Technologies and Processes for the Advancement of Materials

Thermal processing

ISSUE FOCUS ///

CERAMICS / INDUSTRIAL GASES

CERAMIC FIBER HIGH TEMPERATURE INSULATION SOLUTION

COMPANY PROFILE ///

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APRIL 2024
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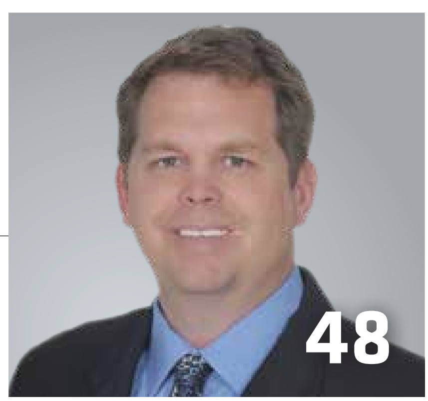
JOHN LUDEMAN

VICE PRESIDENT OF OPERATIONS /// ADVANCED HEAT TREAT CORP.



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FROM THE EDITOR ///

Diving into ceramics

I am never not blown away by how much of our daily lives is touched by products that are heat treated. From the time you get up in the morning until the time you hit the sack at night, you are constantly interacting with the heat-treated world.

That being said, thanks for checking out the current issue of *Thermal Processing*, where we're always keeping that window open on the world of heat treating.

With this issue focusing on ceramics, as well as industrial gases, our feature articles shine a spotlight on these topics.

Ceramics continues to be a growing part of the heat-treating industry, and there is quite a bit in this issue that will discuss this vital segment of the industry. That being said, we have been working hard since the beginning of the year to grow *Thermal Processing's* ceramics coverage to reflect the industry as well.

Our cover story, from NUTEC's Christian Tavira and Mauricio Díaz, takes a look at ceramic fiber, and how it — in its various forms — has ideal characteristics for thermal applications within industries that handle high temperatures.

Also, on the subject of ceramics, I am pleased to re-introduce our column on ceramics, "Ceramics Works." This column will fall intermittently throughout the year, trading places with Metal Urgency. Experts from Chiz Bros. have agreed to share their insights on the ceramic world, and I am so excited to introduce our first column from Mark Rhoa, VP of sales for Chiz Bros. In the column, he discusses how the industry is feeling the heat to reduce its carbon footprint and how ceramics can assist in this goal.

On the subject of industrial gases, our second focus article takes a deep dive on the nitrogen gas quenching pressure effect on BS S155 alloy steel in a vacuum furnace.

In addition to Rhoa's expert advice, be sure you check out the latest from our other columnists as well.

You'll find all that and more in this month's issue.

Keep in mind that *Thermal Processing* is here to get your message out to your customers, whether that be with news releases that we happily share with our readers or advertising that can drive home what your company can offer. There are options available, and *Thermal Processing's* primary goal is to help you with your company's mission in any way we can.

As always, thanks for reading!

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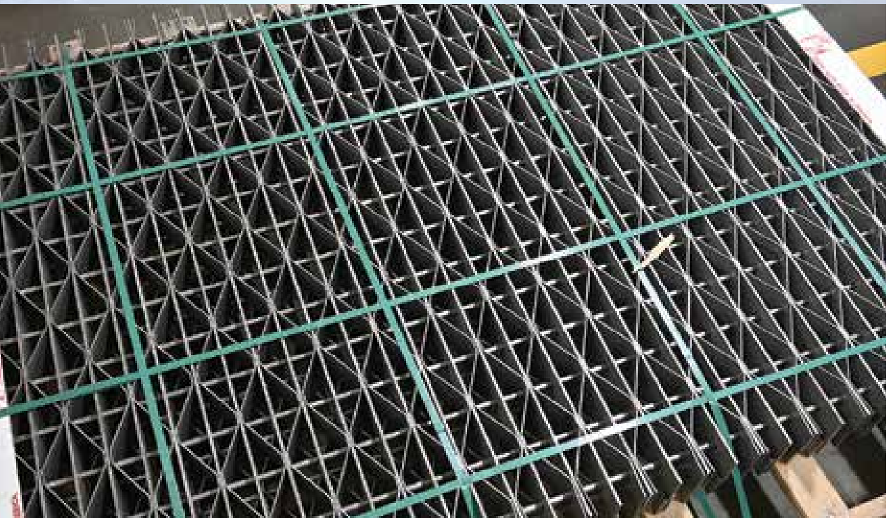

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Nippon Steel Corporation will use ENERGIRON® technology to conduct experimental operation of reduced iron with hydrogen. (Courtesy: Tenova)

Tenova to provide hydrogen EDRP plant in Japan

Tenova, a leading developer and provider of sustainable solutions for the green transition of the metals industry, was recently awarded a contract for an experimental direct reduction plant (EDRP) operated by Nippon Steel Corporation, and entrusted by the New Energy and Industrial Technology Development Organization (NEDO). Nippon Steel Corporation is Japan's largest steelmaker and one of the world's most prominent steel producers. The plant will be installed in the Hasaki R&D Center of Nippon Steel Corporation.

This facility will be used for the demonstration test of "Development of Direct Hydrogen Reduction Technology for Reducing Low-Grade Iron Ore with Hydrogen Alone / Development of Technology for Direct Hydrogen Reduction," which was adopted by NEDO's Green Innovation Fund in December 2021. This project is being undertaken by a consortium formed by Nippon Steel Corporation, JFE Steel Corporation, and the Japan Research and Development Center for Metals.

The DR plant, based on the ENERGIRON® Direct Reduction (DR) technology, jointly developed by Tenova and Danieli, will use hydrogen as reducing gas, although it will retain the flexibility to use different gases in any combination or proportion. To this end, the plant will be equipped with Tenova's signature CO_2 capture equipment that allows to curb overall emissions when the plant operates with mixes of gases containing carbon.

"With this contract, it has been confirmed once again that ENERGIRON is the best available cutting- edge technology for DRI plants," said Stefano Maggiolino, Tenova HYL president & CEO. "We are delighted to contribute to this project and supply the very first experimental direct reduction plant fed by hydrogen in Japan."

MORE INFO www.tenova.com

Solar Manufacturing ships Mentor Pro for vacuum annealing

Solar Manufacturing recently shipped a Mentor® Pro Model HFL-3036-2IQ vacuum furnace to a customer specializing in engineered knitted wire mesh solutions. They are a U.S.-based company and a global supplier for the automotive, food service, and janitorial industries. The furnace will be primarily used for vacuum annealing materials that are susceptible to adverse effects of their mechanical properties when exposed to any levels of oxygen or nitrogen.

The Mentor Pro features a molybdenum shielded hot zone measuring 18" wide x 18" high x 36" deep, capable of operating temperatures up to 2,400°F, and a workload weight capacity of up to 1,000 pounds and includes the SolarVac® Essentials PLC-based control system. The internal gas cooling system with a 50 HP drive motor is capable of quenching workloads at 2-bar positive pressure in either

The Solar Manufacturing Mentor® Pro Model HFL-3036-2IQ vacuum furnace features a molybdenum shielded hot zone measuring 18" wide x 18" high x 36" deep, capable of operating temperatures up to 2,400°F. (Courtesy: Solar Manufacturing)

SEND US YOUR NEWS Companies wishing to submit materials for inclusion in Thermal Processing's Update section should contact the editor, Kenneth Carter, at editor@thermalprocessing.com. Releases accompanied by color images will be given first consideration.

Evergreen Kiln Technologies, LLC will operate as a subsidiary of Can-Eng Furnaces International, Ltd. (Courtesy: Can-Eng)

nitrogen or argon.

"Our customer started running trials with our affiliate commercial heat treater, Solar Atmospheres," said Jason Davidson, regional sales manager. "Once the trial results proved the heat-treat cycle, and the furnace demonstrated it could process the required quantities, the customer had confidence to place the purchase order with us."

MORE INFO www.solarmfg.com

Evergreen Kiln signs partnership with Suzhou Kilnpartner

Evergreen Kiln Technologies, LLC, in Niagara Falls, United States, and Suzhou Kilnpartner Mechanical Technology Co., Ltd., in China, announced a strategic partnership between both parties.

This partnership was developed to service and support the growing demands of the North American lithium-ion battery market. This partnership will provide the market's battery material producers with access to the most modern and innovative kiln system solutions for producing cathode (LFP, NMC), and anode active materials.

Evergreen Kiln Technologies, LLC will operate as a subsidiary of Can-Eng Furnaces International, Ltd., where Can-Eng will share more than 60 years' experience designing and developing customized thermal processing solutions.

This partnership between the two companies encompasses various areas including marketing, brand collaboration, technological development, production, and engineering, as well as after-sales services. The goal is to create innovative methods for the thermal processing of battery powder. Together, the companies are committed to forming a collaborative alliance to provide the best kiln solutions to their customers in North America.

MORE INFO www.can-eng.com

Polish company installs latest Nitrex nitriding system

Extral Sp. z o.o., a Polish company specializing in aluminum extrusions has bolstered its manufacturing capabilities to better serve the construction, automobile, and machinery industries. Alongside acquiring a new aluminum extrusion press, the company ordered a Nitrex nitriding system featuring the exclusive Nitreg® technology to nitride H11 and H13 extrusion dies of various sizes.

This investment coincides with Extral's expansion of its operational footprint in Poland, including the construction of a new building to house the extrusion press and Nitrex furnace. This expansion enables the company to diversify its range of extruded products while maintaining a focus on sustainability and energy efficiency. The new nitriding installation will contribute to these objectives by providing more efficient use of process gases and electricity.

Previously, Extral outsourced its nitrid-

Extral Sp. z o.o. ordered a Nitrex nitriding system featuring the exclusive Nitreg® technology to nitride H11 and H13 extrusion dies of various sizes. (Courtesy: Nitrex)

ing operations to a local heat treater due to quality issues encountered with an underperforming in-house nitriding unit. However, this latest investment enables them to bring nitriding operations back in-house, ensuring better control over the quality and consistency of their nitrided dies while also benefiting from expedited turnaround times.

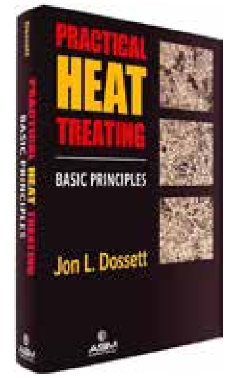
The turnkey nitriding system includes an NX-1015 pit-type furnace with a 2-ton (4410-lb) load capacity and NITREG technology, offering proven nitriding treatments that optimize die performance and throughput while concurrently reducing tooling costs.

"Working with Extral on this project has been a pleasure," said Marcin Stoklosa, project manager at Nitrex. "I have known the key contacts at Extral for nearly a decade, having met them and discussed their needs at various trade shows across Europe. Seeing customers invest in their business and achieve their goals, especially when it aligns with our values of innovation and sustainability, is always rewarding."

MORE INFO www.nitrex.com

New heat-treat book covers quality, processes, glossary

"Practical Heat Treating: Processes and Practices" by Jon L. Dossett covers processes, equipment, and the management of heat-treating systems and operations. It is a companion book to "Practical Heat Treating: Basic Principles" (ASM International, 2020). The book covers surface hardening of steel, carburizing, carbonitriding, nitriding, and ferritic nitrocarburizing. Quality assurance and specifications and problems associated with heat-treated parts are covered as well. A glossary of heat-treating terms is also included in the book.



"Practical Heat Treating: Processes and Practices" is available now at prepublication prices. (Courtesy: ASM International)

This thorough and practical coverage on the basic principles of heat treating will be a useful, attractive, and essential addition to the bookshelf of anyone with an interest in heat treating.

It is available now at a prepublication price of $215, and the ASM members' prepublication price is $160.

MORE INFO www.asminternational.org

Ipsen USA celebrates record performance in 75th year

In 2023, Ipsen celebrated its 75th anniversary. In a year that commemorated the past, Ipsen also achieved several notable accomplishments, including record revenue and significant growth.

Soaring aftermarket sales drive record revenue: Ipsen experienced exceptional performance in the aftermarket sector, achieving a 38 percent increase in replacement hot zone orders for both Ipsen and non-Ipsen furnaces compared to their previous record year. This surge in sales demonstrates Ipsen's position as a trusted provider of aftermarket support for the vacuum furnace industry.

Key achievements highlight operational excellence:

» **Global Reach:** Ipsen shipped more than 50 vacuum furnaces to customers across 10 countries, showcasing their international presence and ability to cater to diverse customer needs.

» **Production Expansion:** To meet the growing demand, Ipsen strategically

expanded their hot zone production capacity by repurposing the former Ipsen Ceramics facility. This expansion ensures efficient production and timely fulfillment of customer orders.

» **Quality and Precision:** Ipsen conducted more than $1 million in calibration and temperature uniformity surveys, demonstrating their commitment to supporting their products with quality services.

» **Accreditation for Excellence:** Ipsen completed ISO/IEC 17025:2017 accreditation for pyrometry services, a testament to their adherence to the highest industry standards.

» **Investing in the Future:** Recognizing the growing service needs of the industry, Ipsen made significant investments in its workforce by hiring more than 60 new employees in 2023. Additionally, they established a dedicated team for recruiting and training field service engineers, positioning themselves to further amplify their service presence in the years to come.

Ipsen's 75th anniversary year was a resounding success, marked by record-breaking achievements, strategic expansion, and a commitment to quality and customer satisfaction. With a focus on continued growth and investment in its people, Ipsen is primed for an even brighter future.

Ipsen's 75th anniversary year was a resounding success, marked by record-breaking achievements, strategic expansion, and a commitment to quality and customer satisfaction. (Courtesy: Ipsen)

MORE INFO www.ipsenusa.com

Seco/Warwick Group recently opened Seco/Lab, a modern Production Automation and Mechatronics Laboratory, at the University of Zielona Góra. (Courtesy: Seco/Warwick)

Seco/Lab opens at University of Zielona Góra

Seco/Warwick Group, an industrial furnace manufacturer and a leader in metal heat treatment, recently opened Seco/Lab, a modern Production Automation and Mechatronics Laboratory, at the University of Zielona Góra. The laboratory will help University of Zielona Góra students acquire practical skills, which will be an advantage in the labor market.

The Seco/Warwick Group has been recognized for years as one of the most dynamic companies investing in innovation. The company has received numerous accolades including the title of "Merit for Invention" on the occasion of the 100th anniversary of the Polish Patent Office, or "The one who changes Polish industry," and multiple awards for "Innovator," "Innovator of the Year," and "Innovative Company."

Seco/Lab is also the name of the Seco/Warwick R&D center and metallographic laboratory. The Polish R&D Department started in 2006 with three employees, and today it is a dynamic organizational unit cooperating with many universities and employing over a dozen highly qualified employees, including scientists, automation engineers and outstanding heat-treatment, thermochemical and metallurgy specialists. The Seco/Warwick Group's second Research and Development Center is located in the United States in Buffalo, New York.

