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AEROSPACE APPLICATIONS / CERTIFICATIONS

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WITH CARBIDE FORMATION & DISSOCIATION

COMPANY PROFILE //

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Thomas Lord, Sales Director
United States ALD Port Huron
ALD Thermal Treatment Inc.
2656 24th Street
Port Huron, MI, USA 48040
Cell Number +1 (810) 300-1437
Email: tlord@alddt.net

Christopher Totten, Sales - Canada / USA,
Office Phone +1 810 357 0634
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Edwin Orozco, Sales Director - Mexico
Office Phone +52 844 866 9791
Cell Phone +52 1 844 277 2257
ventas@alddt-mexico.com
eorozco@alddt-mexico.com

Moises Garcia - Sales Director - Bajío
Cell Phone +521 (844) 277 2254
ventas@alddt-mexico.com

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FROM THE EDITOR //



October brings a wide-range of heat-treat topics

I know it feels like we've just entered the 47th month of 2020, but keep focused. It's still a "new normal," but we can get through it and come out stronger than before. And isn't that what good heat treatment is all about?

Part of what I enjoy about being editor of *Thermal Processing* is bringing you information about the heat-treating industry, and it's always an extra pleasure to bring you such a wide scope of topics, especially in a season that is synonymous with cornucopia.

That's right. Our October issue boasts a cornucopia of articles where I'm sure you'll find at least one that's of interest. (Although I bet you'll find much more than that.)

The aerospace industry is an important user of the services and products within the heat-treat industry, so our cover story is devoted to that subject. Our Metal Urgency columnist, Justin Sims, has pulled double duty this month. In addition to his column, he has penned an article about low pressure carburization modeling and its importance as high-strength steels within the aerospace sector become more prevalent.

As technology has advanced, the need for more precise and accurate certifications has become a highly sought-after aspect of the heat-treat world.

In that vein, the Nadcap accreditation process can be complex and multi-faceted.

To help steer you through this, *Thermal Processing* offers up a case study where Roy Adkins, corporate director of quality at Braddock Metallurgical and Nadcap Supplier Support Committee (SSC) Task Group representative for heat treating, describes his perspective and experience of Nadcap audits.

Quality Counts columnist Jason Schulze also dives into the certification topic with an expanded column on the key pyrometric changes to AMS2750F.

Ceramics is a big part of heat-treating, so we wanted to represent that important topic in this issue as well. Our friends at CeraMaterials share their insights on how to install ceramic fiber module lining on a curved vessel wall.

In this month's Hot Seat, Dr. Scott MacKenzie continues his series on the heat-treatment of aluminum, and Sims' Metal Urgency article rounds out our expert columnists' contributions with a look at how heat-treat modeling can improve the press-quenching process.

See what I mean? A lot of interesting articles to exercise your heat-treating brain cells. It's important to stay focused and alert as we hopefully continue our slow churn to normalcy.

With that said, enjoy this month's issue, and, as always, thanks for reading!

KENNETH CARTER, EDITOR
editor@thermalprocessing.com
(800) 366-2185 x204

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David C. Cooper
PUBLISHER

EDITORIAL

Kenneth Carter
EDITOR

Jennifer Jacobson
ASSOCIATE EDITOR

Joe Crowe
CONTRIBUTING EDITOR

SALES

Dave Gomez
NATIONAL SALES MANAGER

Ben Keaten
REGIONAL SALES MANAGER

CIRCULATION

Teresa Cooper
MANAGER

Jamie Willett
ASSISTANT

DESIGN

Rick Frennea
CREATIVE DIRECTOR

Michele Hall
GRAPHIC DESIGNER

CONTRIBUTING WRITERS

PHILIP KENT
D. SCOTT MACKENZIE
JASON SCHULZE
JUSTIN SIMS
DEL WILLIAMS



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UPDATE /// HEAT TREATING INDUSTRY NEWS



The Grieve Corporation provided a 1,250°F (667°C) inert atmosphere oven for a customer using it for heat treating firearms components at its facility. (Courtesy: Grieve Corporation)

1,250°F inert atmosphere oven available from Grieve

The Grieve Corporation provided a 1,250°F (667°C) inert atmosphere oven for a customer using it for heat treating firearms components at its facility. Workspace dimensions of this oven measure 48" W x 48" D x 36" H. 30 KW are installed in Incoloy sheathed tubular heating elements, while a 1,400 CFM, 1-1/2 HP recirculating blower provides horizontal airflow to the workload. Inert atmosphere ovens protect parts from oxidation using any non-flammable gas such as nitrogen, argon, or carbon dioxide.

This Grieve inert atmosphere oven features 12" insulated walls, all interior seams

welded gas-tight, an air jacket on the inner oven for cooling, 16" high integral oven stand, 16-gauge 304 stainless steel interior and enamel-painted aluminized steel exterior. The oven is reinforced for 2,000-pound loads, allowing the customer's part rack to sit on the oven work space floor.

The oven meets all requirements for inert atmosphere construction, including those in NFPA 86, FM, and OSHA standards.

Controls on this Grieve oven include a programmable temperature controller with data logging capability, 975 CFM cooling blower with air flow safety switch, and automatic purge solenoid. An inert atmosphere inlet (1/2" NPT) with pressure regulator maintains positive pressure within the oven.

MORE INFO www.grievencorp.com



The furnace is controlled by a Honeywell program control and corresponding overtemperature protection. (Courtesy: L&L Special Furnace Co.)

