2026, full compliance will be enforced, including the purchasing of CBAM certificates based on verified emissions.

As companies gear up for this new regulatory landscape, accurate and high-quality carbon data is essential. Here's a clear guide to help your organisation collect high quality data for CBAM compliance.

Step 1: Understand your CBAM obligations

Before diving into data preparation, it is important to determine whether your company is subject to CBAM and what goods you import fall under the scope. During the transitional phase, importers must submit CBAM reports every quarter via the EU's CBAM Transitional Registry.

Each report must include:

- Total embedded emissions (both direct and indirect) per tonne of imported product.
- Production site details of non-EU suppliers.
- Methodologies used to calculate emissions.
- Verification status (verification is optional in the transitional phase but required later).

Knowing exactly what to report and by when helps you prioritise data collection and supplier engagement.

Step 2: Map your supply chain

CBAM focuses not just on the final imported goods, but on how and where they were produced. Start by mapping your supply chain

for all products within the CBAM scope. This includes:

- Identifying non-EU suppliers and production facilities.
- Understanding the production processes involved (especially energy-intensive steps).
- Collecting supplier contact information and establishing communication channels.

This mapping exercise is the foundation for gathering reliable primary data from your suppliers, which is preferred over using default values.

Step 3: Collect primary emissions data

Primary data is key for CBAM compliance. You should aim to collect actual emissions data from suppliers, including:

- Direct emissions from production (e.g. combustion of fossil fuels on-site).
- Indirect emissions from electricity consumption (based on the regional or national grid mix).

Data collection from your suppliers is one of the biggest challenges and probably the most time-consuming task for CBAM declaration. Creating a strong communication channel with your suppliers is essential to reduce uncertainties and avoid last minute hassles. When requesting data, ensure suppliers are aware of the EU-approved calculation methods, such as those in the EU's CBAM Implementing Regulation or ISO standards.



By a joint effort with businesses and their international suppliers it is possible to make an important positive impact into climate change mitigation.

Encourage them to maintain documentation and logs to support future audits.

Step 4: Apply the correct methodology

CBAM requires that emissions be calculated using specific methodologies. These should:

- Align with EU guidance (e.g. EU ETS Monitoring and Reporting Regulation).
- Include all relevant emission sources and account for carbon content in raw materials where applicable.
- Distinguish between direct and indirect emissions clearly.

Use the official CBAM communication templates and tools where possible. These are designed to help importers ensure consistency and comparability across submissions.

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Some businesses may choose to use Life Cycle Assessment (LCA) or carbon accounting data, to accurately report their emissions and identify potential reduction opportunities when possible.

Step 5: Prepare for verification (even during the transitional phase)

Although third-party verification is not mandatory during the transitional phase (2023–2025), preparing your data as if it were being audited is a smart move. To do this:

- Keep source documents from suppliers (e.g. meter readings, fuel receipts).
- Record calculation steps and assumptions clearly.
- Organise your data in a format that can be easily reviewed and checked.

From 2026 onwards, emissions data must be verified by an accredited verifier. Starting early helps build confidence in your processes and avoid future penalties.

Step 6: Create an internal CBAM reporting system

Consistency and accuracy in reporting will require internal systems that support:

- Quarterly data collection and aggregation.
- Data validation workflows.
- Version control and audit trails.

If your company already reports emissions under frameworks like Carbon Disclosure Project (CDP),

Greenhouse Gas (GHG) Protocol, or European Union Emissions Trading System (EU ETS), you may be able to adapt these systems. However, CBAM's focus on product-level emissions and import volumes means new processes and coordination with procurement teams will be needed.

CBAM marks a fundamental shift in how international trade interacts with climate policy.

While the compliance requirements may seem complex, they also present an opportunity for businesses to gain better visibility into their supply chains and take a proactive role in carbon emissions reduction strategies. By implementing sustainable practices along their supply chain, businesses can become more resilient to carbon border taxes.

By starting early, building strong data quality practices, and fostering transparent supplier relationships, your organisation can not only meet CBAM audit requirements but also position itself as a leader in sustainable trade. CBAM represents an innovative opportunity to work towards decarbonisation, by a joint effort with businesses and their international suppliers it is possible to make an important positive impact into climate change mitigation.

At Tunley Environmental we help organisations to be prepared and verify their carbon data is ready for CBAM compliance as well as understanding their supply chain and identify opportunities for carbon emission reductions. We tailor our PhD-level advice to your organisation, simplifying the process for data collection and verification of data quality. ■