"The equipment in our laboratories and our excellent team of scientists allow us to research metal heat-treatment technology and verify innovative ideas," said Sławomir Woźniak, president of the Seco/Warwick Group's Management Board. "We conduct a number of metallographic tests, which are then the basis for proposing appropriate technology to the customer, or in other words, verifying customer requirements. Using the laboratory equipment, you can quickly and professionally check the effects of tests and technological processes. The Research and Development Center provides extensive opportunities to create and test new or significantly improved solutions for the metal heat-treatment industry.

"Together with the University of Zielona Góra, we decided that the almost identical Seco/Lab research laboratory should also be within the reach of students and allow them to acquire practical skills at this stage of their educational path," Woźniak said. "When designing our joint laboratory, we placed particular emphasis on the imperative of gaining practical knowledge in the field of heat treatment process automation and digitization. Universities should not educate only in theoretical terms. Today, in the era of automation and artificial intelligence, practical skills will be the main advantage on the labor market. At the same time, we hope that the best university graduates will want to continue their careers connected with metal heat treatment in the Seco/Warwick Group."

Seco/Lab is the name given not only to the laboratory at the University of Zielona G ra, but also to the research and development center in Świebodzin. The Seco/Warwick R&D Center is divided into two areas. In the first stage of development, technological tests are carried out using industrial equipment. During the second stage in the laboratory, test material preparation is carried out, i.e. material from technological tests is prepared for further examination and the prepared samples are analyzed.

Seco/Warwick is a company producing equipment for metal heat treatment and has its own metallographic laboratories.

"Most often we conduct microscopic observations and hardness measurements," said Łukasz Piechowicz, Director of the Seco/Warwick Group's R&D Department. "The properties of a given material result directly from its microstructure, which is why microscopic examination is so important. By viewing the material at appropriate magnification, you can assess the treatment correctness, detect possible errors, and sometimes also learn about its history. Important information about the heat-treatment results can also be obtained from hardness measurements. The data acquired is used to develop technology and build innovative solutions, as well as obtain heat treatment with better technical parameters and in many cases, reduce production costs. Many solutions are implemented thanks to Seco/Lab. The lab has also been instrumental when developing and improving technologies to reduce the carbon footprint generated by metal heat treatment equipment."

The cooperation between Seco/Warwick and the University of Zielona Góra began almost 10 years ago. In 2021, a joint subsidized project entitled, "Autonomous system for monitoring and processing operating parameters of a pit furnace for the needs of Industry 4.0 in low-pressure carburizing processes" was completed. The obtained project results can be used in many industries, including the renewable energy sector. Seco/Warwick and the University of Zielona Góra also cooperate within the international innovation network SUPRA, which was created by a community of industrial and research partners in the field of production technology. Currently, both Seco/Warwick and the University of Zielona Góra focus on promoting practical knowledge and skills in the field of industrial process automation among students, hence, the idea to create Seco/Lab.

The cooperation with UZ is not the only one in the Seco/Warwick Group's broad portfolio of science and industry connections.

Scientific teams of the Lodz University of Technology, together with Seco/Warwick, have carried out as many as 21 research projects for 25 years. As a result, these modern technologies were created — FineCarb® and PreNitLPC® vacuum carburizing. These technologies have been implemented into several hundred vacuum furnaces operating on five continents.

Together with the Poznań University of Technology, Seco/Warwick has worked on the development of gas nitriding technology using the ZeroFlow method. Jointly with the Wrocław University of Science and Technology, the use of gas nitriding technology to extend the life of forging tools was investigated, and with the Rzeszow University of Technology — the development of single-crystalline technology for casting turbine blades using the DGCC (Developed Gas Cooling Casting) method became a reality.

MORE INFO www.secowarwick.com

Nitrex vapor phase aluminizing furnaces are purposefully engineered with moving bases and a fixed heat chamber, enhancing operational efficiency. (Courtesy: Nitrex)

Engine manufacturer adds Nitrex VPA furnaces

Nitrex has announced its newest order for two vapor phase aluminizing furnaces to a leading jet engine manufacturer who is scaling up production of high-performance blades and vanes.

In a move aimed at elevating its manufacturing capabilities, a leading jet engine manufacturer and a loyal repeat customer of G-M Enterprises, a Nitrex company, is gearing up to integrate two cutting-edge vapor phase aluminizing (VPA) coating furnaces during the first half of 2024. This strategic investment not only marks a bold step forward in the company's ongoing commitment to advancing aerospace manufacturing but highlights a continued partnership that has seen the customer acquire various types of Nitrex vacuum furnaces for multiple locations.

These high-capacity, low-maintenance automated retort VPA furnaces are purposefully engineered with moving bases and a fixed heat chamber, enhancing operational efficiency. Each retort is seamlessly sealed to the moving bases, allowing for concurrent handling of two loads, each containing three coating cans. The result is a streamlined

process that runs two cycles back-to-back, completing the treatment within just over 24 hours. The automated furnace supports unattended start-ups, empowering operators to focus on preparing loads for the second system which facilitates concurrent operations for heightened productivity.

"Our VPA furnaces ensure seamless operations, providing our customer with a competitive edge in production capacity," said Robert Huckins, national sales manager. "This is crucial in meeting escalating demand while delivering high-performance and longer-lasting blades and vanes vital for high-temperature fired engines."

A standout feature of the Nitrex VPA design is the raised fixed heat chamber, effectively shielding operators and the furnace room against potential heat exposure. This innovation eliminates the need for cumbersome protective heat suits. The hot retort remains securely housed within the insulated furnace, prioritizing operator well-being. Furthermore, this safety measure confines the load base and retort/coating load within the SAR/VPA furnace housing until the retort temperature drops below 150°C (300°F). This meticulous attention to safety underlines the commitment to operational excellence throughout the entire process.

This strategic investment not only underscores the manufacturer's commitment to staying at the forefront of technological advancements but also solidifies a lasting partnership, showcasing the mutual trust built over multiple acquisitions of various vacuum furnaces.

MORE INFO www.nitrex.com

Solar Atmospheres adds third car bottom air furnace

Solar Atmospheres of Western PA recently commissioned their third car bottom

Solar Atmospheres of Western PA's newly installed car bottom air furnace is a benefit to customers and for production as it can be used for heavy parts as well as long components. (Courtesy: Solar Atmospheres of Western PA)

air furnace manufactured by Heat Treat Equipment Inc.

This large Class 2 air furnace with a maximum operating temperature of 1,350°F measures 60" wide x 38" high x 168" deep. The newly installed equipment joins two other HTE car bottom furnaces that are 14' long and 20' long respectively.

"The addition of this large air tempering/aging equipment compliments our five state-o-the-art vacuum car bottom furnaces very nicely," said Bob Hill, president of Solar Atmospheres of Western PA and Michigan. "Instead of hardening and triple tempering this 6,000-pound H13 die exclusively in a vacuum environment, Solar can save our customers and our company over 100 hours of valuable and expensive vacuum processing time. After successfully hardening in vacuum at 1,850°F +/- 10°F, the fully hardened die was transferred to the air car bottom furnace for the triple temper operation of 1,025°F +/- 10°F. These large and uniform car bottom furnaces are a win/win for both the customer and for production — not exclusively for heavy parts but also when treating long components."

MORE INFO www.solaratm.com

Wisconsin Oven ships custom batch ovens

Wisconsin Oven Corporation announced the shipment of two custom-designed gas fired batch ovens with roll-up doors. The ovens will be used to hold molded urethane wheels prior to a curing process.

The batch ovens have a maximum operating temperature of 350°F and work chamber dimensions of 9' wide x 4'6" long x 10'6" high. The ovens are designed with electrically operated roll-up doors in the front of the oven constructed from high-temperature fabric. The door controls allow the door to open halfway or all the way by a command from a loading robot. In addition to the roll-up door on the front, a bi-parting, side-hinged, horizontal swing door is located on the rear of each oven.

These batch ovens feature a horizontal airflow arrangement, which is ideal for

The Wisconsin Oven batch ovens have a maximum operating temperature of 350°F and work chamber dimensions of 9' wide x 4'6" long x 10'6" high. (Courtesy: Wisconsin Oven)

products arranged in multiple tiers where heated airflow cannot be directed vertically through the product. Both ovens use a Watlow F4T digital controller that includes a 4.3" color touch screen, PID temperature control with adaptive tuning, and Ethernet communication capabilities for temperature control. A remote display for the flame relays is also mounted to each control panel to provide an annunciation of operation along with fault and diagnostic information.

"Using a roll-up door design greatly reduces the overall oven height in comparison to vertical lift doors," said Tom Trueman, sales engineer. "This type of design can be used for applications with operating temperatures up to 300° F or even higher in certain cases."

Unique features of these custom batch ovens include:

- Electrically operated roll-up doors.
- Robot-operated door controls for loading and unloading.
- Horizontal swing door at the rear of each oven.
- Air heat burner rated at 1,200,000 BTU per hour.
- 6,000 CFM direct-driven recirculation blower.
- Watlow F4T temperature controller.
- Ethernet communications capability.

These custom batch ovens were fully factory tested and adjusted prior to shipment from the facility. All safety interlocks were checked for proper operation and the equipment was operated at the normal and maximum operating temperatures. An extensive quality assurance check list was completed to ensure the equipment met all Wisconsin Oven quality standards.

MORE INFO www.wisoven.com

Igus launches iglide i230 3D printing material

Igus® announced its new iglide® i230 3D printing material for selective laser sintering (SLS). This new powder material can withstand temperatures up to 110°C, expanding the use cases for SLS-printed polymer components.

During SLS, a printer melts plastic powder layer by layer to form bearings and other components. However, parts made from standard SLS printing materials — such as PA (nylon) 12 — are generally limited to applications less than 80°C. Higher temperatures cause the material to become soft and lose dimensional stability, preventing SLS-printed components from being used in applications such as automotive engines.

"As the demand for 3D-printed plain bearings for applications with high ambient temperatures has increased, we have developed a new SLS printing material called iglide i230," said Paul Gomer, 3D Printing Material Developer at igus.

Tests performed according to DIN EN ISO 75 HDT-A and HDT-B have demonstrated iglide i230's heat resistance. Printed parts made from the material do not deform at 80°C. They can withstand long-term exposure to temperatures of 110°C — and even short-term exposure to 170°C without deforming.

"3D-printed plain bearings made from iglide i230 have a significantly longer service life, increase the efficiency of machines, systems, and vehicles, and reduce the need for maintenance," Gomer said.

At the same time, iglide i230 offers 50-percent more mechanical strength than PA 12 at room temperature. "This makes it possible, for example, to achieve the same component strength in plain bearings with a thinner wall thickness and to save room and weight in compact installation spaces," said Gomer.

Other features of iglide i230 include:

- Free of polytetrafluoroethylene (PTFE).
- Roughly 80 percent more wear-resistant than PA 12.
- Has withstood pressures of 94 MPa during bending tests.
- Protects machines and systems from electrostatic discharge.
- Does not require time-consuming relubrication work, as solid lubricants are integrated into the material to ensure low-friction, dry operation.

MORE INFO www.igus.com

Solar Atmospheres of Michigan's Nadcap AC7101/4 accreditation will allow the Chesterfield plant to continue testing for microhardness, surface contamination, intergranular oxidation and grain size which were all previously completed at the Warren facility. (Courtesy: Solar Atmospheres of Michigan)

Solar Atmospheres achieves Nadcap accreditation for Lab

Solar Atmospheres of Michigan successfully achieved Nadcap AC7101/4 accreditation for their captive metallography laboratory.

The accreditation will allow the Chesterfield plant to continue testing for microhardness, surface contamination, intergranular oxidation and grain size which were all previously completed at the Warren facility. In addition to continued testing capabilities, the addition of new metallographic preparation equipment and metallography software will expand Chesterfield's R&D capabilities and assist in new product development.

"This was the next step in moving operations from Warren to Chesterfield," said plant metallurgist Greg Scheuring. "To limit downtime and maintain on-time delivery, we gave ourselves a week to make the move and conduct the audit. It was an extremely abbreviated period of time for such a task but personnel at both facilities pulled together to make it happen. Now the audit is complete with no findings, and we are back up and running. Stellar teamwork all around!"

MORE INFO www.solaratm.com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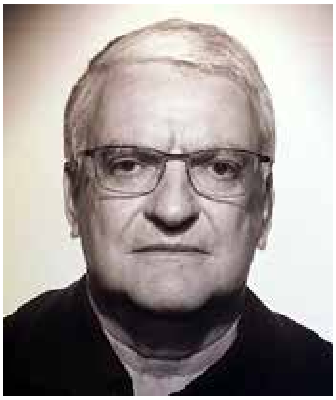
CERAMICS EXPO

Podgornik to be awarded IFHTSE Fellowship at Lecce conference

Prof. Bojan Podgornik, head of the Materials and Technology department at the Institute of Metals and Technology and Professor at the University of Ljubljana, Slovenia, will hold the opening lecture at the 4th Mediterranean Conference on Heat Treatment and Surface Engineering on "Self-lubricating surfaces for hot forming of light-weight alloys."

At this conference, he will also be awarded the IFHTSE Fellowship "in recognition of his significant research work, knowledge contribution, and international activity in the field of heat treatment and surface engineering, focused on deep cryogenic treatment, substrate multi-properties approach, and hard coatings interactions." The award ceremony will be at the combined IFHTSE conferences in Lecce, Italy.

Prof. Bojan Podgornik



Dr. Patrick Jacquot

DR. PATRICK JACQUOT TO BE GIVEN AWARD

Dr. Patrick Jacquot will receive an award at the 4th Mediterranean Conference on Heat Treatment and Surface Engineering. He was IFHTSE president 2016-2017 and served on the Executive Committee of IFHTSE for 15 years. He is a renowned expert of surface engineering and was a leader in the central laboratory of the Bodycote Group.

The citation of the award reads: "in recognition of his extensive contributions to the practical application of new heat treatment and surface engineering technologies and his long-time service to IFHTSE including his presidency." The award ceremony will at the combined IFHTSE conferences in Lecce, Italy.

PROF. IMRE FELDE TO LEAD OPENING LECTURE

The opening lecture of the 5th International Conference on Thermal Process Modeling and Simulation will be by Prof. Imre Felde of the Obuda University, of Budapest, Hungary. Prof. Felde, treasurer of IFHTSE, will be speaking about "Physics-informed neural networks for heat treatment operations."

CONFERENCE UPDATES

4th Mediterranean Conference on Heat Treatment and Surface Engineering (MCHTSE 2024)
April 17-19, 2024 I Lecce, Italy

MCHTSE 2024 will be held together with the 5th International Conference on Thermal Process Modeling and Simulation (5th ICTPMS). These two IFHTSE conferences will be in Lecce, Italy.

The conferences aim to provide a forum where engineers, scientists, researchers, and production managers can review and discuss fundamentals, new challenges, recent progress, and emerging topics in the fields of advanced heat treatment and surface engineering technology.