L&L ships electric box furnace for high-tech ceramics

L&L Special Furnace Co., Inc., has shipped a medium-sized high temperature box furnace to a government military defense organization in the southeastern United States. The furnace is used for military ceramic composite development along with research and development for various other components.

The furnace has a working zone of 24" wide by 18" high by 36" deep. The furnace is rated for continuous operating temperatures up to 2,500°F/1,371°C.

The furnace comes equipped with silicon carbide heating elements for high-temperature operation. The furnace case is sealed from the inside out for use with inert "blanketing gas." Included is an atmosphere flow panel with flowmeter. The hearth is alumina plates supported on the bottom with hard fire brick. The door is an electric vertical counterbalanced door. Included is a step-down transformer to control secondary element voltage. The furnace thermocouples are type S and the furnace is approved by an independent third-party testing facility to ensure the equipment meets all EHS and



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.

current safety standards.

The furnace is controlled by a Honeywell program control and corresponding over-temperature protection. The furnace also has heat shields to ensure that the case temperature is below 120°F. A spare set of elements and thermocouples are included to minimize any unforeseen down time.

All L&L furnaces can be configured with various options and be specifically tailored to meet customers' thermal needs. L&L also offers furnaces equipped with pyrometry packages to meet ASM2750E and soon to be certified MedAccred guidelines.

Options include a variety of control and recorder configurations. A three-day, all-inclusive startup service is offered with each system within the continental U.S. and Canada. International startup and training service are available by factory quote.

MORE INFO www.llfurnace.com

Advanced Heat Treat Corp. announces new UltraOx® logo

Advanced Heat Treat Corp. (AHT), a recognized leader in heat-treat services and metallurgical solutions, has a new logo for its UltraOx® heat treatment. The new logo features an ox, as the term "ox" is often used

as an abbreviation of the term "oxide"—one of the three steps of this protective heat treatment.



AHT Director of Sales and Marketing Vasko Popovski said, "When you think of an ox, you think of strength, confidence, protection, and power. That is exactly how our customers should feel when it comes to using UltraOx on their ferrous alloy applications."

UltraOx is often used by manufacturers serving industries such as firearms, agriculture, automotive, and more. This environmentally-friendly heat treatment provides an aesthetic black color and three protective layers of wear and corrosion resistance.

UltraOx is offered at three of AHT's four locations. These locations include Cullman, Alabama; Monroe, Michigan; and Waterloo, Iowa. Among the three sites, AHT has more than 50 nitriding units enabling them to handle various part sizes and provide customers with quick turnaround.

AHT will also be rolling out a new video.

MORE INFO www.ahtcorp.com

Microsoft, Tenova to aid metals industry with digital future

Microsoft and Tenova, a Techint Group company specialized in innovative solutions for the metals and mining industries, strengthened their partnership for Industry 4.0. Leveraging on the Microsoft Azure platform and Tenova's innovative solutions for the steel industry, the two companies aim to lead the digital transformation of the sector,

which plays a key role in the global economic growth, manufacturing products for a total value of \$2.5 trillion each year and employing more than 6 million people worldwide.*

The goal of this renewed partnership is to provide Italian companies in the metals industry with industrial solutions based on artificial-intelligence technology, in order to give value to the large amount of data coming from industrial plants, with the goal to monitor their operations and performances, as well as guaranteeing the quality of the final product.

This collaboration is grounded on three

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UPDATE // HEAT TREATING INDUSTRY NEWS



Microsoft and Tenova renewed their collaboration with the aim of guiding companies of the metals industry in their digital transformations. ORI Martin and Tenaris are among the companies that have already benefited from this partnership, thanks to technologies that enable better data management.

main pillars: predictive monitoring and maintenance – which allow to establish the health status of plants, to modify production parameters to ensure high performance, and minimize downtime; optimization of operations and internal process management – to improve productivity and scalability in a safe and sustainable way; and collaboration and constant commitment to innovation between technology experts and plants operators (the so-called “human factor”) – capitalizing on the insights related to the use of the machinery thanks to sector-specific knowledge and expertise, so as to transform raw data into relevant information.

Several companies have already adopted Tenova's solutions enhanced by Microsoft technology, including ORI Martin – steel company based in Brescia specialized in the production of high-quality steel, Tenova's partner in the ambitious Lighthouse Plant “Acciaio_4.0.” The aim is to transform the production site of Brescia into a Smart Factory thanks to the application of the enabling technologies of Industry 4.0, thus becoming a model of innovation within the sector, not only at national level.

Tenaris, one of the world's largest manufacturers and suppliers of steel pipes and services to the global energy industry, also established a team of data scientists whose mission is to overcome industrial challenges and exploit digital solutions. Since then, Tenaris has initiated a great variety of use

cases related to industrial processes, some in collaboration with Tenova and Microsoft, aware that the ability to process and interpret large amounts of real-time data plays a crucial role in supporting business continuity globally.

“We are proud of the results achieved so far thanks to the collaboration with Microsoft, through which we have been able to integrate advanced features of the enabling technologies of Industry 4.0 into our systems, with the objective to support customers more effectively in achieving their business goals,” said Antonio Catalano, head of digital transformation at Tenova.