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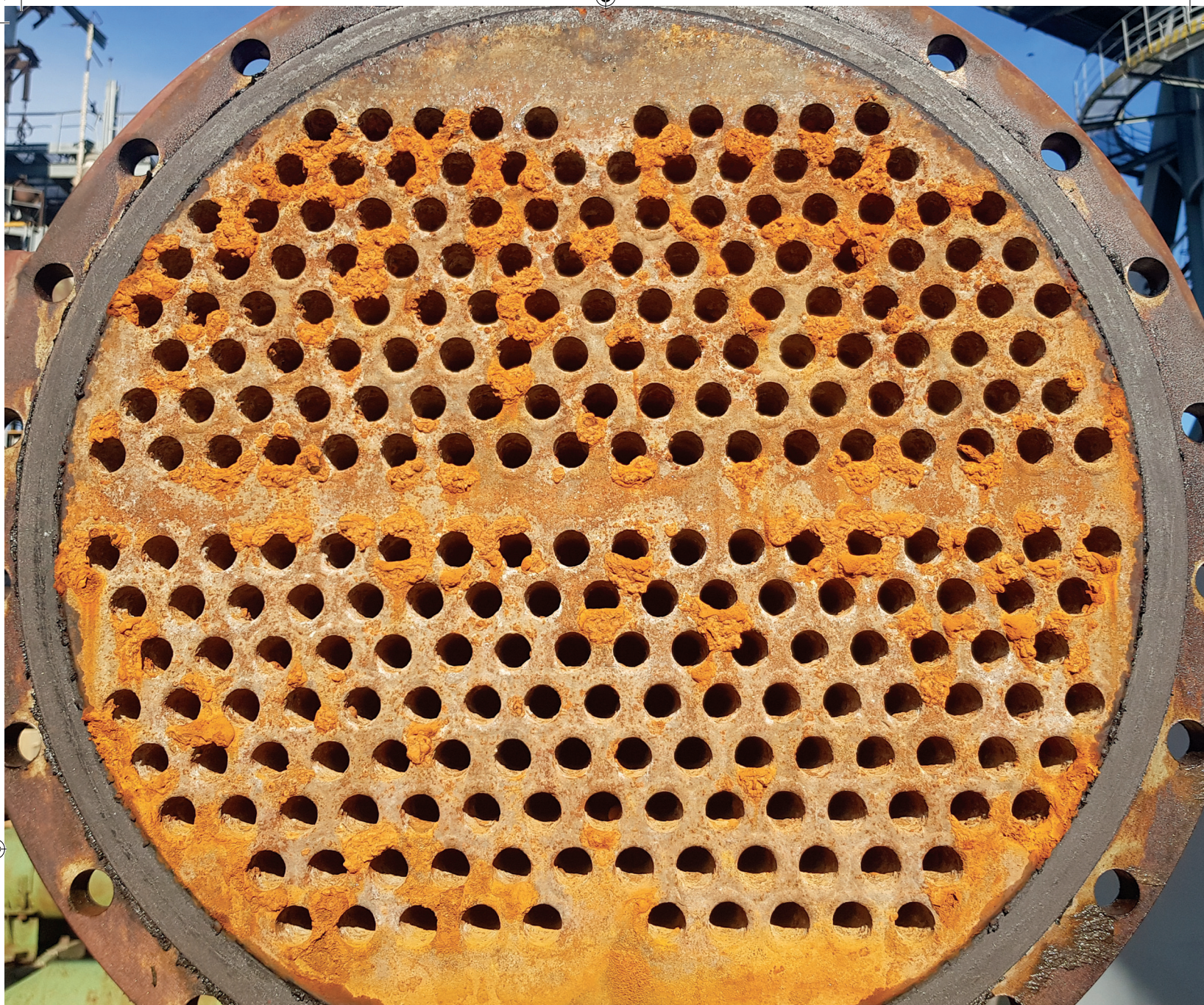
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Researching ways to solve biofilm fouling in heat exchangers

Synthetic biology is transforming industries by engineering microorganisms to solve pressing global challenges. Among these is biofouling in heat exchangers, a problem that reduces efficiency, drives up energy use, and contributes significantly to carbon emissions. Maastricht University's iGEM team, CoreSpin, is developing an innovative spider silk-based solution to prevent biofilm formation and improve heat exchanger performance.

By Katya Mannar and Antonin Śmigiel, CoreSpin, Maastricht University

From the food we eat to the clothes we wear, to the medicines we take, synthetic biology is quietly shaping our modern life. This rapidly

advancing field of science entails the engineering of natural microorganisms and eukaryotic cells to either optimise their native properties or to introduce novel functions through the redesign of a cell's genome (Roberts et al., 2013). While grounded in biological principles, the realm of synthetic biology extends beyond the traditional disciplines of biology. Situated at the interface of science and industry, synthetic biology is a highly interdisciplinary field of research which aims to merge the knowledge of life sciences together with principles from engineering, computer science, and chemistry, amongst others, to design and construct biological

systems (Andrianantoandro et al., 2006). As such, synthetic biology promises a deeper understanding of living systems and the capacity to reinvent them for a given application. Drawing on natural processes, this makes synthetic biology a major driver in transitioning towards a sustainable circular economy through providing innovative solutions for the burning issues of our time (Hassard et al., 2024).

Applications and potential of synthetic biology

A simple bacterium like E.Coli, which is present every human being's, can be modified to have wholly synthetic genetic material to induce a desired protein expression pathway, or even introduce an entirely ex-situ component. This variability allows synthetic biology to be moulded for different applications, meaning that world-changing research could be one custom DNA set away. Synthetic Biology is already in use currently, enabling the production of a life-saving treatment like insulin at a rapid pace (Baeshen, 2014). However, its potential also reaches into offering more sustainable solutions to current industrialised practices. For example, biomining enables cells to extract metals from waste, allowing them to reenter the usage cycle (Schipper, 2014).

iGEM and the Maastricht University team

Competitions like iGEM, which stands for International Genetically Engineered Machine, encourage university and high school students from around the world to solve specific issues using synthetic biology. This year's team from Maastricht University in the Netherlands is interested in using synthetic biology to prevent biofouling of heat exchangers.

Biofouling in heat exchangers

Biofouling is a critical issue for heat exchangers everywhere, like those present in large-scale manufacturing plants and data centres, with heat exchanger fouling alone accounting for a loss of 0.25% of GDP of industrialised countries (Zettler, 2019). Biofouling occurs when dense networks of bacteria, biofilms, adhere to a specific surface. These biofilms contain a high water content, providing unintentional thermal insulation when growing on heat exchangers, with a 0.1mm thick biofilm potentially decreasing thermal conductivity by up to 98% (Rosser, 2024). The heat exchanger system has to essentially overwork itself to compensate for the loss of heat transfer and to maintain the same level of efficiency. Some estimations report the fouling of heat exchangers are responsible for 1-2.5% of global CO₂ emissions (Zettler, 2019) (Müller-Steinhagen, 2009). As a way of amending this loss in efficiency, many heat exchangers have an integrated structure of being

70-80% larger than required because of biofilms (Bansal and Chen, 2006).

CoreSpin's approach to the problem

Initially becoming aware of the problem through a contact from Dell Technologies, Maastricht University's 2025 iGEM team decided to look at their own university's energy centre and found that this issue was also present on a smaller scale. Current methods to clean heat exchangers, face issues with accessibility, time, cost and damage to the infrastructure at hand (Shaurya, 2024). Their team CoreSpin attempts to eliminate these issues in the first place, attempting to create a preventative solution to heat exchanger fouling.

Spider silk as a potential solution

CoreSpin was particularly interested in spider silk, because its exceptional properties made it stand out from other biological materials. Spider silk has impressive characteristics with its tensile abilities similar to that of steel when put into reference per unit of weight (Römer, 2008). Proteins from the dragline silk which spiders produce, have shown high thermal conductivity comparable to that of copper (Huang, 2012). CoreSpin is attempting to attach these dragline spider silk proteins to heat exchanger plates, as a way of providing a biostatic environment for the prevention of microbial attachment, dust particles, and pollen. The attached proteins will form a layer that can maintain a heat transfer efficiency as high as that of an unfouled heat exchanger. This spider silk protein layer will act as a preventative solution to biofouling, while also assisting in optimal heat exchange. Currently, CoreSpin is investigating which composition and structure of spider silk proteins meet their needs for maximum efficiency and functionality.