TPMS-5 aims at covering all aspects of modeling and simulation of thermal processes.

The 29th IFHTSE World Congress, a premier global event dedicated to advancing the fields of heat treatment and surface engineering, will be held September 30 to October 3 in Cleveland, Ohio. (Courtesy: Shutterstock)

»**More info:** www.aimnet.it/eng/manifestazione.php?id=789&idc=4

2nd Bosphorus International Heat Treatment Symposium
April 25-26, 2024 I Istanbul, Türkiye

BHTS'2024 — 2nd Bosphorus International Heat Treatment Symposium will be at the Halic Congress Center in Istanbul April 25-26, 2024, in cooperation with MISAD — Heat Treatment Industrialists Association and METEM-UCTEA, Chamber of Metallurgical and Materials Engineers' Training Center.

With the scope of this symposium, a space will be created where the challenges in advanced heat-treatment technologies, current R&D studies, new developments, and different ideas will be discussed. Within this framework, local, foreign, and international companies are invited that want to exhibit their products, services, and exemplary applications to support them as participants. The symposium is in Turkish and English. Turkish-English simultaneous translation will be provided in all sessions.

»**More info:** www.bhtsheat.com/en

European Conference on Heat Treatment and Surface Engineering 2024 (and A3TS 50th Congress)
June 5-7, 2024 I Toulouse, France

The ECHT 2024 Conference and the 50th Annual A3TS Congress will take place together in Toulouse, France June 5-7, 2024. The focus will be on processes and technologies for a sustainable future in transport and industry. The conference will deal with all fields of heat treatment and surface engineering: heat treatment of metals (iron and steel, non-ferrous alloys); thermochemical treatment of metals; coatings and surface treatments; coatings and surface treatments including dry treatment operations (PVD, CVD, plasma, thermal spraying, etc.); and wet treatment operations (electrochemistry, etc.). Specific sessions will be devoted to the aerospace industry. Additional focus areas include:

»Contribution of innovative heat and thermochemical treatments to EU climate goals.

»Digital technologies in heat treatment and surface engineering industries.

»Coatings made from enhanced materials for electrical and thermal conductivity.

»Surface engineering to address environmental constraints.

»New needs in tribological properties: an open challenge for heat treatment and surface engineering.

»**More info:** echt2024a3ts.sciencesconf.org

29th IFHTSE Congress
September 30-October 3, 2024 I Cleveland, Ohio

The ASM Heat Treating Society (HTS) and the International Federation for Heat Treatment and Surface Engineering (IFHTSE) present the 29th IFHTSE World Congress, a premier global event dedicated to advancing the fields of heat treatment and surface engineering. Co-located with ASM's annual meeting, IMAT 2024, the congress is scheduled for September 30-October 3, 2024 in Cleveland, Ohio.

The 2024 IFHTSE World Congress revolves around the theme "Innovations in Heat Treatment and Surface Engineering for a Sustainable Future." Emphasizing the critical role of these technologies in shaping a sustainable world, the event will explore the latest developments, breakthroughs, and practices that can enhance the efficiency, performance, and environmental impact of heat treatment and surface engineering processes. In addition, traditional heat-treating topics will be offered.

Important dates:

First Draft of Manuscript Due: May 17, 2024.

Editor Feedback to Authors: June 14, 2024.

Final Manuscripts Due: June 28, 2024.

»**More info:** www.asminternational.org/ifhtse-congress

Third International Conference on Quenching and Distortion Engineering
May 6-8, 2025 I Vancouver, Canada

This event will be held in conjunction with AeroMat 2025. This is a continuation of the successful Distortion Engineering conference series and the Quenching and Distortion conference series. The first QDE was in Chicago in 2012 and has occurred at approximately five-year intervals. There is a strong focus on the effects of residual stress during manufacturing and methods to control distortion and residual stress. The call for papers is expected in the next few months.

IFHTSE is a federation of organizations not individuals. There are three groups of members: scientific or technical societies and associations, universities and registered research institutes, and companies.

INDUSTRIAL HEATING EQUIPMENT ASSOCIATION

IHEA's Industrial Heating Decarbonization SUMMIT scheduled for October

IHEA's Industrial Heating Decarbonization SUMMIT will be October 28-30 at the Conrad Indianapolis.

The Industrial Heating Equipment Association (IHEA) recently announced the Industrial Heating Decarbonization SUMMIT on October 28-30 at the Conrad Indianapolis.

"Forging a Sustainable Path for the Industrial Heating Industry," the SUMMIT is being developed to provide a platform for everyone needing to explore all facets of decarbonization as they relate to the industrial process heating industry.

"With all the emphasis to reduce or eliminate carbon in our processes and the challenges that come along with this, there has never been a more opportune time to hold this SUMMIT," said IHEA President Brian Kelly. "It will provide attendees the opportunity to learn more about the different pathways that are possible to decarbonize their processes, along with tools and programs to assist in these endeavors. This is an event not to be missed and unique in its offerings as we look to forge a sustainable path for the industrial heating industry."

Manufacturers face increasing pressures to become more environmentally responsible, and the challenge to implement sustainable energy alternatives looms large for many companies. Rapid advancements in technologies and industry energy infrastructure make planning for sustainable industrial manufacturing a daunting task.

"At IHEA's 2024 Industrial Heating Decarbonization SUMMIT, attendees will benefit from expert advice and practical experiences delivered by industry leaders implementing a wide variety of solutions for sustainable industrial process heating," said IHEA's Sustainability SUMMIT Program Chairman, Jeff Rafter. "Presentations will include a wide range of alternatives to reduce your carbon footprint. Panel discussions will explore best practices and real-world experiences of major manufacturers leading sustainability trends. In total, the IHEA Industrial Heating Decarbonization SUMMIT will provide an invaluable suite of information and networking for any company seeking to address advancements in more sustainable manufacturing."

The preliminary program includes the following topics:

- Sustainability terms and definitions.
- Sustainability and net zero.
- Terms and definitions.
- Sustainability pathways.
- Efficiency and renewable fuels.
- Electrification.
- Carbon credits and carbon sequestration.
- Efficiency in process heating.
- Reducing fuel usage.
- Automation and controls impact.
- Ancillary equipment and system efficiency.
- Calculation and tools.
- Low carbon fuels and hydrogen.
- Electrification (direct vs. indirect).
- Carbon credits and net zero.
- Carbon sequestration.
- DOE programs and tools.
- Benchmarking E.U. to U.S.
- Industry adoption.
- Economics and business concerns.
- The risk of doing nothing.
- Codes and legislation.
- Grants and funding sources.
- Collaboration for decarbonization panel.

A tabletop exhibition will be offered as part of the SUMMIT and sponsorships will be available in April. Registration will also open in April.

Watch for more information or go to www.ihea.org for updates.

Established in 1929 to meet the need for effective group action in promoting the interests of industrial furnace manufacturers, IHEA has expanded and currently includes designers and manufacturers of all types of industrial-heat-processing equipment used for the melting, refining, and heat processing of ferrous and nonferrous metals and certain nonmetallic materials and heat-treatment of products made from them.

IHEA 2024 CALENDAR OF EVENTS

APRIL 8–MAY 19

Fundamentals of Industrial Process Heating Online Course
This course is designed to give the student a fundamental understanding of the mechanisms of heat transfer within an industrial furnace and the associated losses and the operation of a heating source either as fuel combustion or electricity.

Course Fees: $775 IHEA members / $950 non-members

APRIL 18

Sustainability & Decarbonization Webinar Series – Making Decisions: Gas vs. Electric

MAY 16

Sustainability & Decarbonization Webinar Series – Increasing Available Heat to Lower CO_2
This webinar will review the proven methods for heat recovery and emissions reduction and their applicability to processes where fuel savings and/or production increases have not previously justified their implementation.

JUNE 20

Sustainability & Decarbonization Webinar Series – Understanding Carbon Credits & Net Zero

JULY 18

Sustainability & Decarbonization Webinar Series – Industry Adoption: U.S. Codes & Standards

AUGUST 15

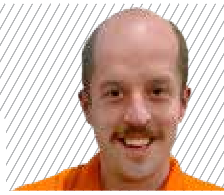
Sustainability & Decarbonization Webinar Series – Renewable Fuels

For details on IHEA events, go to www.ihea.org/events

INDUSTRIAL HEATING EQUIPMENT ASSOCIATION

P.O. Box 679 I Independence, KY 41051
859-356-1575 I www.ihea.org

MARK RHOA
VICE PRESIDENT OF SALES /// CHIZ BROS



The concept of 'going green' is not going to go away, but it needn't be a fearful process if it's seen as a long-term goal with benchmarks along the way.

Feeling the heat to reduce your carbon footprint

Whether it is the government, management, or simply general public pressure, it seems like everyone in our industry is being asked to reduce their carbon footprint. Ceramic fiber insulation can play a big part in your plan to reduce your carbon footprint. No matter where you stand on the issue of "Going Green," it is a reality that we are going to have to live with in the future. This then begs the question: How the heck do we reduce our carbon footprint?

In the refractory and high-temperature insulation world, I like to break this down into three areas:

» **Big picture capital investments:** For the sake of this article, we will focus on switching to electric heating.

» **Improved material performance:** New developments in the ceramic fiber industry allow for the ability to better insulate furnace linings.

» **Routine maintenance items:** Plants can save money and reduce gas usage by keeping an eye on a few key parts of their furnace.

CAPITAL INVESTMENTS

Electrically heated furnaces seem to be growing in popularity, as they present an easy way to point to not directly using fossil fuels. While that may be considered "kicking the can down the road" since the electricity to heat them has to come from somewhere, it is still a viable piece in the green movement. In the heat-treating industry, electrically heated furnaces are playing an ever-increasing role. One of the options for electrically heating a furnace is the "rod over bent" or ELE system. In Figure 1, you'll see that the electric elements are hung on the ceramic fiber modules using ceramic tubes and S hooks. This design minimizes any additional support you may need on the shell. Additionally, since this element system uses ceramic fiber modules, it maximizes thermal efficiency and can even be used with new-age higher insulating fibers that will be discussed later. ELE systems also allow for differing zone temperatures through element layout. Finally, electrically heated furnaces typically require less permitting.

IMPROVED FURNACE LININGS

Back in the early 2000s, when the price of natural gas was above 10 MMBtu, there was a large push to look at various ways to make furnaces more efficient. The fracking revolution quickly reduced the price of natural gas in the U.S., and subsequently decreased the urgency to make furnaces more gas efficient. With the new advent of reducing one's carbon footprint, that push has returned.

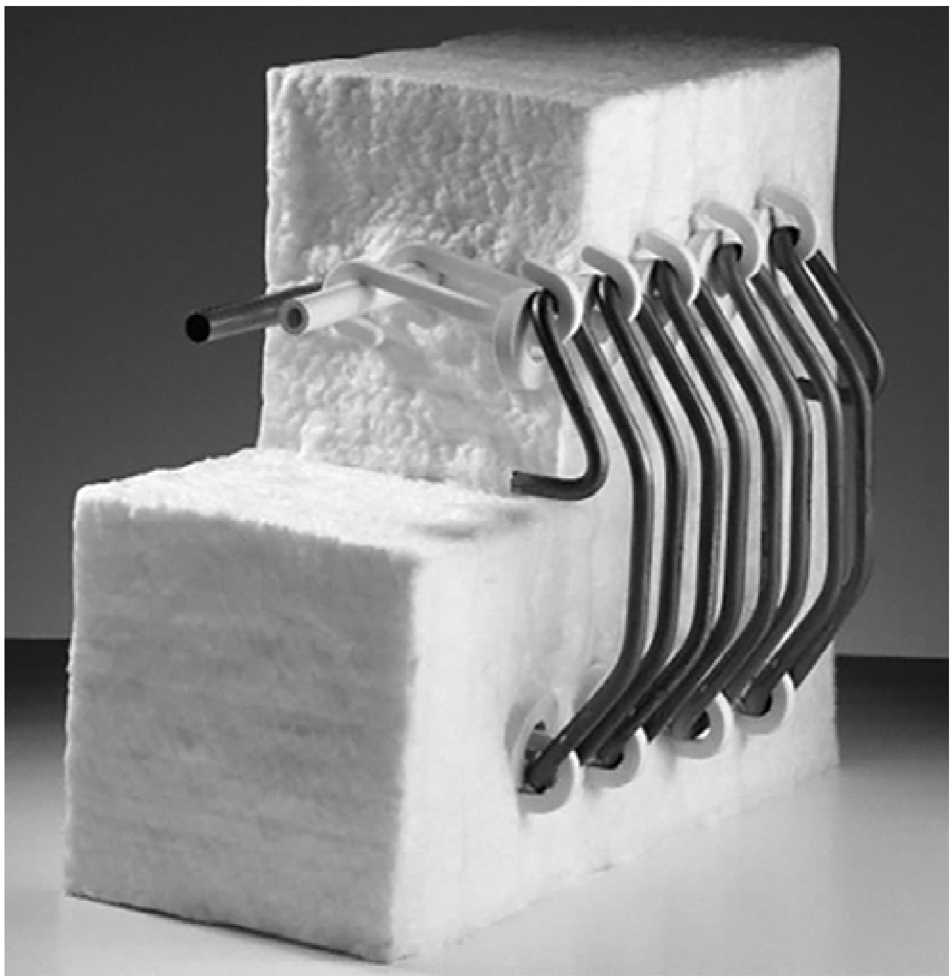


Figure 1

One of the easiest ways to achieve this is by making the furnace linings more thermally efficient. Forging furnaces typically have a ceramic fiber lining on the roof and upper walls. While ceramic fiber is a great insulator in its most basic form, a new product developed by Unifrax now allows for traditional ceramic fiber linings to be up to 20 percent more thermally efficient. This is achieved by manufacturing it in a proprietary process that creates a fiber blanket with less shot. Figure 2 shows the difference between a standard

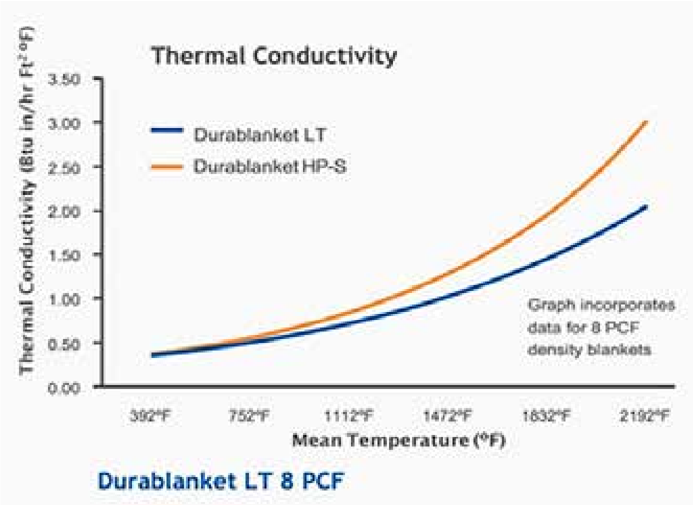


Figure 2

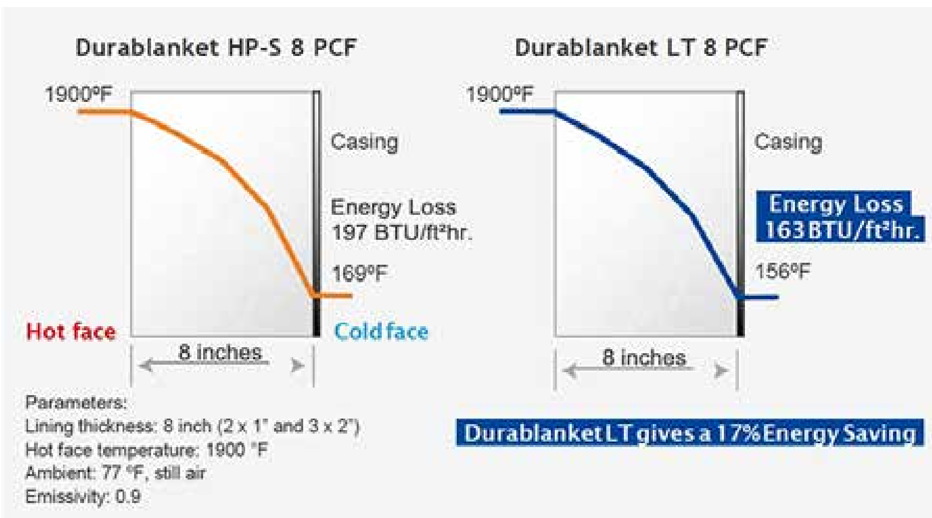


Figure 3

fiber blanket and the new LT blanket.