The Italian steel industry has a long tradition, contributing significantly to the competitiveness and growth of the Italian economic fabric, characterized for the quality of its products. In order to continue to face new challenges from global markets with players of greater production capacity, it is increasingly necessary to focus on new technologies and production process innovation, aspects that will prove decisive for the success of our companies in the coming years. This is why we have chosen to further strengthen our collaboration with Tenova, a leading company which has distinguished itself in recent years by its ability to leverage our Cloud and its associated artificial intelligence and machine learning capabilities, offering highly innovative services to guide steel companies towards the future,”

said Fabio Moioli, director of the enterprise services division at Microsoft Italia.

* “The Role of Steel Manufacturing in the Global Economy,” The World Steel Association, May 2019.

MORE INFO www.tenova.com
www.microsoft.com

Solar Manufacturing adds Met-Pro, Inc. as Michigan rep

Solar Manufacturing added Aaron Ackerman of Met-Pro, Inc. to assume the role of sales representative for Michigan.

Ackerman started in the thermal processing industry in 2004 with Wirco and worked through the ranks from account manager to business development manager. He traveled all over the United States, Canada, and Mexico to assist customers with their alloy needs for furnaces. In 2017, Ackerman joined Met-Pro with previous owner John Hansen, and in June 2018, Ackerman took over the business.

“When the opportunity came up to work with the Jones family, and their line of vacuum furnaces, I knew it would be a great fit to our lineup of the best suppliers in the world in the thermal processing industry,” Ackerman said.

MORE INFO www.solarmfg.com

Bel Air Finishing post processing cell added to Army arsenal

Phillips Federal added the post processing technologies of Bel Air Finishing to support its Public Private Partnership (P3) and additive manufacturing programs at Rock Island Arsenal (RIA).

Bel Air and Phillips, a division of Phillips Corporation, have combined to install a com-



Aaron Ackerman



The training facility will bring the level of printed surfaces to meet or exceed traditional subtractive surfaces. (Courtesy: Bel Air Finishing)

pletely operational cell for post processing of all types of metal and plastic additive manufactured components. The operational system will be used as a training facility for U.S. Army and private DoD contractors involved in 3D printing at any facility in the world.

The Bel Air team is excited to combine with Phillips to teach the various technologies of post processing, which is mostly overlooked in the AM process. The training facility will make the printing efforts more efficient, along with more effective products by bringing the level of printed surfaces to meet or exceed traditional subtractive surfaces.

The cell includes automated build removal, surface grinding, polishing, cleaning and its own closed loop water feed system. Bel Air personnel will bring their 50-plus years of experience to combine with Phillips to be part of numerous scheduled training workshop presentations.

MORE INFO www.belairfinishing.com

Höganäs, Lincotek to develop surface coating solutions

Höganäs Product Area Surface and Joining Technologies (SJT), a world leader in metal powders — and Lincotek Surface Solutions, one of the leading global providers of surface treatments — will cooperate more closely. They agreed to further strengthen their ongoing relationship in product and coating development for thermal spray and surface

technology applications.

The alliance targets the development of complete surface treatments for aerospace, energy, automotive, and other industries. With the combination of the materials expertise of Höganäs and the surface technology expertise of Lincotek Group as an equipment supplier and service provider,

both companies intend to offer newly developed solutions to end user industries for various applications.

"We are delighted that Lincotek has chosen us as preferred material development partner for the Surface Solutions Division. We believe that the new cooperation agreement will further strengthen the ability of

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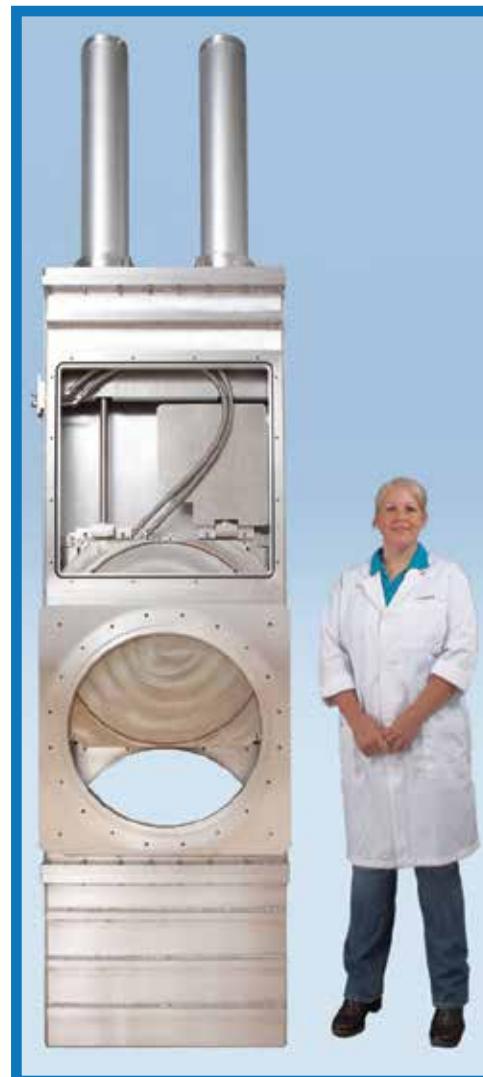
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UPDATE // HEAT TREATING INDUSTRY NEWS

both companies to commonly develop and offer the best materials and coating solutions for the market," said Hans Keller, president of Surface and Joining Technologies at Höganäs. "Our long-term fruitful business relationship with our partner Lincotek built an excellent foundation for this cooperation and we are now looking forward to the next chapter of an exciting journey together."