References are available upon editorial request. ■

About CoreSpin

CoreSpin consists of a group of 14 undergraduate science students from Maastricht University who are passionate about learning and research. They are currently headed by their supervisors, Dr. Erik Steen Redeker and Dr. David Cortens, and are excited to present their research to a panel of judges during the iGEM Grand Jamboree in October.



Heat exchanger fouling assessment

The persistent challenge of fouling in heat exchangers represents one of the most significant operational concerns in process industries today. This phenomenon, characterized by the accumulation of unwanted materials including scale, sludge, biological matter, and corrosion products on heat transfer surfaces, poses a complex challenge that impacts both operational efficiency and equipment longevity. Understanding and assessing fouling has become increasingly critical as industries strive to optimize performance while managing maintenance costs and energy consumption.

By Omari Hussein Sabuni, Mechanical Engineer, Kinyerezi Power Plant

Critical nature of fouling assessment

Fouling assessment stands as a cornerstone of effective heat exchanger management, transcending simple maintenance procedures to become a crucial element of operational strategy. The impact of fouling extends far beyond immediate performance degradation, creating a cascade of effects that can significantly influence overall system reliability and operational costs. As heat transfer efficiency diminishes due to fouling, systems require increasingly more energy to maintain desired process conditions, leading to escalating operational expenses and potential equipment stress. The significance of effective fouling assessment manifests across multiple industrial sectors, from petrochemical processing to food and beverage production. In petrochemical applications, precise fouling monitoring can prevent catastrophic equipment failure and ensure product quality. Power generation facilities rely on accurate fouling assessment to maintain optimal thermal efficiency and prevent unexpected downtime. The

pharmaceutical industry, with its stringent quality requirements, depends on careful fouling monitoring to maintain process stability and product consistency. The benefits of implementing comprehensive fouling assessment programs extend beyond immediate operational improvements. Enhanced operational efficiency through maintained optimal thermal performance translates directly to reduced energy costs and improved product quality. The ability to predict and prevent fouling-related issues minimizes unplanned downtime, while systematic monitoring helps extend equipment life by preventing accelerated wear and corrosion damage.

Performance metrics: Foundation of fouling assessment

Understanding and monitoring key performance indicators provides the foundation for effective fouling assessment. These metrics offer quantifiable insights into system health and fouling progression, enabling operators to make informed decisions about maintenance and operational adjustments. The temperature gradient between inlet and outlet streams serves as a primary indicator of heat transfer efficiency, with any significant deviation from design specifications potentially signaling fouling development. Pressure drop across the heat exchanger provides another crucial metric for fouling assessment. As fouling deposits accumulate within the exchanger, they create flow restrictions that manifest as increased pressure drops. This relationship between fouling and pressure drop often serves as an early warning system, allowing operators to detect developing issues before they significantly impact thermal performance. The overall heat transfer coefficient (U) represents perhaps the most comprehensive indicator of heat

exchanger performance. This value, incorporating all heat transfer resistances within the system, provides a direct measure of fouling impact on thermal efficiency. Regular monitoring of the U-value enables operators to track fouling progression and optimize cleaning schedules. The relationship between energy consumption and fouling also offers valuable insights, as systems typically require increased energy input to maintain desired process conditions as fouling progresses.

Advanced monitoring technologies and techniques

Modern fouling assessment has evolved significantly with the introduction of sophisticated monitoring technologies. Non-destructive testing methods now provide unprecedented insight into fouling conditions without requiring system shutdown. Ultrasonic testing techniques can accurately measure deposit thickness and distribution, while infrared thermography reveals temperature patterns that indicate fouling-related heat transfer inefficiencies. Radiographic testing offers detailed visualization of internal fouling deposits, enabling precise targeting of cleaning efforts. Online monitoring systems have revolutionized the approach to fouling assessment by providing real-time data on critical parameters. Advanced flow sensors detect subtle changes in fluid dynamics that might indicate developing fouling issues. Temperature sensors, strategically placed throughout the system, monitor performance degradation patterns, while pressure transducers provide continuous pressure drop data for early fouling detection. The integration of these monitoring technologies with sophisticated data analysis systems enables comprehensive performance trending and predictive maintenance planning. Historical data analysis, combined with real-time monitoring, helps establish fouling patterns and optimize maintenance schedules. This data-driven approach ensures that cleaning and maintenance activities align with actual system needs rather than arbitrary schedules.

Integrated assessment methodologies

Effective fouling assessment requires a holistic approach that combines multiple evaluation methods and monitoring strategies. This integrated methodology begins with establishing accurate baseline performance metrics when the system is clean, providing a reference point for future comparisons. Regular monitoring and inspection protocols, aligned with these baseline measurements, enable precise tracking of fouling progression. The calculation of fouling factors provides quantitative measures of fouling impact, helping operators make informed decisions about maintenance timing and methods. The fouling factor equation, $R_o = (1/U_{\text{dirty}}) - (1/U_{\text{clean}})$, offers a standardized method for comparing fouling severity across different operating conditions and equipment types. This mathematical approach, combined with physical inspections and monitoring data, creates a comprehensive picture of system health.



Root cause analysis plays a crucial role in effective fouling management, helping identify specific fouling mechanisms and sources. Understanding whether fouling results from chemical precipitation, biological growth, or particulate deposition enables the development of targeted mitigation strategies. This analytical approach ensures that cleaning methods and preventive measures address the fundamental causes of fouling rather than just treating symptoms.

Advanced prevention and mitigation strategies

The implementation of effective fouling prevention and mitigation strategies requires a sophisticated understanding of both fouling mechanisms and available treatment technologies. Chemical cleaning methods have evolved significantly, moving beyond simple acid or alkaline treatments to include targeted formulations designed for specific fouling types. These advanced chemical solutions must balance cleaning effectiveness against potential impacts on heat exchanger materials, requiring careful selection based on metallurgy, operating conditions, and fouling characteristics.