While these fancy numbers are nice, the real question is, what does this mean to me from an energy savings standpoint? At 1,900°F, an 8# density lining will yield a cold face temperature of 169°F using traditional ceramic fiber blanket. With the new LT blanket in the same conditions, the lining causes a cold face temperature of 156°F. (See Figure 3.) This translates to a reduction in the loss of BTU/Ft2HR of 34. This reduction can vary based on temperature, lining thickness and density, but with these conditions you get a 17 percent energy savings. Outside of reducing the carbon footprint, this will save money on the gas bill and increase the life of the furnace lining.

ROUTINE MAINTENANCE ITEMS

While going green can sound great, we all know the realities of budget constraints. This can be especially burdensome on old furnaces that have been around for ages. Thankfully, there are some simple steps and best practices that furnace operators can implement to run their furnace more efficiently. The area that typically loses the most heat on a furnace is around the door. The mechanical abuse, along with the constant thermal shock of opening and closing, lead to increased degradation of the insulation lining.

Following are a few quick tips for better efficiency:

» **Furnace door design:** Design your furnace doors with a module perimeter that can be easily removed and replaced. This prevents the additional cost of relining the whole furnace due to wear and tear on the sealing surface.

» **Fill in hot spots immediately:** The longer a hot spot lingers, the bigger the problem will become and BTU loss will increase exponentially.

» **Test out fiber lintels and jambs:** While they are not the ideal solution for every type of forge furnace, a well-designed fiber lintel and jamb can help with increasing thermal efficiency and reducing the wear and tear of thermal shock.

Another key spot that can often lead to increased heat loss is the burner area. There are plenty of old furnaces with old burner systems out there. When burner blocks begin to show signs of wear, they are also likely becoming less efficient. This would typically be due to leaks in any of the cracks and any reduction in the block thickness, leading to a reduction in insulating value. Just as important as the burner block itself is ensuring that there is a proper seal between the block and furnace lining. High temperature mat (low density stuffing material) or a pumpable fibrous material are two typical solutions for the issue.

The biggest challenge I hear with going green is the fear of increased cost or loss of operational efficiency. These are valid concerns, as it doesn't do a company any good to go green and then have to close its doors in two years. Reducing one's carbon footprint should be seen as a long-term goal, with benchmarks along the way. Proper communication to the entire team, along with tangible numbers and benefits, go a long way to ensuring employees buy into the program. After all, sometimes simply complaining about "The Feds" is a great way to get everyone on board with the plan.

ABOUT THE AUTHOR

Mark Rhoa is the VP of Sales for Chiz Bros, a refractory and high insulation company with a focus on ceramic fiber insulation. Chiz Bros. is a family-owned business that is proud to supply ceramic fiber blanket, board and modules that are made in the USA. www.chizbros.com

D. SCOTT MACKENZIE, PH.D., FASM
SENIOR RESEARCH SCIENTIST–METALLURGY /// QUAKER HOUGHTON INC.

Tank size, ambient temperature, and operating temperature factor in determining proper fill depth without risking a spill, fire, or explosion.

Thermal expansion of mineral oil quenchants

In this column, I will discuss the thermal expansion of oil. This information is primarily important for initial fills of a quench tank.

INTRODUCTION

Oil, when heated, expands. This is important for the initial fill of the quench tank, as well as determining the expansion of the oil during quenching. The goal is to provide adequate freeboard so that the oil does not overflow the quench tank and potentially cause a fire or explosion, or a large spill.

Often, a furnace manufacturer will have already determined the maximum volume of the oil allowable during quenching. However, this volume is calculated at the temperature of use, not ambient temperature for filling. If the quench tank is initially filled to the maximum level, and the oil is heated to the operating temperature, the oil will expand and potentially cause a fire or explosion hazard. Therefore, it is necessary to know how much oil to put in the tank, so that when the oil is heated, it will expand to the proper level.

CALCULATION

The thermal coefficient of expansion is dependent on the dynamic viscosity of the fluid. The unit of dynamic viscosity in CGS units is the poise, named after Jean Léonard Marie Poiseuille. It is commonly expressed as *centipoise* (cP). Chu and Cameron [1] established a correlation for the thermal expansion of mineral oils over a wide range of dynamic viscosities and is shown in Figure 1.

While the scatter of the measurements was large ($R^2 = 0.772$), a linear regression of the data resulted in the following equation (in units of °F^{-1}):

$$\alpha = [5.5 - \log_{10}\mu] \times 10^{-4}$$

Where α is the thermal coefficient of expansion, μ is the dynamic viscosity oil at 100°F in centipoise. For a typical quench oil with a kinematic viscosity of 22 cSt, the thermal expansion coefficient is 0.0004223 °F^{-1}. This is converted to metric units by multiplying by 1.8 to get the units in °C^{-1}.

The commonly found kinematic viscosity (cSt) found in most technical data sheets to dynamic viscosity used in this equation can be found by multiplying the specific gravity by the kinematic viscosity:

$$\mu = \nu \times S_g$$

Where ν is the kinematic viscosity in centistokes, and S_g is the specific gravity of the product. Typical values for different products over a range of viscosities are shown in Table 1.

The thermal expansion of mineral oil is calculated from the following equation:

$$V_f = V_0 + \left[\alpha \times V_0\left(T_f - T_0\right)\right]$$

Simplifying:

$$V_f = V_0\left[1 + \alpha\left(T_f - T_0\right)\right]$$

Where V_f is the final volume, α is the thermal coefficient, V_0 is the initial volume, T_f is the final temperature, and T_0 is the initial temperature. The thermal expansion of the products shown in Table

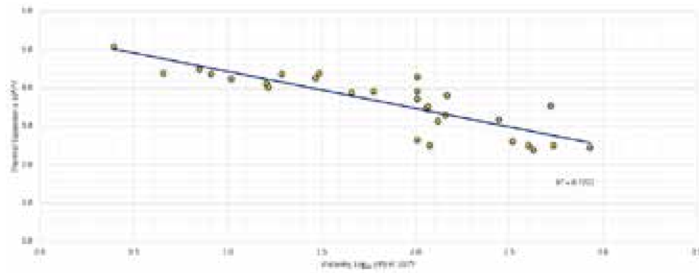


Figure 1: Thermal expansion coefficient (per °F) at ambient pressure. Viscosity in cP at 100°F, after [1].

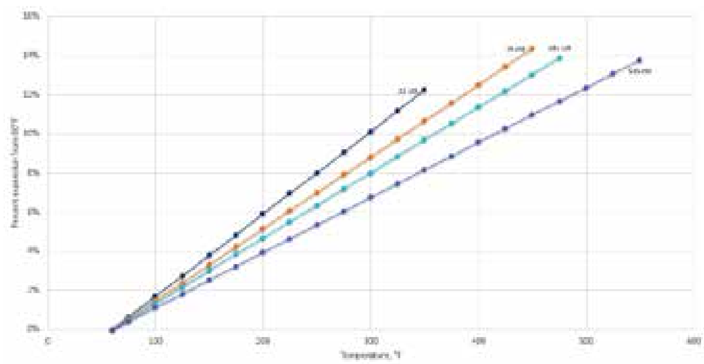


Figure 2: Percent expansion of oils shown in Table 1 from 60°F to different temperatures.

Product	Specific Gravity	Kinematic Viscosity at 100°F (SUS)	Kinematic Viscosity 100°F (cSt)	Viscosity (cP)
Houghto-Quench™ 100	0.86	106	22.0	18.92
Mar-Temp™ 355	0.87	350	75.0	65.25
Mar-Temp™ 755	0.88	745	160.8	141.50
Mar-Temp™ 2565	0.92	2433	525.0	483.00

Table 1: Typical data sheet values for different products over a wide range of viscosities.

1, up to their flash point, is shown in Figure 2. For most products, the expansion is on the order of 15 percent when approaching the flash point of the oil.

EXAMPLE CALCULATION

In this instance, I have a new installation of a furnace, nominally designed for 3,000 gallons of oil when up to the operating temperature of 180°F. The oil is a typical fast, cold oil with a viscosity of 26.1cSt at 100°F, and a specific gravity of 0.86. The ambient temperature of the shop is 75°F. I want to know how much to buy for the initial fill.

The first thing to determine is the dynamic viscosity in cP. Since the kinematic viscosity of the product is 26.1 cSt, and the specific gravity is 0.86, the dynamic viscosity in cP is 26.1 cSt * 0.86 = 22.44 cP. Substituting this value into the following equation, the coefficient of thermal expansion is determined:

$$\alpha = [5.5 - \log_{10}\mu] \times 10^{-4}$$

Or a value of α = 4.083 x 10-4/°F.

Since the desired volume of oil at the operating temperature is 3,000 gallons, this is the final volume, V_f. Rearranging the volume equation

$$V_f = V_0\left[1 + \alpha\left(T_f - T_0\right)\right]$$

To yield the initial volume, results in:

$$V_0 = \frac{V_f}{\left[1 + \alpha\left(T_f - T_0\right)\right]}$$

Substituting the known values (final volume of 3,000 gallons, initial temperature 75°F, and operating temperature of 180°F):

$$V_0 = \frac{3000\ gallons}{\left[1 + \frac{0.0004083}{°F} * (180°F - 75°F)\right]} = 2877\ gallons$$

For my quench tank, I would need to buy 2,877 gallons of quench oil to fill my 3,000-gallon quench tank at the operating temperature of 180°F. Realistically, 3,000 gallons would probably be bought to compensate for drag-out, but the quench tank would initially be filled with 2,877 gallons that would expand to 3,000 gallons as the quench tank was heated to the operating temperature.

CONCLUSIONS

In this short article, a method has been shown to determine the thermal expansion of an oil once the specific gravity and kinematic viscosity are known. This allows a quench tank to be filled and brought up to operating temperature without fear of overflowing the quench tank.

Should there be any suggestions regarding this column, or suggestions for new columns, please contact the editor or myself.

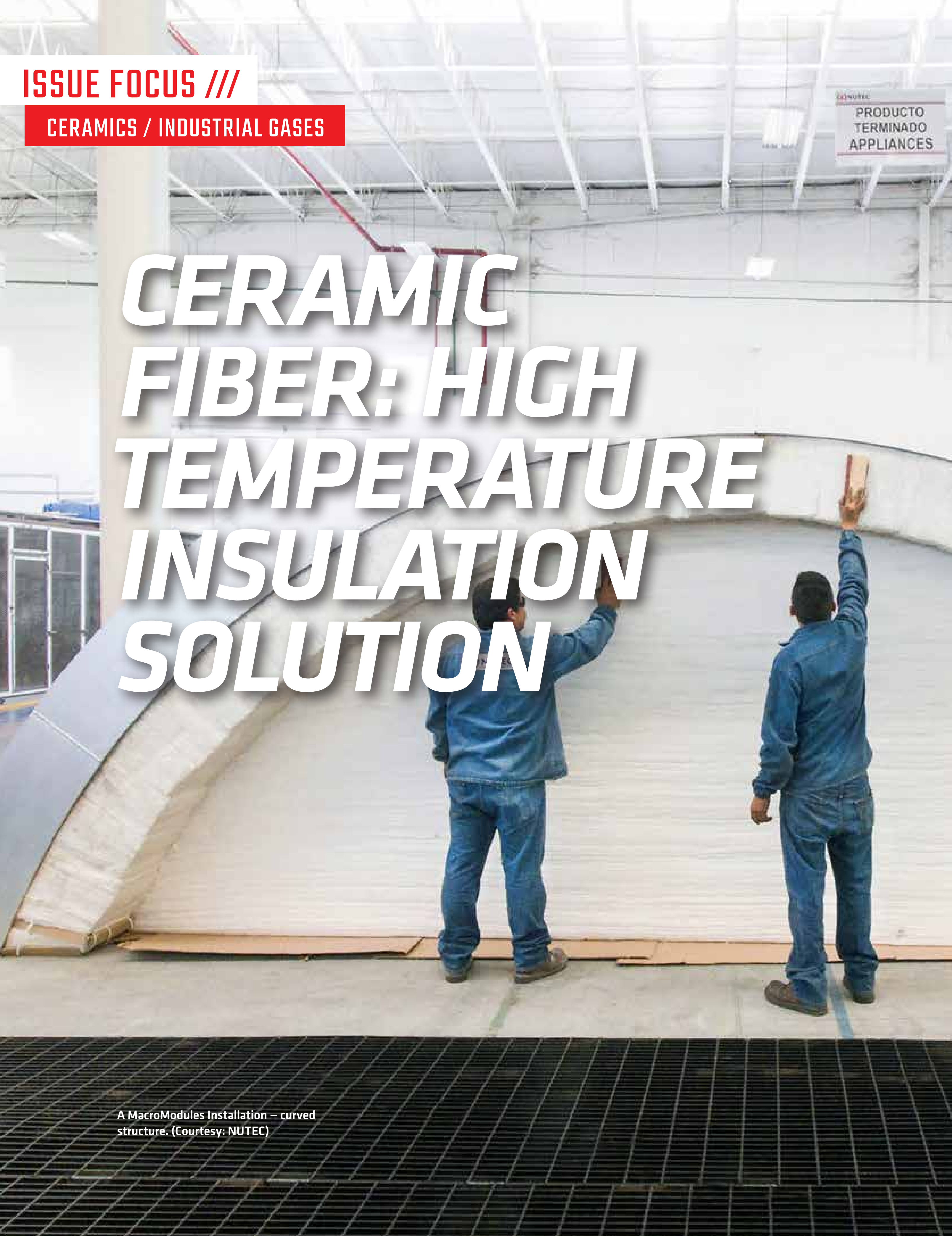
REFERENCES

[1] P. S. Chu and A. Cameron, "Compressibility and Thermal Expansion of Oils," Journal of the Institute of Petroleum, vol. 49, no. 473, pp. 140-145, May 1963.