Winfried Schaler, Group CEO at Lincotek, said, "To join forces is very exciting for us. We have been cooperating with Höganäs for many years. Today, market dynamics are changing rapidly and we need to provide answers to the latest development needs in the industry. Innovation, quality, cost and efficiency are major drivers and combining our development efforts will reduce the time to market for new solutions."

Höganäs and Lincotek have been working together for a number of years.

MORE INFO www.hoganas.com

Gallos adds Can-Eng mesh belt heat-treat furnace line

Can-Eng Furnaces International, Ltd. recently delivered a high-capacity mesh belt heat-treatment furnace line to Gallos Metal Solutions Inc. in Milwaukee, Wisconsin.

Specializing in continuous mesh belt atmosphere heat treatment, Gallos selected Can-Eng to provide a custom-engineered continuous atmosphere heat-treating system to be used primarily for demanding processing including carbonitriding and carburizing, while allowing for neutral heat treatment with a production capacity up to 4,000 lb/hr. This furnace line is part of Gallos' massive plant expansion and modernization project, which has more than doubled the existing plant square footage, increased capacity, and added automation.

Can-Eng's highly engineered and custom system allows for an increase in usable hearth area to provide high-volume processing when running products requiring carbon diffusion and lighter belt loading.

This new capacity addition features a computerized controlled automated bin dumping and vibratory part feeder system,



Can-Eng's system allows for an increase in usable hearth area to provide high-volume processing when running products requiring carbon diffusion and lighter belt loading. (Courtesy: Can-Eng)

dunk and spray pre-washer, protective atmosphere-controlled mesh belt hardening system, oil quench, dunk and spray post wash system, forced recirculation temper furnace, in-line post cooling system, and Can-Eng's PETTM Level 2 SCADA system. By integrating Can-Eng's Level 2 Automation, Gallos provides access to vital tracking of products' status, detailed process data for continuous process improvements, comprehensive equipment diagnostics, cost analysis, and inventory management.

This project marks the fourth Can-Eng mesh belt furnace line to be in operation at this facility.

MORE INFO www.can-eng.com

Pemamek LLC names Pavlock regional sales manager

Finland-based global welding automation leader Pemamek Oy and its North American subsidiary Pemamek LLC, have named Michael Pavlock as the regional sales manager for the Texas region.

Michael Pavlock will head the sales efforts for PEMA brand equipment and solutions throughout Texas, the Gulf Coast states,

and Oklahoma. His experience in the metals and metal fabrication industries as regional sales manager at Metaltech Service Center, Inc. (Mobile, Alabama) and as an account specialist at Texas Iron and Metal (Houston, Texas) have provided Pavlock with a thorough understanding of the characteristics of different metals, the best welding and joining solutions available, and the ability to successfully communicate this to new and existing customers.



Michael Pavlock

"Michael brings to Pemamek a wealth of knowledge about the industry, materials, and the welding process which allows him to make quick entry into the welding automation marketplace," said Michael Bell, director of sales, Pemamek North America, LLC.

Pavlock will be key in familiarizing manufacturers in the Texas region with Pemamek's automated robotic welding solutions, including its PEMA WeldControl Welding Automation Software, a forward-thinking approach in which the software communicates in concert with the work-piece automation devices, welding power supply, and visioning systems. This new

technology increases throughput by allowing advanced programing of the workpieces to enhance workflow.

MORE INFO www.pemamek.com

Solar Atmospheres adds sixth all-metal hot zone furnace

Solar Atmospheres recently installed another all-metal hot zone vacuum furnace at its 1969 Clearview Road facility in Souderton, Pennsylvania.

This is Solar's sixth all-metal hot zone furnace installation, and the fourth for its climate-controlled room. The furnace is a new Mentor model, built by sister company Solar Manufacturing, has a working zone of 12" x 12" x 18", and is the first of its kind. The additional furnace increases Solar's capacity for processing sensitive materials such as PH



The Solar all-metal hot zone vacuum furnace makes it possible to reap the benefits of an all-metal furnace while minimizing the overall cost.

stainless, nickel-based superalloys, titanium, and ferritic/austenitic stainless steels, yet focuses on smaller lots and one-off items. The furnace makes it possible to reap the

benefits of an all-metal furnace while minimizing the overall cost.

MORE INFO www.solaratm.com

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UPDATE // HEAT TREATING INDUSTRY NEWS

Rex Heat Treat first in U.S. to install Super IQ® system

The Super IQ® hybrid system, a conventional and vacuum furnace in one by Seco/Warwick, premiered in October at ASM2019 and now it operates for the first American customer.

Rex Heat Treat, a commercial heat-treater specializing in the aerospace market, has become the first company to install and commission the new Super IQ® gas carburizing furnace. Over the past several years, Rex has commissioned several new Seco/Warwick Group vacuum furnaces at its Lansdale, Pennsylvania, location as part of a plant modernization initiative. So, when Super IQ was introduced in 2019, it represented another opportunity to upgrade their through-hardening and carburizing capabilities alongside their legacy harden and temper furnaces, while using their existing loader, baskets, and washing system.

Super IQ was designed specifically to eliminate the need for endogas and its inherent flames and carbon monoxide dangers. Instead, Super IQ allows clean processing and can even achieve higher temperature carburizing to speed cycles and improve yields in certain steels in a clean and cool manner. Parts also come out much cleaner and brighter.