Mechanical cleaning techniques have also advanced considerably, incorporating innovative technologies that improve cleaning efficiency while minimizing system downtime. Modern hydroblasting systems utilize precisely controlled water jets that effectively remove stubborn deposits without risking damage to underlying surfaces. The development of automated pigging systems has revolutionized cleaning procedures in certain applications, allowing for regular cleaning without requiring system shutdown. These innovations in mechanical cleaning have significantly reduced maintenance time while improving cleaning effectiveness.

Operational optimization plays a crucial role in fouling prevention. Advanced flow modeling and computational fluid dynamics (CFD) analysis enable operators to identify and maintain optimal flow velocities that minimize fouling tendencies. Temperature control strategies, informed by sophisticated monitoring systems, help avoid conditions conducive to fouling formation. These operational adjustments, while subtle, can significantly impact fouling rates and system performance. Water treatment technologies have become increasingly sophisticated, incorporating multiple

treatment approaches to address various fouling mechanisms simultaneously. Modern treatment programs often combine chemical additives, advanced filtration systems, and innovative softening processes to create comprehensive solutions for fouling prevention. The integration of real-time monitoring systems with treatment programs allows for dynamic adjustment of treatment parameters based on changing system conditions.

Surface engineering and innovative technologies

The application of advanced surface treatments and coatings represents a frontier in fouling prevention technology. Modern anti-fouling coatings utilize novel materials science developments to create surfaces that actively resist fouling accumulation. These coatings work through various mechanisms, from creating ultra-smooth surfaces that minimize fouling adhesion to incorporating active compounds that discourage biological growth or scale formation.

Automated cleaning systems have emerged as a transformative technology in fouling management. These systems range from simple automatic brush systems to sophisticated robots capable of navigating complex heat exchanger geometries. The integration of artificial intelligence and machine learning algorithms has enhanced the capability of these systems to adapt their cleaning patterns based on fouling distribution and severity.



Economic impact and performance optimization

The economic implications of effective fouling management extend far beyond direct maintenance costs. A comprehensive economic analysis must consider multiple factors, including energy efficiency, production capacity, maintenance requirements, and equipment longevity. Advanced fouling management programs can deliver substantial cost savings through reduced energy consumption, with some facilities reporting energy savings of 15-30% through improved fouling control.

The impact on system reliability and maintenance scheduling represents another significant economic consideration. Predictive maintenance strategies, enabled by sophisticated fouling monitoring systems, allow facilities to optimize maintenance intervals based on actual system conditions rather than fixed schedules. This approach not only reduces

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unnecessary maintenance but also minimizes the risk of unexpected failures that could result in costly emergency shutdowns.

Equipment life extension through effective fouling management provides substantial long-term economic benefits. By preventing accelerated wear and corrosion damage associated with severe fouling, facilities can significantly extend the operational life of heat exchange equipment. This life extension, combined with reduced maintenance requirements and improved energy efficiency, contributes to a compelling return on investment for advanced fouling management programs.

Future trends and emerging technologies

The future of fouling assessment and management promises even greater advances through the integration of emerging technologies. The development of smart sensors and Internet of Things (IoT) connectivity enables increasingly sophisticated real-time monitoring and control systems. Machine learning algorithms are beginning to demonstrate remarkable capability in predicting fouling trends and optimizing cleaning schedules based on historical and real-time data. Nanotechnology applications in surface treatments and coating systems show promising results in fouling prevention. These advanced materials can create surfaces with unprecedented fouling resistance while maintaining excellent heat transfer characteristics. The combination of these new materials with traditional prevention methods offers

the potential for significant improvements in fouling management effectiveness.

Conclusion

The comprehensive assessment and management of fouling in heat exchangers require a sophisticated integration of monitoring technologies, prevention strategies, and economic considerations. Success in this area demands a balanced approach that combines technical expertise with practical operational experience. As technology continues to advance, the opportunities for improving fouling management will continue to expand, offering new possibilities for enhancing heat exchanger performance and reliability. ■

About the author

Omari Hussein Sabuni is an experienced mechanical engineer at Kinyerezi Gas Power Plant, specializing in heat exchanger design, optimization, troubleshooting and providing practical solutions for various heat exchanger problems. He is skilled in analyzing thermal systems and developing innovative solutions to enhance heat transfer efficiency and adept at conducting feasibility studies, performing risk assessments, and ensuring compliance with industry standards.



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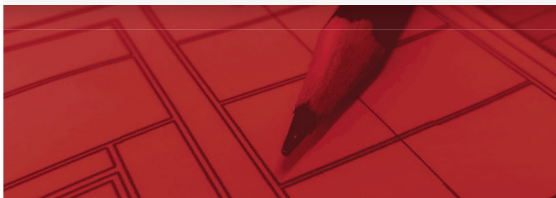
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Product News

OptiCool launches RDHx for AI and HPC workloads



OptiCool Technologies has launched its new 120kW Rear Door Heat Exchanger (RDHx) – the highest-capacity rear door heat exchanger (RDHx) on the market. Capable of removing up to 120kW per rack, it's purpose-built to meet the extreme thermal demands of next-generation AI and HPC workloads. Engineered for seamless retrofit into existing environments, the new 120kW Rear Door Heat Exchanger – the highest-capacity unit of its kind – supports rack densities of up to 120kW and removes the need for separate zones or major infrastructure overhauls. Its proprietary two-phase refrigerant design, based on the thermodynamics of phase change, removes heat from the rack and returns it into the space at room

neutral ambient temperature. This launch expands OptiCool's existing RDHx lineup (30kW and 60kW), delivering a modular, high-capacity option for operators balancing density, uptime, and energy use. OptiCool's Rear Door Heat Exchanger system requires significantly less energy than traditional air-based cooling approaches, helping operators reduce cooling costs and improve energy efficiency. The 120kW Rear Door Heat Exchanger leverages the same ultra-efficient design principles as OptiCool's lower-capacity units, which have achieved power usage effectiveness (PUE) as low as 1.02 in tested deployments. This helps data centers advance ESG goals while preparing for next-generation compute demands.