ABOUT THE AUTHOR

D. Scott MacKenzie, Ph.D., FASM, is senior research scientist-metallurgy at Quaker Houghton. He is the past president of IFHTSE, and a member of the executive council of IFHTSE. For more information, go to www.quakerhoughton.com.

CERAMIC FIBER: HIGH TEMPERATURE INSULATION SOLUTION



A MacroModules Installation — curved structure. (Courtesy: NUTEC)

Ceramic fiber in its various forms has ideal characteristics for thermal applications within industries that handle high temperatures.

By CHRISTIAN TAVIRA and MAURICIO DÍAZ

Ceramic fiber is essential in various industries involving high-temperature operations. It offers superior thermal resistance for protecting structures, equipment, and machinery from steel and glass production to airplane and space vehicle manufacture.

What is high temperature ceramic fiber?

Ceramic fibers are synthetic materials comprised of small filaments made from high-purity aluminosilicate minerals.

Thanks to their particular properties and composition, ceramic fiber products contribute to preventing and reducing heat losses, in addition to protecting, providing insulation, and optimizing the energy performance of equipment, structures, and process machinery.

CHARACTERISTICS OF CERAMIC FIBER

Ceramic fiber is an ideal insulator in high temperature environments due to its characteristics. These characteristics include:

» **Low density.** Due to its composition, ceramic fiber has a lower density than other materials, giving it an advantage in its lightness and flexibility. This makes it easy to install and transport.

» **Low heat storage.** It cools down more quickly, making it ideal when immediate access and handling are required. It has proven excellent for both intermittent and continuous operation applications.

» **Low heat loss.** It can reduce heat transfer and provide good thermal protection.

» **Resistance to thermal shock.** It withstands sudden changes in temperature without suffering damage.

» **Low thermal conductivity.** This reduces heat transfer and provides efficient heat shielding.

BENEFITS OF REFRACTORY CERAMIC FIBER

Compared to conventional materials, ceramic fiber products boast a range of superior attributes:

» **Exceptional temperature resistance:** Ceramic fiber products can withstand temperatures up to 2,600°F (1,425°C), making them suitable for high temperature environments.

» **Outstanding thermal insulation:** With low thermal conductivity, ceramic fiber products effectively prevent heat transfer, contributing to energy efficiency and cost savings.

» **Enhanced durability:** Ceramic fiber products exhibit exceptional abrasion and thermal shock resistance, ensuring long-lasting performance, even under demanding conditions.

» **Inherent fire safety:** Ceramic fiber products are inherently incombustible and do not emit toxic fumes in case of fire, promoting safety in workplace environments.

» **Ease of application:** These products are ready to use, eliminating the need for mixing or preparation, and streamlining installation processes.

These characteristics make ceramic fiber products an ideal choice for repairing or augmenting the insulation of various equipment, including furnaces, boilers, pipes, and storage tanks.

Their application effectively enhances thermal efficiency, reduces energy consumption, and extends maintenance intervals.

CLASSIFICATION OF HIGH TEMPERATURE INSULATION FIBERS

High temperature insulating wools are used in applications that can exceed 1,112°F (600°C). Depending on the application, they come in various product formulations and chemistries/temperatures. Three main categories are easily available on the market.

CHEMICAL COMPOSITION/TEMPERATURE CLASSIFICATION

» **Refractory Ceramic Fiber.** An example of this from NUTEC includes its MaxWool 2300, which is composed of a mixture of alumina and silica. This material can be used for temperatures up to 2,300°F (1,260°C). Another example is MaxWool 2600, composed of a mixture of alumina, silica, and zirconia. This material can be used for temperatures up to 2,600°F (1,425°C).

» **Low Biopersistent fiber.** This product is comprised of low biopersistence fibers (also known as biosoluble fibers). They contain a chemical composition of calcium oxide, silica, and magnesium oxide. This product is used at temperatures up to 2,200°F (1,200°C).

» **Polycrystalline fiber wool.** This product is made from fibers that contain a polycrystalline mullite chemical composition, which allows for high tensile strength, durability, and low shrinkage at high temperatures.

PRESENTATION/PRODUCT CLASSIFICATION

High-temperature fibers appear like cotton wool when manufactured. These fibers can be shaped into different products depending on the needs and the type of application. The most common forms include:

» **Blankets.** Fibers are converted into a blanket through a weaving process. They're used to reduce energy consumption, improve the performance of thermal processes, and increase fire safety in different industrial applications.

» **Bulk.** Fibers collected after the fiberization process and whose main application is to be used as a raw material for other manufacturing processes.

» **Boards.** Composed of fibers and a variety of organic and/or inorganic binder fillers that acquire a rigid quality through the vacuum-forming process. They are commonly used as sheeting/cladding and thermal barriers in high temperature equipment.

» **Paper.** This is a light refractory material. It is strong and can be cut with a utility knife, scissors, or a standard steel razor. Its flexibility allows it to be wrapped or rolled to conform to whichever shapes are required.

» **Modules.** Fiber blocks are designed to protect industrial furnaces and provide a high-quality insulation system for different processes. Each module is continuously compressed and folded

Ceramic fibers are synthetic materials comprised of small filaments made from high-purity aluminosilicate minerals. (Courtesy: NUTEC)

according to a density that contributes to providing a longer useful life to industrial furnaces.

REFRACTORY CERAMIC FIBER COATINGS AND MIXES

Other types of ceramic fiber applications include refractory ceramic fiber mixtures and coatings. These wet products, such as pastes and cements, improve energy efficiency in high temperature industrial processes.

Refractory ceramic fiber coatings and mixes (wet products) are crucial, but what exactly are they? These products offer moldable insulation solutions in various forms, including pastes. Typically, they are prepared using an industrial mixer, combining water, ceramic fiber, and other additives to achieve the desired physical properties.

Some of these products incorporate a vegetable dye that can aid in their application and inspection. Green is standard, but other colors can be used to suit a company's specific needs.

TYPES OF REFRACTORY CERAMIC FIBER COATINGS AND MIXES

For example, NUTEC manufactures a diverse range of wet products categorized by their type and application:

Moldable products

These products possess a malleable consistency, allowing for effortless shaping with manual tools such as spatulas. Their user-friendly nature makes them a preferred option for exterior repairs and maintenance tasks. In some cases, they can even act as a sealant, effectively repairing cracks and preventing further damage.

Additionally, these ceramic pastes excel in lining channels that transport molten metals, demonstrating exceptional resistance to high temperatures without compromising their integrity.

Pumpable products

Pumpable products are fluid-like materials that can be pumped and applied using specialized guns connected to hoses.

Their primary application is in the quick repair of operating equipment, as the heat generated during the application process aids in the drying and hardening of the ceramic coating.

These materials are injected into predrilled holes or cracks on the equipment's surface.

Rigidizing products

Rigidizing compounds enhance the hardness and resilience of insulating materials, particularly ceramic fiber blankets. By stiffening the fibers, these compounds extend the service life of the insulation and minimize erosion caused by hot gases.

Additionally, they curtail the release of fiber particles into the surrounding environment, promoting safer working conditions and preventing product contamination during manufacturing processes.

Coatings

Ceramic fiber coatings serve a dual purpose: repairing the thermal insulation of a furnace and preventing wear before its first operation. Among the various formulations available, SealCoat, for example, stands out for its ability to protect the outer surface of installed fiber modules from abrasion and erosion caused by combustion gases.

In essence, these coatings play a pivotal role in extending the integrity and lifespan of the insulation.

Cement products

These are adhesives to bind insulating materials, such as blankets or boards, to metal surfaces. They can also be used to join insulating materials, offering application versatility.

The cements exhibit a thick, creamy consistency, making them suitable for application with a brush or spatula. They can be diluted with water for broader coverage and then used to coat various refractory materials. Once dried, they form a hard, abrasion-resistant layer, ensuring long-lasting performance.

HOW ARE WET PRODUCTS MADE?

While ceramic fiber remains the primary component, NUTEC employs ceramic fiber blankets instead of introducing alumina, silica, or zirconia.

These blankets are cut to specific dimensions before being ground and thoroughly blended with a combination of solid and liquid mineral ingredients.

CONSIDERATIONS

Although these are high-quality products, there are certain factors to consider:

» **Shelf Life in Storage.** Due to their aqueous composition, these products have a maximum shelf life of six months before becoming unusable. This means maintaining just small inventories and manufacturing them to order.

» **Freezing.** Low temperatures can irreversibly damage these materials, so protecting them from extreme cold during transport and storage is crucial.

» **Appropriate equipment.** Pumpable products require abrasion-resistant hoses capable of withstanding extreme injection pressures.

» **Expert application.** To ensure maximum effectiveness and safety, it is recommended that trained personnel carry out installation.

Considering these precautions, refractory ceramic fiber coatings and mixes such as those offered by NUTEC are ideal solutions to reduce energy consumption and costs throughout the industry.

Their superior thermal insulation properties and high-temperature resistance make them valuable for various applications. Businesses can significantly reduce energy consumption, extend maintenance intervals, and enhance operational efficiency using these products.

With proper storage, handling, and application, refractory ceramic fiber coatings and mixes can provide long-lasting performance and significantly save costs over time.

INDUSTRY APPLICATIONS

Due to its characteristics, ceramic fiber has various industrial applications. For example:

» **Ceramics and glass industry.** For insulation in kiln and furnace car seals, and lining in doors and walls.

» **Automotive industry.** For electric vehicles and conventional powertrains, from exhaust heat shields and airbag inflators to lithium battery separators.

» **Construction industry.** For both ventilation ducts or grilles (commercial premises, hotels, restaurants, and casinos), chimneys, and prefabricated duct systems.

» **Oil & gas industry.** Protects structures and equipment, such as pyrolysis ovens, heaters, walls, roofs, and crude oil heaters.

» **Power generation industry.** For boilers, turbines, and pipe insulation, among others.

CONCLUSION

Ceramic fibers have a high thermal resistance. Their low conductivity and low heat storage improve process efficiency and promote energy savings.

The type of ceramic fiber needed will be determined by the temperature level used and the kind of equipment needed to be protected from heat.

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NITROGEN GAS QUENCHING PRESSURE EFFECT

ON BS S155 ALLOY STEEL IN VACUUM FURNACE

The influence of nitrogen gas quenching pressure on the dimensional change of the actuator gear planet part made from BS S155 alloy steel was investigated in this study, and the results show that a 1.5 bar nitrogen gas quenching pressure improves the dimensional stability over a 4.5 bar nitrogen gas quenching pressure.

By AGUS MULYADI HASANUDIN and EDDY SUMARNO SIRADJ

The production of metal and alloy products requires the use of heat treatment. During the heat-treatment process, quenching is a crucial step. The quenching medium can be anything from water, a salt bath, oil, air and gas. In a vacuum furnace, pressurized gas, most frequently nitrogen (N2) gas, serves as one of the quenching mediums. One of the drawbacks of the quenching process is the distortion and dimensional change of the parts. This article aims to investigate the influence of nitrogen gas quenching pressure on the distortion and dimensional change of aerospace actuator gear planet parts made from BS S155 alloy steel. BS S155 is the British aerospace equivalent of U.S. steel grade 300M (4340M); it is a vacuum-melted grade supplied in the normalized and softened condition to allow for final heat treatment and widely used with products such as undercarriage components, gears, and shafts. Gear-planet parts were heat treated and quenched with pressurized nitrogen gas as an independent variable of the experiment, then double tempered as required for the specification. Following this, optical microscopes, tensile, and hardness tests in accordance with ASTM E8 and ASTM E92, as well as dimensional analysis, were used to characterize the parts. The results demonstrate that nitrogen gas quenching at 1.5 bar pressure improves dimensional stability without degrading the mechanical properties of the part, with the maximum dimensional distortion being 0.06% or 20 µm, while the mechanical properties result for the two nitrogen gas quenching pressures were less significantly different.

1 INTRODUCTION

Heat treatment is a crucial process for manufacturing metal and alloy parts and offers many benefits long term. From increasing strength and ductility to increasing resistance to corrosion, heat treatment offers safety, durability, and cost efficiency for companies that use any kind of metal part, whether it is in the aerospace, automotive, oil and gas, alternative energy, or even forged wheel industries. Heat treatment is the process of heating and cooling a material to alter its physical and chemical properties. Although heat treatment offers several benefits, including increased strength, improved wear resistance, and reduced stress, it also has several conditions that can occur if the heat-treatment process is not appropriate or not well controlled, that should be considered before undertaking this process, including distortion, surface oxidation or other contaminants, increased expense, and the possibility of material or part cracking or breaking [1]. Non-uniform heating, austenitizing temperatures that are too low or too high, phase changes during heating and cooling, and non-uniform quenching can all cause distortion [17,13]

During the quenching process, residual stresses and distortions are developed in response to non-uniform cooling and phase transformations [14,10,11]. Several methods have been used to evaluate and simulate the distortions that are promoted after quenching [15]. Imam Basori [7] investigated the quenching and tempering effect on the microstructure and mechanical properties of steel Armor application made from AISI 4340 alloy steel, and the result showed the quenching process promoted the phase transformation of the shape like a needle of martensite, while the tempering process promotes the transformation of martensite to bainite. M.M. Nunes et al [16] investigated the relationship between austenizing temperature, soaking time, and quenching medium and their impact on mechanical properties as well as material distortion. However, the quenching media in this study were only oil and water, and the final result showed the material distortion was mainly affected by the variation of the austenizing temperature and soaking time, and the material distortion affected by the variation of the quenching media (oil and water) was less significant.

The aim of this investigation was focused on the dimensional change of the aerospace actuator gear planet parts made from BS S155 alloy steel as an effect of different nitrogen gas quenching pressure as part of the improvement from quality issues. BS S155 is the British aerospace equivalent of U.S. steel grade 300M (4340M/AMS 6257), which is a vacuum-melted grade supplied in the normalized and softened condition to allow for final heat treatment and widely used in products such as undercarriage components, gears, and shafts [2].