"The Super IQ is a well-thought-out replacement to the traditional-gas-fired IQ furnaces. The technological advances allow us to run at higher temperatures, vacuum carburize, and clean harden with no decarburizing effects. The fact that our existing systems fit perfectly with this new addition helps to minimize the overall investment and accelerate successful integration. We expect the Super IQ to reduce operating costs, improve safety, and enable more environmentally friendly processing," said Johnathan Rex, general manager at Rex Heat Treat.

Seco/Warwick engineers envisioned Super IQ to change the market, because it is an affordable successor technology in batch harden and quench markets. The furnace takes decades of proven technologies and integrates them into a single system for easy implementation with standard quench oils.

"Our alternative to the integrated



Seco/Warwick's Super IQ furnace is primarily designed for carburizing processes at elevated temperatures and hardening. (Courtesy: Seco/Warwick)

hardening furnace — i.e. the Super IQ — was created in response to the needs of heat-treatment companies. The industry required a safer, cleaner, faster, and more effective carburizing method. Compared to traditional methods, Super IQ® provides many benefits, but especially productivity improvements. It works in higher temperature ranges, which translates into shorter cycles with no reduction in furnace life. As a result, it delivers more efficient production for less. This is a game changer the world over," said Piotr Zawistowski, managing director of Seco/Vacuum, Seco/Warwick's subsidiary.

Rex Heat Treat, with facilities in Lansdale and Bedford, Pennsylvania, and Anniston, Alabama, has been operating continuously since 1938. Over three generations, it has developed a progress model based on the use of innovation to meet customers' current and future needs. Because of this development strategy, Rex can effectively serve clients in demanding industries.

MORE INFO www.secowerwick.com

Magnetic Specialties ships mining duty transformers

Magnetic Specialties, Inc. recently shipped three 1MVA, three-phase step down transformers for use in a demanding mining application.

Each transformer features a 13,200V Delta Primary with two 2.5 percent full current above and below nominal voltage taps designed for 60kV BIL. The Wye Secondary is a 480/277V configuration. These mining transformers feature copper windings and mitered cores. The 6,200-pound core and coil assembly were designed using proprietary software and Solidworks® 3D modeling.

MORE INFO www.magspecinc.com

Cold water without unwanted waste heat in production area

Gwk Gesellschaft Wärme Kältetechnik mbH introduced a mobile water-cooled teco cw series. The innovative cw units are connected to the machine cooling system just like a temperature control unit. As a result, there will be no warm exhaust air in the production area as would be the case with air-cooled compact refrigeration units. Unlike traditional cooling units, a cw unit can be used to produce cold water with a temperature of 0°C without the need for adding an anti-freeze agent to the water.

Cold water is often required for individual units only and not for all production machines so that a central refrigeration system, and the associated extensive pipe system would not be worthwhile. In these cases, users tend to rely on refrigeration units that are mobile, air-cooled, and compact.



It looks like a normal temperature control unit but it is actually a cooling unit for temperatures from 0°C to 25°C. (Courtesy: gwk)

The disadvantage of this method is the additional heat generated in the production area by the exhaust air of the refrigeration units. This is particularly annoying during the warmer seasons. With the cw series, gwk now offers a compact alternative solution with a high level of performance.

The mobile units are equipped with the proven control system as well as other well-established and reliable components of the teco c series made by gwk. As a result, in the event of problems, the user benefits from quick and trouble-free service thanks to standardized spare parts.

The most important difference is the temperature range. While teco c series units supply warm water, the teco cw unit supplies cold water. All of the units are equipped with a leak stop function and mold draining function. The users can connect the units to the production machine via serial interfaces.

Unlike traditional cooling units, a gwk cw unit can be used to produce cold water with a temperature as low as 0°C without the need for adding an anti-freeze agent, e.g. glycol, to the water. Even a comparably high-water temperature of 25°C cannot be readily produced with traditional units.

The pump output is specifically adapted to the requirements of plastics-processing applications with flow rates of 60 l/min max. and pump pressure values of 3.5 or 5.8 bar max. The refrigeration capacity up to 4 kW or 10 kW is optimized for the production machinery.

The teco cw units have an optimized

refrigeration circuit with very small fill quantities so that they are exempt from any regular statutory leak tests. The water-cooled version does not have a fan and, therefore, it is particularly quiet.

Gwk Gesellschaft Wärme Kältetechnik mbH, with its headquarters in Meinerzhagen, is part of the technotrans group and a sys-

tem supplier of cooling, temperature control, and water supply systems for the plastics-processing industry. The solutions cover the entire production process from cooling and temperature control up to the water treatment phase.