Johnson Controls expands thermal management offering



Johnson Controls (JCI) has expanded its data center thermal management offerings with the launch of its Silent-Aire Coolant Distribution Unit (CDU) platform. This latest addition to Johnson Controls' end-to-end thermal management portfolio enables data centers to seamlessly transition to liquid cooling as rack densities rise. The Silent-Aire CDUs offer a wide range of scalable cooling capacities from 500kW to over 10MW in flexible designs that are uniquely tailored to suit the needs of any data center deployment. With the rapid growth of AI and increasing demand for computing power, denser chips are generating more heat, making cooling innovation a critical priority. Silent-Aire CDUs allow for precision cooling of this equipment, enabling

data center owners and operators to deploy the latest in semiconductor technology. Positioned either in-row adjacent to heat-generating equipment or in the whitespace perimeter, Silent-Aire CDUs are designed for flexibility to support a wide range of liquid-cooling configurations and hybrid designs to deliver precise, efficient cooling of high-performance environments ranging from edge-based inference to large AI factories. This launch builds on Johnson Controls' broad portfolio of existing Silent-Aire, York, and M&M Carnot thermal management products that serve data centers worldwide. By adopting Johnson Controls' comprehensive thermal management solutions, owners and operators can significantly improve total facility efficiency.

Modine opens India facility



Modine® (MOD), a diversified global leader in thermal management technology and solutions, officially opened its new 100,000 ft² facility in Chennai,

India. The event marked the beginning of full-scale, in-region production of Airedale by Modine™ data center cooling equipment and a strategic positioning to meet accelerated demand from data center customers across the Asia-Pacific (APAC) region. The launch event featured remarks from senior leadership, a tree-planting ceremony, and the unveiling of the first locally manufactured unit—the AireWall ONE™ fan wall. Completed on schedule, the unit features 70% locally procured components, and the team is actively working to increase local sourcing. More ranges are being incorporated into the production schedule to match

increasing data center demand across the Asia Pacific region, which analysts believe is growing at a compound annual growth rate (CAGR) of 13%. The state-of-the-art facility in Chennai complements Modine's recently announced investment to expand U.S. production, reinforcing the company's strategy to serve high-growth markets. The increasing use of AI applications has driven demand for Airedale by Modine data center cooling solutions, including high-efficiency chillers, indoor air systems, next-generation liquid cooling technologies, intelligent controls, building management systems (BMS), and a global service network.

Alfa Laval and AquaGreen sign MoU

Alfa Laval and AquaGreen have officially signed a Memorandum of Understanding (MoU) to strengthen collaboration in the transformation of biomass and waste into renewable thermal energy and biochar. This strategic partnership marks a significant step forward in advancing sustainable water and waste management technologies. By combining Alfa Laval's expertise in decanter centrifuge technology with AquaGreen's innovative Integrated Drying & Pyrolysis (IDP)

system, the two companies aim to deliver comprehensive, high-efficiency solutions for sludge dewatering, CO₂ reduction, carbon sequestration, elimination of environmental pollutants, and resource recovery. The collaboration supports municipalities and industries in meeting their environmental goals while contributing to the circular economy. The MoU outlines joint activities including market development, technology innovation, after sales services, and knowledge sharing, with a focus



on delivering integrated solutions that reduce environmental impact and promote long-term sustainability.

Kaltra's second factory reaches nominal capacity of 800,000 units



Kaltra announces that its second microchannel heat exchanger manufacturing facility, opened earlier this year, has now reached its nominal capacity of 800,000 units per year. This capacity adds to the 3 million units per year nominal output of Kaltra's main factory, further strengthening the company's ability to respond to rising global demand. The new factory is equipped with state-of-the-art automation, including automatic core builders for precise coil assembly, a complete range of fin machines covering all fin sizes and pitches, and a continuous-type CAB furnace enabling reliable, high-volume brazing. These investments ensure consistent quality, scalability, and efficiency across production.

Spanning 16,000 m², the site combines the manufacturing plant with office space and well-structured loading yards, designed for streamlined logistics and smooth material flow. The high degree of automation aligns with Kaltra's strategy to reduce lead times, improve repeatability, and deliver maximum flexibility to its customers. This achievement builds on Kaltra's earlier 2025 automation upgrades and underscores the company's long-term commitment to growth, innovation, and leadership in thermal management solutions. Kaltra's second factory has reached its nominal capacity of 800,000 microchannel heat exchangers annually, adding to 3 million at its main site.

Lithoz is developing a ceramic heat exchanger

Lithoz is developing and additively manufacturing a ceramic heat exchanger for hydrogen-electric propulsion systems as part of the TRIATHLON project consortium. Funded by the European Union's Horizon Europe Research and Innovation Action (RIA) programme, TRIATHLON is working to unite skills towards the development of disruptive

approaches to design more robust, low-maintenance, low-emission, highly responsive hydrogen-electric powertrains for megawatt class aircraft. Lithoz is printing the heat exchanger in aluminium nitride (AlN), believing that these systems manufactured with this material will help to decarbonise aviation, improve system efficiency and sustainability, and reduce maintenance.

Metso introduces data-driven performance services



Metso is launching Data-driven Performance Services to empower the mining industry with faster, fact-based issue resolution. Metso's Data-driven Performance Services are a set of innovative equipment performance solutions designed to help customers prevent production losses, avoid safety risks, and ensure consistently optimized operations. Data-driven Performance Services offer harmonized service capabilities that cover the entire minerals processing flowsheet. Metso's transformative data-driven solutions are a combination of intelligent thresholds, advanced analytics, and AI-enabled diagnostics capable of capturing and describing complex cases for faster action. The analytics and AI capabilities are complemented by Metso's continuously expanding global network of data-driven experts to ensure consistent and responsive service delivery. The enhanced remote monitoring and troubleshooting capabilities reduce the need for onsite inspections and resident experts.

Metso's Data-driven Performance Services are designed for site maintenance and operations teams to maximize equipment availability, reliability, and performance through two scalable service levels: Data-driven Technical Support provides fast and fact-based troubleshooting and issue resolution. Through live equipment data, Metso's experts can improve first-time fix rates and reduce production losses. The expanded data-driven expert network ensures consistent delivery of services. Data-driven Condition Monitoring enables early detection of equipment related issues and failures through continuous remote monitoring. AI-powered analytics and expert diagnosis ensure prioritized actions, reducing unplanned downtime and safety risks, improving availability, uptime, and performance. Combined with Life Cycle Services, Metso can conduct the corrective actions efficiently on-site.