2 RESEARCH METHODOLOGY

A vacuum furnace with gas pressure quenching was used for the investigation, with a hot zone size of 600 mm x 600 mm x 900 mm, a maximum temperature of 1,200°C, and a maximum gas quenching pressure of 10 bar from SECO Warwick Poland. To heat the actuator gear planet part, BS S155 alloy steel material with a hardening temperature of 870°C ± 6°C with a soaking time of 30 minutes (-0, +15 minutes), followed by a double temper at 285°C ± 6°C with a soaking time of 2 hours, 30 minutes (-0, +20 minutes). The independent variable of the experimental method was only the nitrogen gas quenching pressure, and the dependent variable was the dimensional change, while the other heat-treatment parameters such as temperature, soaking time, heating rate, and cooling rate remained the same as the controlled variable.

2.1 Material Preparation

Aerospace actuator gear planet parts made of BS S155 alloy steel were used as specimens for this experiment. The specimens were machined to standardized dimensions to ensure uniform dimension across the specimens. Two types of actuator gear planet parts were used as specimens — actuator gear planet parts type 1 and type 2. An illustration of these specimens is shown in Figure 1, and the dimension requirements of the actuator gear planet part of the type 1 and type 2 specimen are list in Table 1.

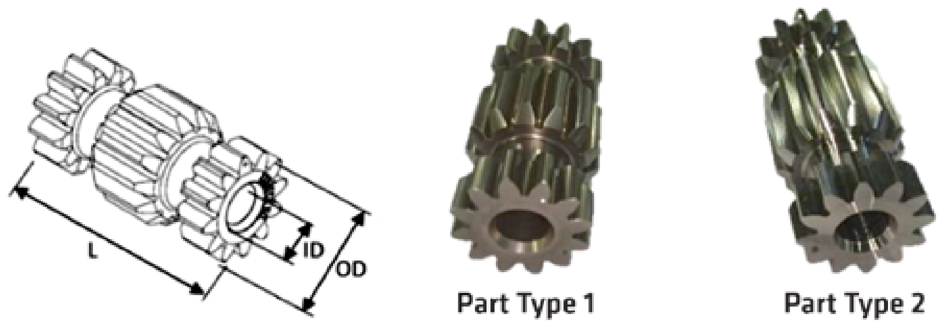

Figure 1: Illustration of an actuator gear planet. Part types 1 and 2 are different in L (length) dimensions.

2.2 Dimensional Measurement

The dimensions of the specimens were measured using precision measurement techniques (Klingenberg Precision Measuring Machine) before and after the heat treatment. Measurements include length (L), outside diameter (OD), and inside diameter (ID).

Dimension	Gear planet type 1	Gear planet type 2
OD	30.51 - 30.56 mm	30.51 - 30.56 mm
ID	10.952 ± 0.025 mm	10.952 ± 0.025 mm
L	60.50 - 60.60 mm	69.57 - 69.67 mm

Table 1: Requirements of dimension for actuator gear planet parts.

2.3 Heat Treatment

The specimens were divided into two groups: One was quenched using nitrogen gas at a pressure of 1.5 bar, and the others were quenched using nitrogen gas under a high pressure of 4.5 bar. The specimens were heated to a predetermined temperature and subsequently quenched with pressurized nitrogen gas. Gas quenching parameters, such as the nitrogen gas composition, pressure, and quenching duration, were carefully controlled.

From Table 2, specimen 1 is for an actuator gear planet type 1 and specimen 2 is for an actuator gear planet type 2. A and B in Table 2 refer to the low and high pressures of nitrogen gas quenching. The chemical composition of the Type 1 and Type 2 specimens are listed in Table 3.

No.	Specimen No.	Nitrogen gas quenching pressure
1	1-A	1.5 bar
2	1-B	4.5 bar
3	2-A	1.5 bar
4	2-B	4.5 bar

Table 2: Test specimen variations.

3 RESULT AND DISCUSSIONS

3.1 Chemical Composition Analysis

The chemical composition of the actuator gear planet parts was characterized to comply with material requirements. The actual chemical composition was determined using an ELANIK handheld laser induced breakdown spectroscopy (LIBS) analyzer.

From Table 3, it can be observed that the chemical composition of these types of actuator gear planet parts are obtained in the range of standard requirements according to BS S155 specification.

Content	BS S155 Specification	Actual Type 1	Actual Type 2
C	0.39 - 0.44	0.421	0.432
Si	1.50 - 1.80	1.661	1.672
Mn	0.60 - 0.90	0.732	0.817
P	0.015 max	0.008	0.005
S	0.015 max	0.009	0.008
Cr	0.70 - 0.95	0.838	0.878
Mo	0.30 - 0.45	0.382	0.417
Ni	1.65 - 2.00	1.970	1.773
V	0.05 - 0.10	0.089	0.065

Table 3: The chemical composition (Weight %).

3.2 Dimensional result

The dimensions of the specimens were measured before and after nitrogen gas quenching under different gas pressure. The results of the measurements are shown in Figure 2 below, whereas it can be seen from the figure that the distortion dimension of the outside diameter does not seem to be much different under low- and high-pressure nitrogen gas quenching; however, the distortion dimension of length is likely different, where both under low and high pressure, the distortion is high. The distortion dimension of the Type 1 specimen was lower than that of the Type 2 specimen. Looking at the distortion of the inside diameter for both types 1 and 2, as can be seen in the figure, it seems that both specimens have high distortion results; however, for the Type 2 specimen, the distortion is slightly smaller than of Type 1, and all the distortion of the part of the specimen is shrinkage compared with the outside diameter and length are likely expanded. The quenching pressure plays a significant role in determining the rate at which the material is cooled. Higher quenching pressures generally result in faster cooling rates. The microstructure of a material is influenced by the cooling rate during quenching, rapid

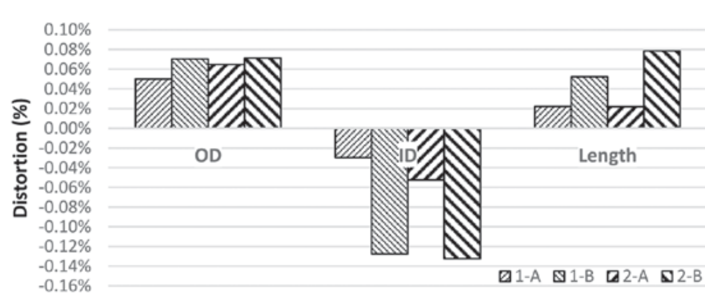

Figure 2: Distortion of dimension specimen type 1 and type 2 under gas quenching pressure of 1.5 bar and 4.5 bar.

cooling can promote the formation of a fine-grained microstructure. In the case of steel, for example, it can lead to the formation of martensite, a hard and brittle phase associated with high hardness and strength. High quenching pressure can cause non-uniform cooling across the material. Variations in cooling rates across the material

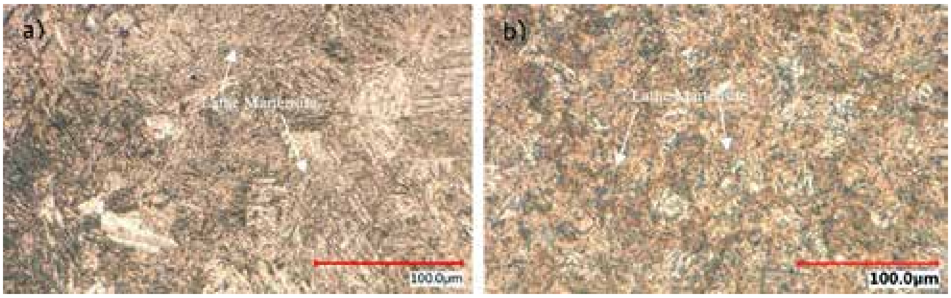

Figure 3: Microstructure of specimen type 1 after heating at 870°C, soaking time 30 minutes, and under nitrogen gas quenched pressured of (a) 1.5 bar (b) 4.5 bar.

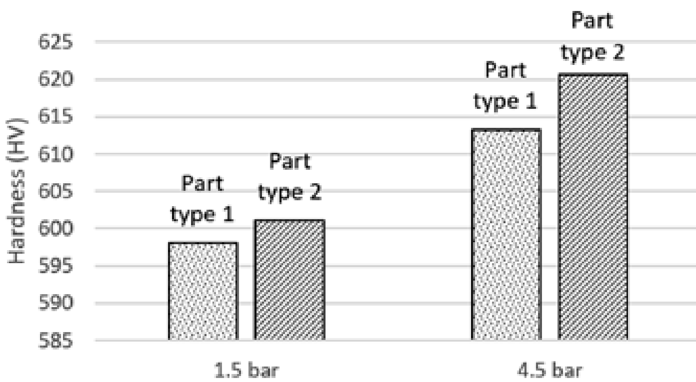

Figure 4: Hardness vs. gas quenching pressure.

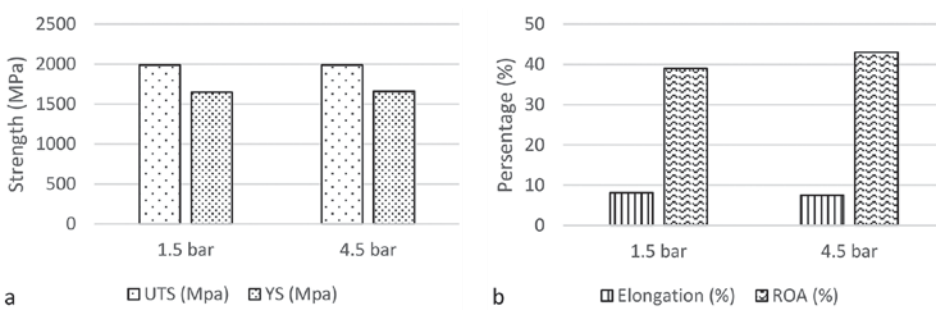

Figure 5: Correlation between tensile properties and gas quenching pressure a) UTS and YS vs. gas quenching pressure. b) Elongation and ROA vs. gas quenching pressure.

Specimen No.	Gas Quenching pressure	UTS (MPa)	YS (MPa)	Elongation (%)	ROA (%)	Hardness (HV)
Reference *	Max 5 bar	1930 min	1590 min	7 min	25 min	580 min
1-A	1.5 bar	1990	1650	8.1	39	598
1-B	4.5 bar	1990	1660	7.5	43	613
2-A	1.5 bar	1990	1610	8.9	38	601
2-B	4.5 bar	1995	1670	7	47	621

* BSI, 2014; Aircraftmaterialsuk.com Ltd, 2023

Tabel 4: Tensile and Hardness result.

can result in differential thermal contractions, leading to distortion. Distortion may manifest as warping, bending, or uneven dimensional changes in the material.

The percentage dimensional change was determined and compared between the two- nitrogen gas quenching pressure value as shown in Figure 2.

3.3 Microstructural Analysis

Microstructural examination was conducted to observe any changes in the structure of material owing to different gas quenching pressure values. The microstructure of the heat- treated specimens was analyzed using an optical microscope (OmniMet/Olympus) with prior standard metallographic preparation according to ASTM E3 [6], while the microstructure was revealed using a 2% Nital etchant according to ASTM E407 [3].

BS S155 alloy steel has high hardenability; therefore, it was expected that all the analyzed specimens would present the martensitic phase. The micrographs in Figure 3a show a less lathe martensitic structure as a result of the nitrogen gas quenching pressure of 1.5 bar, while Figure 3b shows a more lathe martensite sharper and needle structure as a result of the nitrogen gas quenching pressure of 4.5 bar. The quantity of martensite formed during heat treatment, especially in the context of quenching, is directly related to the mechanical properties of the steel. Higher martensite content generally leads to increased hardness but can also result in dimensional changes and potential distortion. Achieving the desired balance between hardness and dimensional stability requires careful control of the heat treatment process, considering factors such as quenching rate and severity.

3.4 Mechanical Properties Evaluation

The selected specimens were characterized for their mechanical properties, such as hardness as per ASTM E92 [4] and tensile properties as per ASTM E8 [5], to determine any correlation between dimensional change and material properties. Table 4 lists the expected linear tensile and hardness results for each specimen. For a nitrogen gas quenching pressure of 1.5 bar, the mechanical properties result is lower than the result for a nitrogen gas quenching pressure of 4.5 bar, but all the results were still within the specification requirements.

The resulting distortions by the manufacturing processes, such as heat treatment, can increase the cost of producing a component by 20 to 40 percent where additional machining steps are required. Consequently, it is very important to predict and minimize distortions [8].

The results indicate the gas quenching pressure differences have a distinct effect on the dimensional change of specimens [12]. Nitrogen gas quenching with 1.5 bar pressure demonstrates a low dimensional distortion 0.03-0.05% in ID, 0.05-0.06% in OD and 0.02% in length, which corresponds to a value of approximately 3-6 µm dimensional change in ID, 15- 20 µm dimensional change in OD and 12-15 µm dimensional change in Length, and for 4.5 bar gas quenching pressure result showed 0.13% dimensional distortion in ID, 0.07% in OD and 0.05% - 0.08% in length, which corresponds to a value of approximately 14-15 µm dimensional change in ID, 20-25 µm in OD and 40-50 µm in length.

The hardness difference of the nitrogen gas quenching pressure shown in Figure 4 has 15.25 HV or 2.55% difference for part type 1 and 19.58 HV or 3.26% difference for part type 2, which means the 4.5 bar

gas quenching pressure affects the higher hardness value result. All mechanical property results for tensile are still within the requirements, as shown in Figure 5a: the correlation between strength (UTS and YS) vs. nitrogen gas quenching pressure, and as shown in Figure 5b: the correlation between elongation and ROA vs. nitrogen gas quenching pressure. The gas quenching pressure 4.5 bar affects the higher mechanical properties (hardness and tensile strength).

The correlation between dimensional change and mechanical properties suggests that nitrogen gas quenching with 1.5 bar pressure provides enhanced dimensional stability without compromising the mechanical performance of specimens, with maximum dimensional distortion 0.06% or 20 µm dimensional change.

4 CONCLUSIONS

The influence of nitrogen gas quenching pressure on the dimensional change of the actuator gear planet part made from BS S155 alloy steel was investigated in this study. The results show that a 1.5 bar nitrogen gas quenching pressure improves the dimensional stability over a 4.5 bar nitrogen gas quenching pressure. This study shows that, for heat treatment with 1.5 bar nitrogen gas quenching pressure, the maximum dimensional distortion is 0.06% or 20 µm dimensional change. The findings provide useful insights for industries that rely on BS S155 alloy steel, enabling them to optimize their heat-treatment processes for improved dimensional control. However, this data will be used to determine the final dimension during the machining of the product prior to heat treatment. Although this investigation only focused on nitrogen gas quenching pressure, further investigation is required for other heat-treatment-process parameters such as austenizing temperature, soaking time, and gas blower fan speed and its effect on the dimensional change and mechanical properties of the parts.