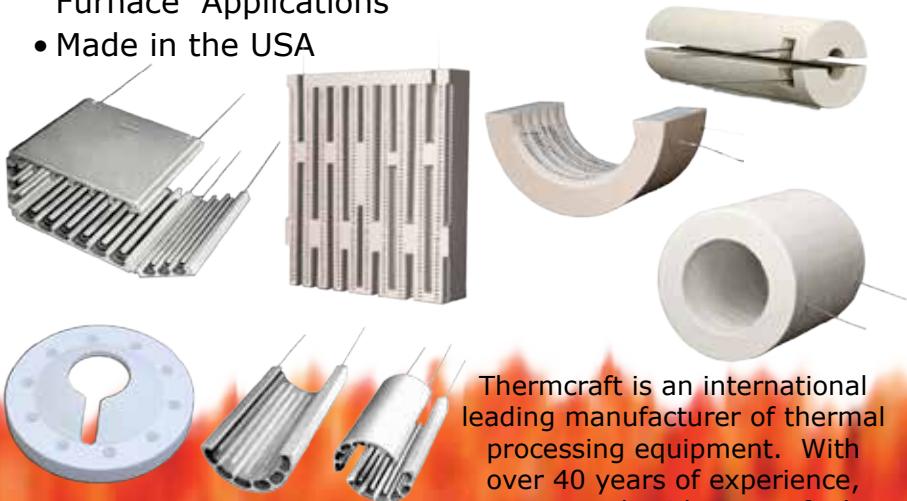
MORE INFO www.gwk.com



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INDUSTRIAL HEATING EQUIPMENT ASSOCIATION

IHEA's 2020 fall combustion and safety seminars go virtual



Each fall, the Industrial Heating Equipment Association (IHEA) brings industrial process heating professionals together to provide combustion and safety education for the industry. This year will look different, but IHEA will still deliver essential content through a virtual platform. IHEA is committed to continuing to provide a base of industry knowledge even in challenging times. These seminars are a great resource for those who are responsible for the operation, design, and maintenance of industrial process furnaces and ovens.

The IHEA Virtual Fall Seminars will be over two consecutive weeks in November, Wednesday-Friday each week. Each day will consist of three presentations from 11 a.m. to 2 p.m. EST. The agendas for the virtual seminars contain vital topics that have been adapted to online versions so attendees can still get the information they need whether they are working from home or in the office.

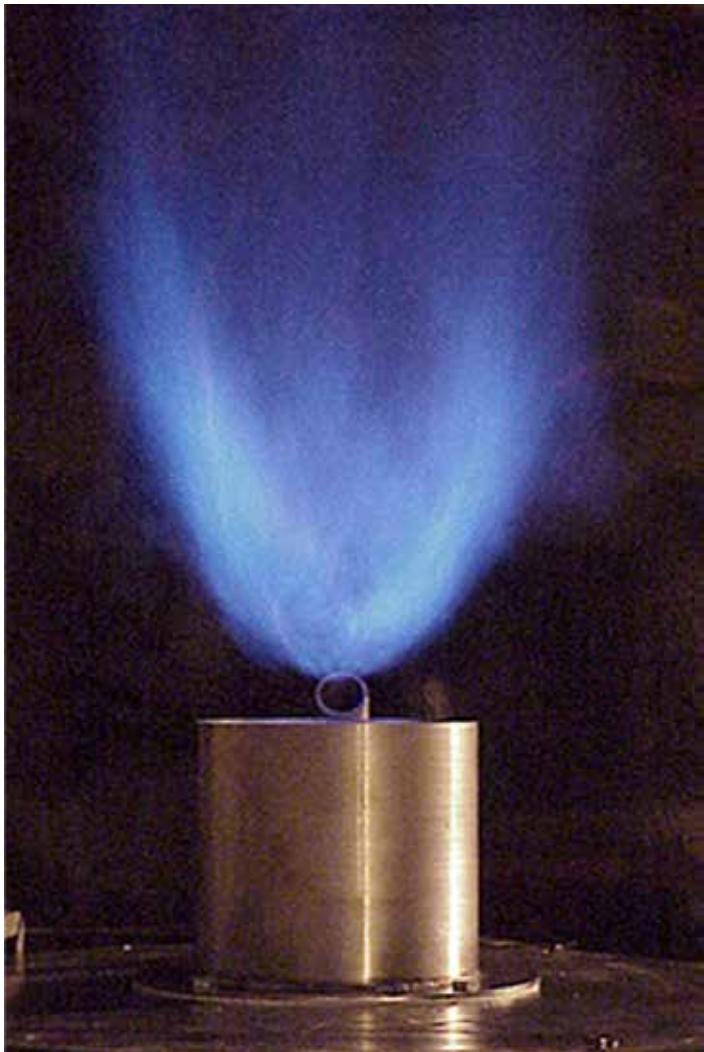
2020 VIRTUAL COMBUSTION SEMINAR

November 11-13

For more than 50 years, IHEA has offered this valuable educational seminar for those in the heat-processing industry. IHEA is fortunate to have the support of member company experts to provide the instruction. Attendees will receive a flash drive containing presentations.

Topics to be covered during this three-day virtual seminar include:

- **Fundamentals of Combustion:** Keenan Cokain, Bloom Engineering Co., Inc.
- **Burners and Nozzles:** Brian Kelly, Honeywell Thermal Solutions.
- **Practical Fluid Flow & Piping Practices:** Bob Sanderson, Rockford Systems.



- › **Combustion System Safety:** Bryan Baesel, Honeywell Combustion Safety.
- › **Flame Safety and Sequence Control:** Scott Fogle, SCC Inc.
- › **Fuel/Air Ratio Control:** Bob Sanderson, Rockford Systems.
- › **Heat Application - Low Temperature:** Ryan McClain, MP Combustion.
- › **Heat Application - High Temperature:** B.J. Bernard, Surface Combustion.
- › **System Troubleshooting:** Brian Kelly, Honeywell Thermal Solutions.

2020 VIRTUAL SAFETY STANDARDS AND CODES SEMINAR

November 18–20

This seminar covers critical safety information for those involved with a wide range of industrial thermprocess applications. Attendees will receive a printed copy of the current NFPA 86 Standard for Ovens and Furnaces.