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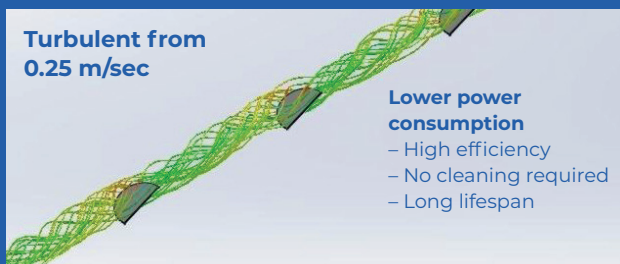
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Stratex Consulting partners with OMEEL Coils



Stratex Consulting has partnered with OMEEL Coils to focus on building structured systems in

two key areas: Operational Excellence and Strategic HR Re-engineering. This partnership aims for a long-term growth vision of becoming a top player in the HVAC and heat exchanger industry. OMEEL Coils, with over two decades of industry experience, offers a wide range of industrial and commercial products such as air/water cooled condensers, evaporators, oil coolers, marine coolers, low-temperature units, fan coil units, condensing units, chilling plants, and air handling units. With increasing demand and expansion into new markets, the company is strengthening its internal systems to support scale and performance. Stratex will work closely with the OMEEL team to implement structured operational systems

that simplify day-to-day functions and improve overall coordination. Initiatives will include 5S implementation, lean practices, and a complete inventory management overhaul to improve process ownership, cleanliness, and efficiency. The HR initiative will redesign the organization's structure and roles to ensure workforce alignment with business needs. With the business gearing up for long-term expansion, the focus is on building systems that are easy to manage, provide visibility across departments, and enable teams to operate with great coordination. Both operational and people-related improvements are expected to help OMEEL increase speed, reduce errors, and make better use of available resources.

Baker Hughes selected by Fervo Energy to deliver geothermal power generation equipment

Baker Hughes (BKR), an energy technology company, has announced an award from Fervo Energy Company, the leader in next-generation geothermal energy, to design and deliver equipment for five Organic Rankine Cycle (ORC) power plants at Fervo's Cape Station power generation project near Milford, Utah, United States. Once operational, the five Cape Phase II ORC plants will generate approximately 300 megawatts of clean, reliable, and affordable power to the grid, equivalent power to approximately 180,000 homes.

Baker Hughes' equipment is designed to operate with Fervo's cutting-edge Enhanced Geothermal Systems (EGS), resulting in a fully integrated power plant that drives scalability in sustainable baseload power generation. The award is for

Fervo-exclusive surface power generation equipment leveraging Baker Hughes' geothermal solutions portfolio, which spans subsurface and production technology through to power generation solutions.

Baker Hughes' engineering and equipment scope for the project includes design and delivery of equipment for five 60-MWe ORC units, including the engineering, manufacturing, and supply of turboexpanders and the BRUSH™ Power Generation generator. The order, to be booked under the Industrial & Energy Technology segment of Baker Hughes, follows previous awards from Fervo Energy for subsurface drilling and production technologies from the company's Oilfield Services & Equipment business.



The Cape Station project includes Cape Station Phase I, which is poised to deliver 100 megawatts (MW) of baseload clean power to the grid beginning in 2026, as well as Cape Station Phase II, which will generate an additional 400 MW and come online by 2028. The full Cape Station development has received permitting approval for up to 2 GW of reliable and renewable energy.

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Project News

McDermott awarded deepwater subsea contract by PTTEP



McDermott has been awarded a large offshore subsea contract by PTTEP Sabah Oil Limited (PTTEP) for the Block H gas field expansion project, located offshore Sabah, in East Malaysia, covering the Alum, Bemban, and Permai deepwater fields. Under the scope of the contract, McDermott will deliver engineering, procurement, construction, and installation (EPCI) services for a carbon steel pipeline, along with transportation and installation of key subsea umbilicals, risers, and

flowlines (SURF) components. The infrastructure is part of a broader system designed to support the delivery of additional feed gas to the Petronas Floating Liquefied Natural Gas Dua (PFLNG DUA) facility, which has been producing from Block H's Rotan and Buluh fields since 2021. Engineering and project management will be led from McDermott's Subsea and Floating Facilities team in Kuala Lumpur, while offshore installation will leverage the company's versatile marine construction fleet. Operated by PTTEP on behalf of partners Petronas Carigali and PT Pertamina Malaysia Exploration Production, the Block H development is a cornerstone of Malaysia's deepwater gas strategy, with expansion expected to increase domestic gas supply, supporting long-term energy security and economic growth.

CDB marks milestone with financial close on Dominica Geothermal Energy Project



The Caribbean Development Bank (CDB / the Bank) has reached financial close on a facility for the landmark Dominica Geothermal Energy 10MW Project. The facility is made available to the Geothermal Power Company of Dominica (GPC), which was established specifically to implement the project. GPC is a wholly owned subsidiary of Ormat Technologies Inc., a leading international geothermal developer. This transaction is the first geothermal project in the region to reach this stage with a private sector partner. The power plant development phase is being implemented as a private sector-led initiative, with CDB acting as the lead financial arranger. The project has secured USD 34.8 million in concessional funding. Of this

amount, USD 25.4M is provided by the Green Climate Fund (GCF) in the form of a concessional loan, which was mobilized through the Inter-American Development Bank (IDB)-GCF program titled "FP020: Sustainable Energy Facility for the Eastern Caribbean." An additional USD 9.4M is being provided from Canada's Supporting Resilient Green Energy Initiative in the Caribbean (SuRGE) programme. The CARICOM Development Fund (CDF) is also contributing USD 15M in loan financing out of its own capital fund resources, as the major element of the CDF's Country Assistance Programme for Dominica. The project is expected to enhance energy security, stabilise tariffs, cut greenhouse gas emissions, and drive long-term economic growth.