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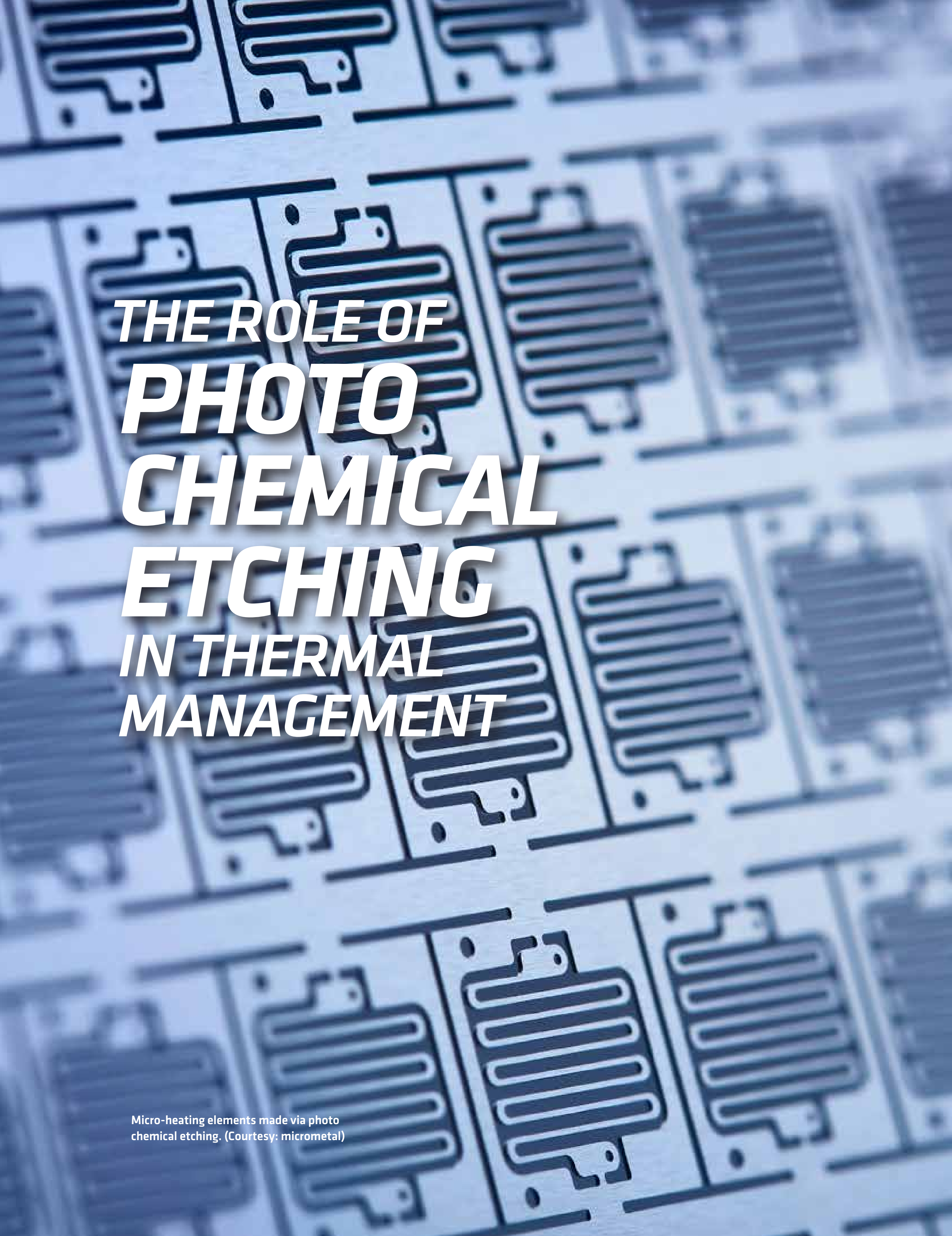
THE ROLE OF PHOTO CHEMICAL ETCHING IN THERMAL MANAGEMENT



Micro-heating elements made via photo chemical etching. (Courtesy: micrometal)

The PCE process efficiently manufactures precise metal parts for thermal management in microelectronic devices, ensuring high accuracy without stress or deformation.

By JOCHEN KERN

The photochemical etching (PCE) process is distinguished by its capacity to fabricate metal parts with unparalleled accuracy. This process sidesteps the typical stresses and deformations linked to conventional metalworking, such as stamping or laser cutting, which can compromise material integrity. Such fidelity is crucial in the manufacture of components for thermal management systems, where material integrity and component precision are non-negotiable for ensuring effective heat creation or dissipation. PCE's ability to craft parts with smooth, burr-free edges and exact dimensions means heat-management components work more effectively, bolstering the reliability and extending the service life of micro electronic devices.

One of the most significant advantages of the PCE process is its extraordinary flexibility in handling a wide array of metals and alloys. This adaptability is crucial for the production of bespoke thermal management solutions that are specifically tailored to meet the unique requirements of various microelectronic devices. By accommodating different metals, PCE allows for the customization of components to align with distinct thermal properties and constraints of the devices they are designed for. This means that heat sinks, TIMs, and other critical components can be engineered to optimize heat dissipation for each specific application, from smartphones to high-powered computing systems. The precision afforded by PCE ensures that these customized solutions fit seamlessly into the devices, enhancing their performance and durability. The ability to quickly switch between materials and designs without the need for extensive retooling is a further benefit, reducing lead times and costs.

As portable microelectronic devices evolve, becoming more compact yet more powerful, the demand for proficient thermal management escalates. PCE meets this challenge by enabling the production of components that effectively manage heat, while conforming to the trend of device miniaturization. In this way, the PCE process supports the move toward sleeker electronic devices by allowing for the creation of small, complex components that fit into tight spaces without compromising on thermal management efficacy. This is essential as the electronics industry continues to place a premium on the compactness of devices. In addition, PCE's design flexibility also ensures thermal management solutions keep pace with the swift advancement in electronic technology, offering a scalable solution for future needs.

The PCE process presents substantial economic advantages as well, enhancing its attractiveness for manufacturing precise metal components for thermal management solutions. PCE's efficiency comes from the fact it is a streamlined production process, which involves fewer steps. Also, the use of wear-free photo tools extends the lifespan of production equipment, while the process's ability to produce large volumes of parts ensures consistent quality without the cost of frequent tool replacement. PCE's scalability makes it a versatile choice for industries seeking sustainable and cost-effective manufacturing solutions.

PCE's influence extends beyond production — it catalyzes innovation within the microelectronics sector. As the industry relentlessly drives toward further miniaturization and enhanced performance, PCE provides the tools necessary to realize these ambitions. PCE not only facilitates the present requirements but also anticipates future demands, establishing itself as a pivotal technology in the advancement of microelectronic device design and functionality. Its role in the progression of microelectronics will likely continue to grow, underscoring the importance of adaptive and advanced manufacturing techniques in the tech landscape.

PCE & THERMAL MANAGEMENT – CASE STUDIES

Micro-heating management involves the precise control and distribution of heat at a micro-scale level in various applications, using components such as micro heating elements (providing localized heat), heat exchangers (facilitating efficient heat transfer), and cooling plates (dissipating heat to maintain optimal operating temperatures). These components are essential in applications requiring fine thermal control, such as in microelectronic devices, medical equipment, and specialized industrial processes.

MICRO-HEATING ELEMENTS

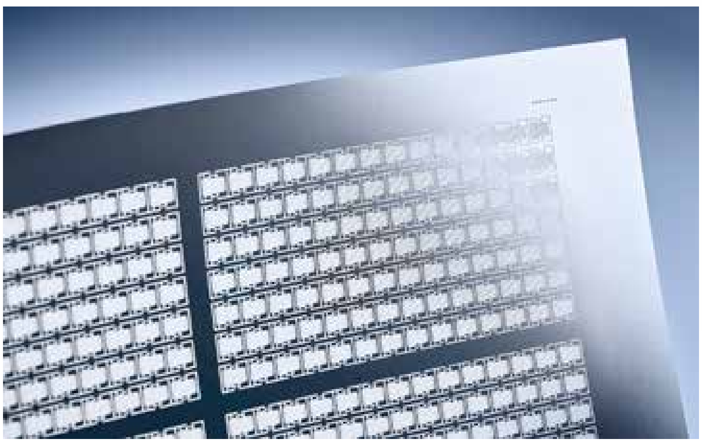
Manufacturing micro-heating elements as used in PCR equipment and e-cigarettes presents a set of intricate challenges, one of the major challenges being ensuring precision and uniformity in temperature distribution. Another issue is the selection and processing of suitable materials for micro-heating elements, as they typically need to be able to withstand high temperatures and thermal cycling without degrading. Additionally, as devices become more compact, their internal components, including heating elements, need to be smaller and more complex.

This miniaturization adds another layer of complexity to the manufacturing process, which traditional methods find challenging to meet. PCE offers a range of advantages in this context as it allows for the creation of components with high precision and uniformity, which is essential for consistent heat distribution in micro-heating elements. It doesn't induce stress in materials, helping to maintain their integrity and properties — a crucial factor for components that are exposed to high temperatures. PCE is also adept at producing intricate components, and is extremely cost-effective, especially when it comes to mass production. The process can be scaled easily, making it suitable for mass production without compromising on quality. Additionally, the ability to rapidly prototype with PCE allows for quicker design changes and innovation, a significant advantage in fast-paced industries.

HEAT EXCHANGERS

Manufacturing micro-precision heat exchangers means achieving intricate and accurate channel geometries essential for efficient heat transfer, and managing the mechanical and thermal stresses that conventional machining methods can introduce. In traditional

A cooling plate made via photo chemical etching. (Courtesy: micrometal)



Manufacturing micro-precision heat exchangers means achieving intricate and accurate channel geometries essential for efficient heat transfer. (Courtesy: micrometal)

manufacturing processes, metal is often pressed to create the desired geometry and flow channels for heat exchangers, which can be time-consuming, expensive, and may cause material stress or burrs that require additional post-machining work.

PCE is exceptionally well-suited for manufacturing micro-precision heat exchangers as it is capable of producing complex components with fluidic channels — such as plate heat exchangers — with high precision. One of the key advantages of the process is that it eliminates mechanical and thermal stresses typically associated with traditional pressing methods, and allows for low-cost, quickly adaptable digital tooling, making it ideal for optimizing designs at minimal cost. PCE can achieve precision microchannels with consistent accuracy, enhancing the compactness and efficiency of heat transfer. It is also compatible with a range of materials, including stainless steel, aluminum, titanium, and Inconel, which are often challenging to process using conventional methods. The scalability and versatility make photochemical etching an advantageous choice for both prototyping and high-volume production of heat exchangers.

COOLING PLATES

Manufacturing micro-precision cooling plates is difficult due to the intricacy and accuracy of the cooling channels and the overall dimensional precision of the plates. One significant challenge is ensuring uniformity and precision in the micro-scale features critical for effective heat dissipation. Traditional machining methods might introduce mechanical stresses or deformities, compromising the efficiency of the cooling plates. Additionally, achieving the high level of detail necessary for micro channels, which is essential for efficient heat transfer, is often time-consuming and expensive using conventional methods. The complexity of design and the need for high precision in such small scales add to the manufacturing difficulties.

PCE is well-suited for producing micro-precision cooling plates due to its ability to create intricate, detailed designs with high precision and consistency. This process allows for the fabrication of complex patterns and microstructures in metals, crucial for the effective performance of micro-cooling systems. The etching process ensures uniformity in component thickness and avoids introducing stresses or deformities, vital for the functionality and longevity of cooling plates.

SUMMARY

The PCE process efficiently manufactures precise metal parts for thermal management in microelectronic devices, ensuring high accuracy without stress or deformation. It handles diverse metals, creating tailored thermal solutions such as heat sinks and TIMs for everything from smartphones to powerful computers. As devices shrink, PCE produces the necessary small, detailed parts, aiding device miniaturization. Economically, it cuts costs and lead times with a simplified process while enabling scalable production. PCE's precision is vital in micro-heating elements and cooling systems, allowing for complex, micro-precise components that bolster device performance and thermal management.

ABOUT THE AUTHOR

Jochen Kern is head of sales & marketing for micrometal. micrometal GmbH (incorporating HP Etch and Etchform) specializes in the industrial production of highly precise metal components. The three companies photo-chemically etch very large numbers of parts for a multitude of industries with an accuracy that is unique. The companies etch a huge range of metals, and deliver customer-specific, clean, complex components, free of stress and burrs. micrometal's, Etchform's, and HP Etch's combined processes and expertise offer the right solution for every challenge. The companies provide a one-stop-shop to customers looking to benefit from a world-class photo-chemical etching service. For more information, go to www.micrometal.de.

COMPANY PROFILE ///

WACKER CHEMICAL CORPORATION

PROVIDING SUSTAINABLE HEAT TRANSFER SOLUTIONS

The CSP demonstration plant Prometeo in Almeria, Spain. It is the loop where Helisol first qualified for EU and state-funded projects with academic and industrial partners. The CSP system is a parabolic-through (line-concentrating) technology used to collect solar thermal energy using mirrors (parabolic mirrors, seen here), a receiver tube or absorber, and heat transfer fluid (HTF) to convert the heat into steam. The heat transfer fluid used in this system is Helisol (2015 - 2017 Helisol 5A, 217 – 2020 Helisol XA, and, since 2020, Helisol XLP). (Courtesy: Wacker Chemical Corporation)

Wacker Chemical Corporation produces and provides a sustainable range of heat-transfer fluids, reflected in its line of Helisol® products.

By KENNETH CARTER, Thermal Processing editor

Heat transfer fluids can be a vital part of industrial applications where systems need to heat up or cool down during a production process. These fluids are often necessary to ensure the efficient transfer of heat.

Not only can this efficient transfer affect the bottom line, but using heat transfer fluids that will have a minimal impact on the environment is also becoming an integral part of industrial heat-treat applications.

HELISOL® RANGE OF PRODUCTS

Wacker Chemical Corporation has been committed to producing efficient, economical, and environmentally friendly fluids used in a multitude of industries for more than a century.

"Wacker is highly focused on sustainability, reflected in developing the Helisol® range of heat transfer fluids (HTF)," said Raj Prasad, Marketing Manager Chemical Industries at Wacker Chemical Corporation. "Helisol is not only produced using bio-methanol, but the product itself is completely recyclable even after several decades in various applications such as CSP (concentrated solar power) plants that use solar energy for industrial heating."

Wacker does not just stand ready to offer innovative fluid solutions, but the company is also working to offer those fluids with a commitment to a greener way of producing them, according to Prasad.

"Wacker's philosophy is based on a strong ESG with a strong commitment to making the energy transition and reversal of climate change a success," he said. "Wacker has joined the Race to Zero and the UN's carbon neutrality initiative with a new ambitious target to achieve net zero in 2045. Wacker also practices social responsibility, supporting education, transparent dialogue with neighbors, encouraging employees to support each other and work toward the common good, and supports the internationally acknowledged 3R principle (Replace-Reduce-Refine) in the context of animal experiments."