The three-day virtual seminar will include the following sessions presented by IHEA members who are experts in safety:

- › **Overview of NFPA 86 Standards for Ovens & Furnaces, including Administration, References & Definitions:** Kevin Carlisle, Karl Dungs.
- › **Gas Line Evacuation Purgung & Charging:** Kevin Carlisle, Karl Dungs.

› **Furnace Heating Systems, including Class B Furnace Considerations:** Bryan Baesel, Honeywell Combustion Safety.

› **Safety Equipment & Application, including Safety Shutoff Valves:** Aaron Zoeller, SCC Inc.

› **Safety Equipment & Application with Safety Controls & Devices:** Michael San Antonio, Fireye.

› **Class A Ovens & Furnaces and Thermal Oxidizers:** Jason Safarz, Karl Dungs.

› **Safety Equipment & Application, including Programmable Logic Controller Systems:** Bryan Baesel, Honeywell Combustion Safety.

› **Special Atmospheres for Class C Ovens & Furnaces:** Anthony Cherol, Surface Combustion.

› **Class C Furnace - Quench & Molten Salt Bath:** Anthony Cherol, Surface Combustion.

› **Commissioning, Operations, Maintenance, Inspection & Testing:** Aaron Zoeller, SCC Inc.

Registration fee for each 3-day virtual event is \$295 for IHEA members and \$350 for non-members. Register for both seminars and take advantage of our multiple seminar discount: \$499 for members; \$599 for non-members. Attendees who complete each seminar will receive a certificate awarding PDHs following the conclusion of the seminars.

For additional details and to register, go to: www.ihea.org and click the Education & Events tab.

IHEA 2020 CALENDAR OF EVENTS

OCTOBER 5–NOVEMBER 15

Fundamentals of Process Heating On-Line Course

6 Week Online Course | Registration open until October 1

This course provides an overview of the fundamentals of heat transfer, fuels and combustion, energy use, furnace design, refractories, automatic control, and atmospheres as applied to industrial process heating. Students will gain a basic understanding of heat transfer principles, fuels and combustion equipment, electric heating and instrumentation and control for efficient operation of furnaces and ovens in process heating.

OCTOBER 20–21

Powder Coating & Curing Processes Seminar

Alabama Power Technology Applications Center | Calera, Alabama

The day and a half Introduction to Powder Coating & Curing Processes Seminar will include classroom instruction and hands-on lab demonstrations.

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

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METAL URGENCY //

JUSTIN SIMS

MECHANICAL ENGINEER /// DANTE SOLUTIONS



Heat-treatment simulation software can be used to successfully solve problems during complex gear production.

Modeling can improve press quenching process

A combination of carburization and quench hardening is often used to increase the strength and improve fatigue performance of steel parts. During quenching, stresses caused by the thermal gradient and phase transformations will generate plastic deformation, which will lead to distortion in hardened parts. Gear components with large distortion will increase gear noise and reduce fatigue life in service. Final machining of hardened gears often leads to nonuniform case depth distribution, so a maximum amount of distortion caused by hardening is often specified, and parts with distortion exceeding the specification will be scrapped. Press quenching is one effective way to reduce the distortion amount from a hardening process.

Quench hardening is a transient thermal stress process with phase transformations. The effect of various factors on distortion is nonlinear, and the distortion can only be measured after the process is done. Heat treatment results that are of common interest include the volume fractions of phases, hardness, residual stress, and part dimensional change. The thermal gradients during both heating and cooling work together with the phase transformations to continually change the internal stress and deformation of the part being heat treated. The material response of a specific part during the heat treatment process is difficult to document just using the final measurements. Heat-treatment simulation software such as DANTE makes it possible to understand the material response during the heat-treatment process, including the evolution of internal stresses, part deformation, the phase transformation sequences, and the probability of cracking. Computer simulation has increased the level of understanding of heat-treatment processes because the events that

occur during heating and cooling can be accurately modeled and investigated.

In this case study, the DANTE heat-treatment simulation software is used to model the carburization and press quenching of a spiral bevel gear, with an inner spline. The modeling results are used to understand the causes of distortion, and further studies of the press quench models are used to improve the effectiveness of the press quench tooling design. The gear is made of AISI 9310, with an outer diameter of 16.5 inches and a bore diameter of 5.5 inches. The main concern was the shrinkage of the bore, which was exceeding the tolerances set by the design. To determine the cause of the excessive shrinkage, and explore possible solutions, a CAD model was created of a single tooth sector. The bevel gear tooth was removed, since it was assumed to have a minimal effect on the bore distortion, while the spline tooth on the bore was retained. Figure 1 shows the single tooth model (left) and a closeup of the gap between the bevel and the bottom die (right). The gap distance is set when all components are at room temperature.

The first step when evaluating a press quenching operation using simulation is to determine the effects of the tooling on final distortion. A model was therefore executed that did not have any tooling constraints, labeled 'Immersion Oil Quench' in the plot, as well as a model with the current tooling positions and loads, labeled 'Press Quench' in the plot. Figure 2 shows the prediction of the bore distortion, for the upper and lower sections. For completion, the distortion of the bevel was also examined. Figure 3 shows the axial distortion of the bevel for the immersion oil quench and the press quench processes. Figure 3 shows that the press quench tooling was effective