Panasonic starts operations at the new building in its Czech factory



Panasonic Corporation has announced that Panasonic Heating & Ventilation Air-Conditioning Czech, s.r.o. (PHVACCZ), a subsidiary of Heating & Ventilation A/C Company, started operations at

the new building in its Czech factory, a production site for air-to-water heat pumps. Air-to-water heat pumps utilize heat from the atmosphere to produce hot water, which is then circulated throughout buildings for heating. They minimize environmental impact with less CO₂ emissions compared to fossil fuel-using heaters, they significantly reduce CO₂ emissions and have a lower environmental impact. With the growing awareness of environmental issues and the push toward a decarbonized society, the market is expected to see steady growth over the medium to long term. The Czech factory was established in 1996 as a production site for televisions and began manufacturing air-to-water heat pumps in 2018. Initially, the factory produced only indoor units, but in 2023, it also started producing outdoor

units using the R290 natural refrigerant, making it the first Japanese manufacturer*1 to do so. Furthermore, in 2024, the factory strengthened its role as a key development and production hub by establishing an R&D department to respond swiftly and flexibly to market needs in Europe. To meet the growing demand in the air-to-water heat pump market, a newly constructed building aimed at expanding production capacity has been completed and is now operational. With the completion of the new building, the factory will be able to expand its production lines in response to future demand and enhance automation—such as deploying 80 robots—enabling a future increase in production capacity from 150,000 units*2 to a maximum of approximately 700,000 units*2, which is about 20% higher than the original plan.

Vikram Solar secures 336 MW module supply order from L&T



Vikram Solar has announced a major order win of 336 MW high-efficiency solar modules from L&T Construction. These modules will be deployed in Khavda, Gujarat, a region where the company

has already made significant contributions. As part of this order, Vikram Solar will supply its advanced Hypersol G12R modules, based on N-type technology. This latest module from

Vikram Solar showcases improved bifaciality (upto 80%), better high-temperature performance, and minimal year-on-year degradation ($\leq 0.4\%$). The usage of G12R Modules will enhance the Balance-of-System (BOS) efficiency and help drive down the Levelized Cost of Energy (LCOE), making it more cost-effective and accessible. With ambitious targets and large-scale projects like the Khavda Renewable Energy Park, Gujarat is at the forefront of India's

renewable energy transformation and is setting global benchmarks in solar capacity deployment. It also highlights Vikram Solar's commitment to advancing India's clean energy transition through technological innovation, scalable capacity, and consistent execution. Earlier in May 2025, Vikram Solar secured a 326 MW module supply order from Gujarat Industries Power Company Limited (GIPCL) for the Khavda Renewable Energy Park.

Contract awarded for parts of novel Chinese nuclear project



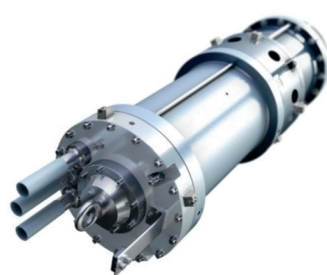
A contract has been awarded for the construction of the conventional islands of the three reactors that will comprise the first phase of the Xuwei nuclear power project in

China. The plant will supply both industrial heating and electricity by coupling a high-temperature gas-cooled reactor with two pressurised water reactors.

Xuwei Phase I was among 11 reactors approved by China's State Council in August last year. China National Nuclear Corporation (CNNC) plans to build two 1208 MWe (net) Hualong One units and one 660 MWe high-temperature gas-cooled reactor (HTGR) unit at the site in Lianyungang, Jiangsu province. The project will be equipped with a steam heat exchange station, which will adopt the heat-to-electricity operation mode for the first time. CNNC describes the project as "the world's first dual-coupling demonstration project combining a third-generation nuclear PWR and a fourth-generation nuclear HTGR". At the plant - very close to CNNC's existing Tianwan plant - demineralised water will be heated

by the primary steam of the Hualong One units to produce saturated steam, and the primary steam of the HTGR will be used to heat the saturated steam for the second time. A contract for the construction of the conventional islands of the three units has now been awarded to a consortium formed by China Energy Engineering, Jiangsu Electric Power Construction No.3 Company, and China National Nuclear Huachen Construction Engineering Company. Under the CNY4.2bn (USD 594M) contract, Jiangsu Electric Power Construction No.3 Company will build the three conventional island power plants, their ancillary facilities, and the construction and installation of some 'balance of plant' components.

Nikkiso launches next-generation pump at Gastech 2025



Nikkiso Clean Energy & Industrial Gases Group (Nikkiso CE&IG) has announced at the Gastech Conference that it has launched a next-generation submerged ammonia pump designed to be the safest and most reliable in the industry. Ammonia is already a key component in fertilizers and is increasingly being used as a clean hydrogen carrier. As demand for handling ammonia has also grown in sectors like power generation, chemical plants, shipping fleets, and export terminals, Nikkiso CE&IG has responded with a first-of-its-kind solution designed to eliminate common maintenance burdens for operators thanks to its seal-less, maintenance-friendly, copper-free

construction and integrated motor-pump system. The pump is capable of delivering more than 2,500m³ per hour and has an industry-leading maintenance record – specifically-designed parts mean the pump lasts significantly longer before any maintenance requirements, with a mean time between outages topping 16,000 hours. The launch of the pump builds on a track record of expertise and innovation, both at Nikkiso CE&IG and its parent company, Nikkiso Co., in serving the ammonia market across a range of applications. Nikkiso CE&IG has four decades of experience in building submersible motor pumps for ammonia service and recently secured approval in principle for a new ammonia fuel supply system, alongside its existing and proven range of purpose-built ambient and electric heat exchangers for ammonia. Nikkiso Co.'s Industrial division has also built more than 7,000 canned motor pumps for use in ammonia handling, and plans to launch a liquid ammonia pump for thermal power generation next year.

Westinghouse expands supply chain with six UK companies



Westinghouse Electric Company has signed memorandums of understanding (MoUs) with six British suppliers to support nuclear new build projects based on AP1000® and AP300™ technologies in the UK and around the world. The agreements bolster Westinghouse's local supply chain to support the UK's ambitious goal of increasing nuclear generation by up to 24GW by 2050. MoUs were signed with William Cook Cast Products, Trillium Flow Technology, Curtiss-Wright Controls (UK), Boccard UK, Bendalls Engineering, and Sheffield Forgemasters. The agreements provide these companies with the potential to supply key reactor components, including valves, pumps, actuators, mechanical, electrical piping and instrument (MEPI)

modules, pressure vessels, tanks, heat exchangers, and piping and cast and forged steel components. The AP1000 reactor is the only operating advanced Generation III+ reactor with fully passive safety systems, modular construction design, and the smallest footprint per MWe on the market. There are six AP1000 reactors currently setting operational performance and availability records worldwide, with 14 reactors under construction and six more under contract. The AP300 SMR is based on the proven technology of the AP1000 reactor. Unlike every other SMR under development with first-of-a-kind technologies and risks, the AP300 SMR uses AP1000 engineering, components, and supply chain to streamline licensing and leverage available technical skills.