PFAS-FREE

To that end, Wacker's Helisol range of heat transfer fluids strongly reflects this philosophy and is one of the leading PFAS-free products for the heat transfer industry, according to Prasad.

"Helisol has a very high thermal stability and can be used at temperatures as high as 425°C (even higher in some applications) starting from as low as minus-40°C," he said. "Helisol also offers a longer lifetime and no fouling of equipment, meaning fewer changes and, therefore, lower operating costs than organic HTFs. Helisol can be used for industrial process heating and cooling in various industries, such as plastics, chemical processing, oil and gas, and food and beverage — to name a few."

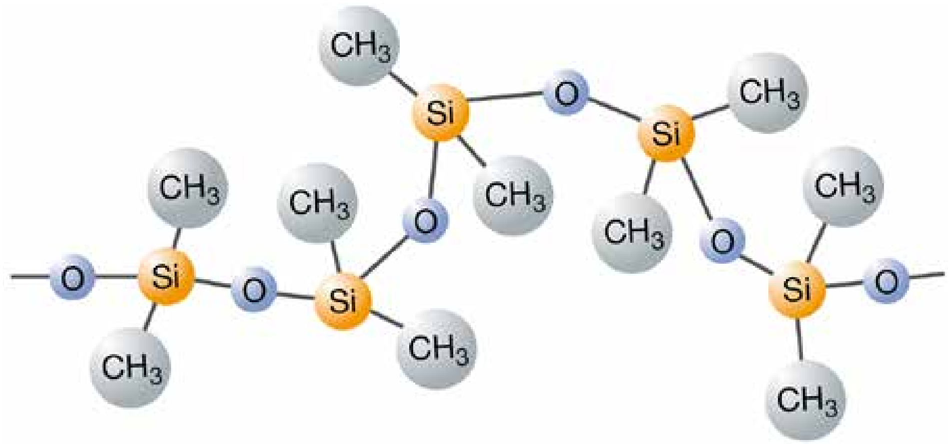
Some specific applications for those industries include:

» Within the chemical and petrochemical industry, Helisol is used for chemical processing, distillation, heating, and drying. It also can be used in manufacturing, refining, transporting, and recycling of petrochemical products.

» For the plastic/textile industry, it can be used for polycondensation and polymerization, as well as for synthetic fiber formulation and processing.

» For energy generation and conversion, heat transfer fluids are used for thermal energy transfer and waste heat recovery.

» Within the food and pharmaceutical industry, Wacker's product is necessary for precise temperature control and for heating and cooling applications.



Helisol 5A structure is a linear, non-reactive polydimethylsiloxane with a viscosity of approximately 5 mm^2/s. Due to its chemical structure, Helisol 5A has an outstanding property profile, which sets it apart from organic materials such as mineral oils. (Courtesy: Wacker Chemical Corporation)

» As Prasad mentioned earlier, Helisol is also a component of concentrated solar thermal energy (CST). For example, a CST plant in Antwerp using Helisol as a heat transfer oil has replaced its annual gas consumption by 500 MWh.

But what exactly makes Wacker's heat transfer fluids unique?

Helisol heat transfer fluids are polydimethylsiloxanes, which are a mixture of linear siloxane compounds. Due to their chemical structure, they undergo so-called rearrangement reactions (equilibration) of their silicone-oxygen bonds when operated at temperatures above 220°C. However, this rearrangement reaction is not a degradation reaction and does not affect the lifetime of the fluid.

Because of this rearrangement reaction, some physical properties of the fluids will change throughout operation. Once the equilibrium fluid composition is reached, the physical properties remain stable.

These unique properties result in Helisol heat transfer fluids not being classified as hazardous.

SUSTAINABILITY GOALS

Being able to offer products that strive to be as environmentally friendly as possible is a goal that is shared by Dr. Christian Hartel, Wacker's president and CEO. This is a goal that he emphasizes will only continue to grow stronger within the company's product line.

"As one of the world's leading manufacturers of specialty chemicals and polysilicon, we play a major role in the energy transition and in reducing the impact of climate change," Dr.Hartel said. "Products that enable our customers to bring climate-friendly and resource-efficient products onto the market already make up about two-thirds of our portfolio. In the coming years, we intend to significantly expand our portfolio of particularly sustainable products and make considerable efforts to de-fossilize our production. We consider that this holds significant potential for our business success."

To continue that streak of success, Prasad said Wacker is driven by in-depth research.

"In partnership with our customers, we identify trends that promise growth and ensure long-term market success and competitiveness," he said. "With a mission to improve human health and safety and protect the environment, we develop scientific solutions for the challenges facing our customers and society. As an innovation-driven organization, we are continuously thinking about tomorrow today and turning good ideas into ready-for-market products."

Heat accounts for about two-thirds of industrial energy needs and almost one-fifth of total global energy consumption. Helisol heat transfer fluids make an important contribution to efficient heat transfer. Helisol heat transfer fluids may be used in various applications: in wood and metal processing, oil refineries, chemical, polymer, and other industries, as well as in solar thermal applications. (Courtesy: Wacker Chemical Corporation)

MULTIPLE ACHIEVEMENTS

Wacker's constant goal of striving for excellence has resulted in many achievements over the company's long history, according to Prasad. In 2016, Wacker invested about $2.5 billion in commissioning a polysilicon asset in Charleston, Tennessee. And in 2021, Wacker acquired a 60 percent stake in specialty silane manufacturer SICO Performance Co. Ltd. in Jining, China.

"Wacker opened our Innovation Center & Regional Headquarters in Ann Arbor, Michigan, in April 2022," he said. "It serves as the headquarters of Wacker's subsidiary, Wacker Chemical Corporation, covering the North and Central American region and providing state-of-the-art lab space for our Biosolutions and Silicones regional divisions' applications and research. The Innovation Center & Regional Headquarters building is the first of Wacker's sites to obtain the LEED certification for implementing sustainability practices and materials in the building design, construction, and operations. Less than 5 percent of businesses in Michigan have achieved this certification."

Circling back to Wacker's sustainability initiatives, Prasad said Wacker is also one of the first companies to have its Net Zero Target for 2045 certified by the Sustainability Science-Based Target Initiative (SBTi) in 2023.

A CENTURY OF BUSINESS

Those serve as just a few examples of Wacker's achievements over its long history, which began in 1914, when, at 68 years old, Dr. Alexander Wacker established Elektrizitats AG as a leading business in the electricity industry, according to Prasad.

"The great visionary that he was, he wanted to build an industrial plant for applications ranging from electrochemicals to organic chemistry," he said. "The now famous Burghausen plant in upper Bavaria was constructed in 1916, with the first products being acetaldehyde and acetic acid."

Demands during WWI led to the production of acetone, which was the starting point that put Wacker on a trajectory to becoming an international chemical company, according to Prasad. Today, Wacker's portfolio includes more than 3,200 products.

LOOKING TO WHAT'S NEXT

As Wacker continues that trajectory into the future, Prasad said that the world's energy transition journey will be an area that the company will lend its considerable expertise in.

"One of the most significant changes is expected to be in the area of energy transition — from fossil fuel and nuclear-based to renewable sources, including solar and wind energy," he said. "The chemical sector is one of the most energy-intensive industries, and Wacker is fully aware of the responsibility it entails. In Germany, the transition to renewable energy sources is underway and is set to account for 80 percent of the total electricity mix by 2030."

In that vein, Wacker aims to cut greenhouse gas emissions in half and reduce energy consumption by 15 percent by 2030, according to Prasad.

"Whether wind power or solar energy, Wacker's products help harvest renewable energy," he said. "Perhaps the best-known example is our hyper-pure polysilicon, the most fundamental raw material for photovoltaics. Wacker is the only company in Europe to produce such hyper-pure polysilicon for photovoltaics."

MORE INFO www.wacker.com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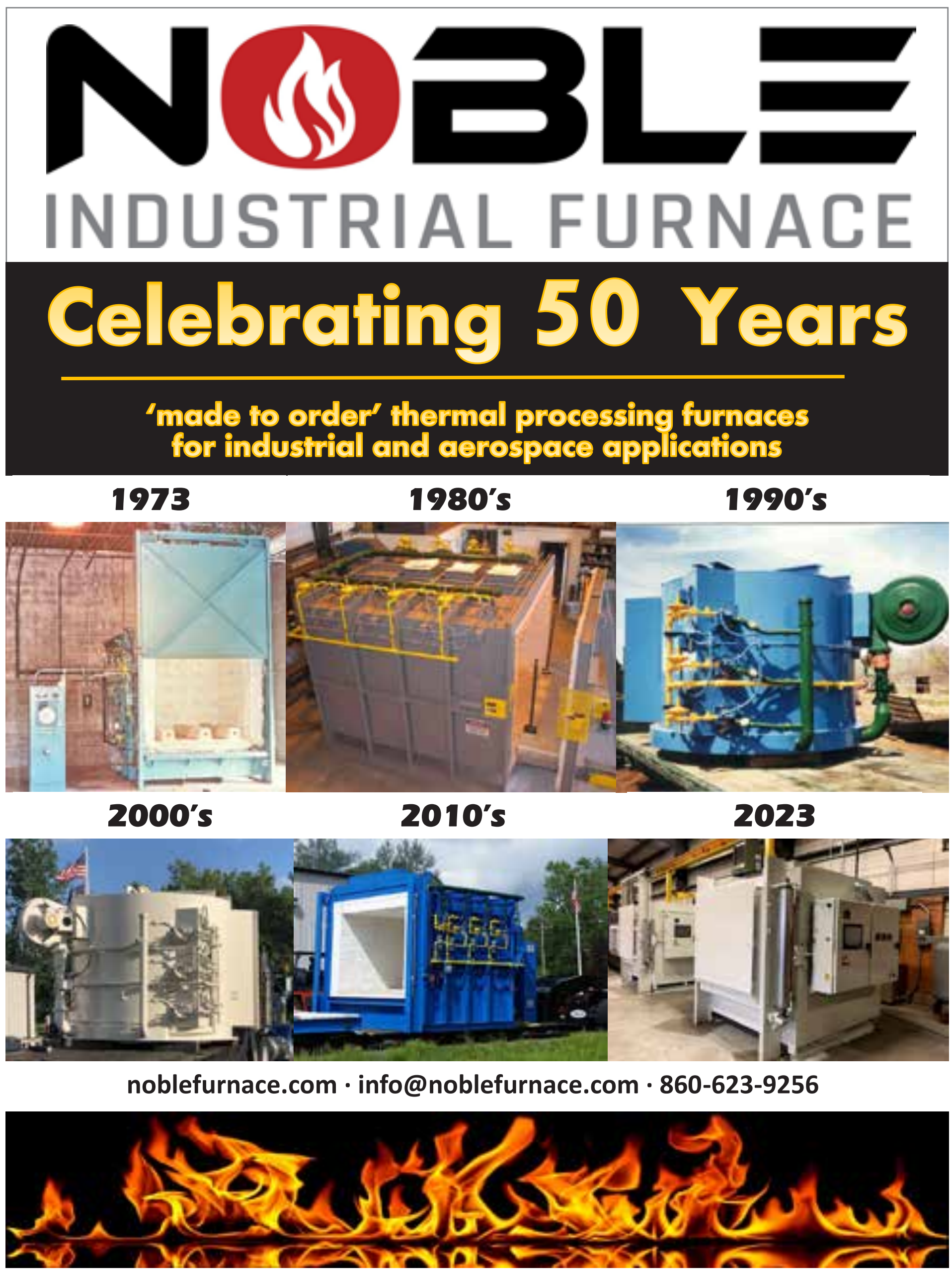
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JOHN LUDEMAN /// VICE PRESIDENT OF OPERATIONS /// ADVANCED HEAT TREAT CORP.

"We value Nadcap. It's not easy to obtain and achieve, and we strive to meet the standard every day."

Advanced Heat Treat Corp recently renewed its Nadcap accreditation in heat treating. Why was this important?
It is important to Advanced Heat Treat to have that Nadcap accreditation. It enhances our ability to serve our customers. It keeps open a customer base that has to have Nadcap as an accreditation to do their work. It's also an indicator to all our customers that quality is a big part of the Advanced Heat Treat daily heartbeat. We value Nadcap. It's not easy to obtain and achieve, and we strive to meet the standard every day. Really, we just love to do it. It's a great way to meet our customer expectations and requirements.

What was involved in renewing the accreditation?
We work to the highest stringent Nadcap requirements every day, which makes that an easier way to prepare for that audit. Nadcap isn't really something you turn off and on. It just doesn't work that way. It's in our everyday standard operating procedures to get to that point. Whether it's every year, every 18 months, or every two years, depending on your Nadcap merit status, you have to have an auditor come in from the Nadcap program and do that evaluation. We've actually had Nadcap accreditation since 2013, and we do have merit status, but prior to that assessment you have to submit a list of documents that they give you, which includes self-assessments, internal customer job audits, internal shop procedures, just to name a few. Those internal audits or assessments are a great way to make sure you're meeting customer requirements and making improvements.

What does the accreditation allow Advanced Heat Treat to do for heat treating?
I think it allows Advanced Heat Treat to show they're a leader in the heat-treat industry. It gives our customers confidence in where they're sending their work and a peace of mind that we're a leader in the business.

In addition to this Nadcap accreditation, Advanced Heat Treat complies with many customer specifications. What are some of those specifications?
We do comply with all the AMS specifications for nitride, which are 2759/6, AMS 2759/8, AMS 2759/10, and AMS 2759/12. We also meet customer specifications for nitride for General Electric, Saffron, Woodward, Cessna, Collins Aerospace, and General Atomics, just to name a few.

Advanced Heat Treat added more nitriding units. How does this addition increase your Nadcap capacity?
Just this week, we're actually installing another nitride unit, which will increase the capacity of our Nadcap nitriding vessel roster across the company. The reason we want to do this is, one, to increase our flexibility to meet or exceed customer expectations for turnaround time, and two, it gives us more ability to be reactive to when customer product comes in.

AHT employees in front of a Nadcap nitriding vessel display AHT's core values. (Courtesy: Advanced Heat Treat Corp.)

Advanced Heat Treat also passed an Aerospace Quality System audit. What will this mean to your customers in the aerospace industry?
Quality is a must for all of our customers, but for our aerospace customers, they have the highest standards for quality in the business. I think having passed this shows Advanced Heat Treat's commitment to quality, attention to detail, and meeting customer requirements. With that quality aerospace system accreditation that we got through Nadcap, it reinforces that is what we strive to do and live to do each day.

Is there anything else that we didn't talk about that you'd like to mention?
I just think from a leadership standpoint at Advanced Heat Treat Corp., I'm just proud of all the people that go into making our Nadcap accreditation a success. That's across the board: from the quality team, the continuous improvement team, the operations team, and the leadership team. If everybody wasn't invested like they are, it would be difficult to achieve merit status and to continue to be successful. I'm very proud of the whole company, in general, to meet those expectations and do it in a very deliberate way.

MORE INFO www.ahtcorp.com

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