Capsol Technologies awarded engineering study for BECCS project



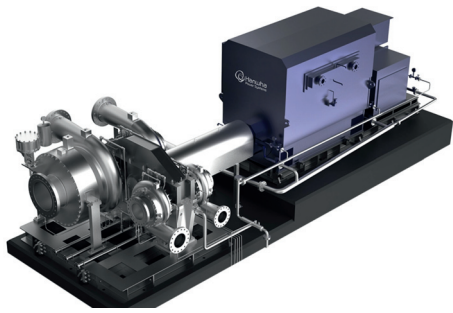
Capsol Technologies, a provider of carbon capture technology, has been

selected by an undisclosed client to deliver a feasibility study for evaluating CapsolEoP® at a biomass fired combined heat-and-power plant in Europe. The study will evaluate a Bioenergy with Carbon Capture and Storage (BECCS) configuration capable of removing more than 200,000 tonnes of CO₂ each year, turning the

facility into a source of durable, net negative emissions. Fueled by waste wood, the facility already supplies renewable heat to nearby communities. A CapsolEoP® plant can efficiently generate additional energy for a district-heating network, optimizing overall energy use and reducing the target cost of high-quality carbon-

dioxide-removal (CDR) credits. Momentum in the voluntary CDR market is accelerating: 15.48 million tonnes of durable CDR were contracted in Q2 2025 – more than all previous quarters combined (13.6 million tonnes), according to CDR. fyi. Growing demand for verifiable removals strengthens the business case for BECCS projects.

Hanwha Power Systems to supply CO₂ MVR compressors



Hanwha Power Systems signed a supply contract last month to deliver CO₂ Mechanical Vapor

Recompression (MVR) compressors for a major carbon capture, utilization, and storage (CCUS) facility at a new combined-cycle power plant in Europe.

The compressors to be supplied for this project play a critical role in enhancing energy efficiency. By compressing low-pressure steam and converting it into high-temperature steam for reuse, the MVR system enables significant reductions in both energy consumption and operating expenditure (OPEX) through efficient heat recovery.

This project is particularly significant as it introduces CCUS technology to a next-generation combined-cycle power plant designed to

minimize carbon emissions. With a facility structure that allows for real-time capture and treatment of CO₂ emissions, the plant is expected to serve as a milestone in driving industrial decarbonization. Commercial operations are scheduled to begin at the end of 2028.

Within the CO₂ capture process, Hanwha Power Systems' MVR compressors ensure system reliability by supplying stable high-temperature steam to the stripper, a crucial unit that separates CO₂ from amine solutions. By reusing low-temperature steam generated during the process, the system maintains continuous capture cycles while reducing overall plant energy consumption and operating costs.

Severn Wye Biochar awarded GBP 600k



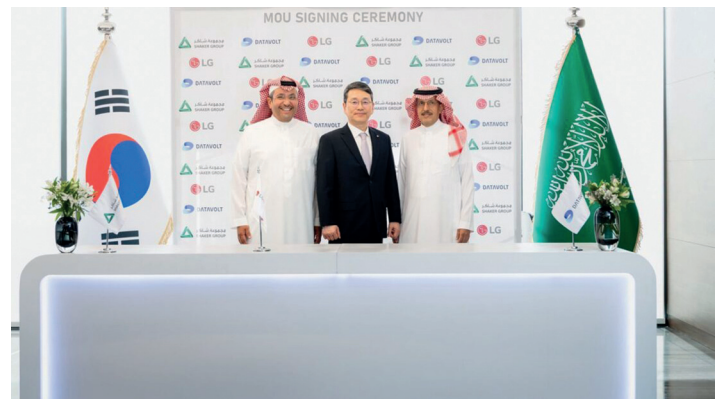
Severn Wye's biochar plant in Warrington has been awarded GBP 600k 'Redress' funding to install and trial two highly efficient generators that operate using a heat-exchange process known as Organic Rankine Cycle (ORC).

If successful, the plant could supply social homes and businesses with clean electricity at below market rates; a first in the UK and also the EU, where biochar manufacturing is more established.

Because of the way it's produced – through a process called pyrolysis

– the electricity would be carbon negative. Pyrolysis involves baking material at high temperatures in low-oxygen conditions. The ORC units are expected to be installed and commissioned by spring 2026, and the three-month trial will start soon after. Redress is funded by energy suppliers that may have breached Ofgem rules, and payments are distributed by the Energy Saving Trust to energy-related projects in England, Scotland, and Wales.

LG taps Middle East growth with NEOM Oxagon AI Data Center Partnership



LG Electronics (LG) CEO William Cho is advancing the company's Global South growth strategy through a strategic partnership to provide cooling solutions for an AI data center under development in Oxagon, the industrial hub of Saudi Arabia's NEOM City project. Cho recently met with Abdulrahman Abunayyan, Chairman of SHAKER Group, the manufacturer and sole distributor of LG Air Conditioners, following the 30th anniversary of the strategic partnership, and Rajit Nanda, CEO of DATAVOLT, a global data infrastructure provider. The parties signed a memorandum

of understanding (MoU) under which LG will supply advanced thermal management solutions for next-generation data centers being developed by DATAVOLT. DATAVOLT, headquartered in Saudi Arabia with offices in the USA, Uzbekistan, India, and the UAE, develops hyperscale data centers that incorporate renewable energy and alternative fuels. Its flagship project in Oxagon is planned as one of the largest AI data centers in the region. DATAVOLT is also investing in hyperscale data centers in Uzbekistan, Bangladesh, and other parts of Asia.

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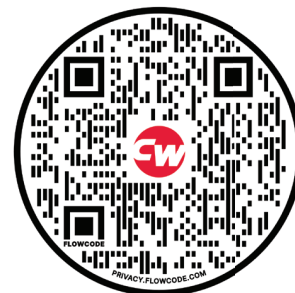
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