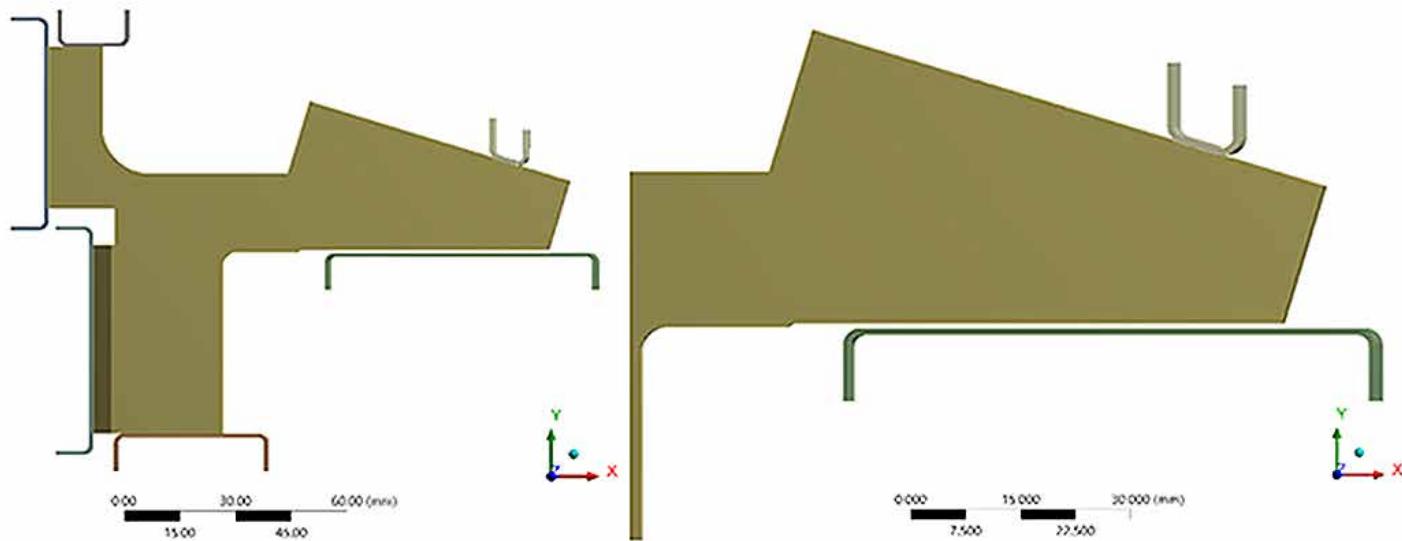


Figure 1: CAD model of single tooth model with press quench tooling, left, and close up of bevel showing gap between tooth and lower die.

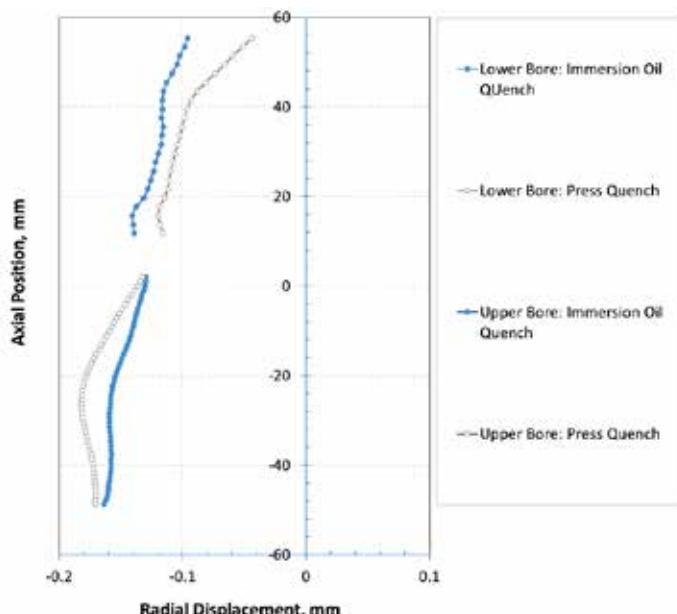


Figure 2: Final radial distortion of the upper and lower sections of the bore for a quench without tooling (Immersion Oil Quench) and the press quenching operation with the tooling originally used.

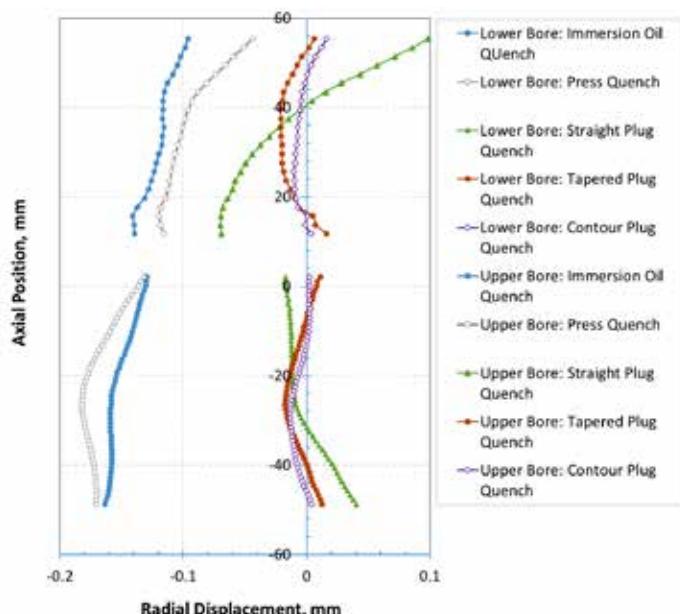


Figure 4: Final radial distortion of the upper and lower sections of the bore for different tooling configurations.

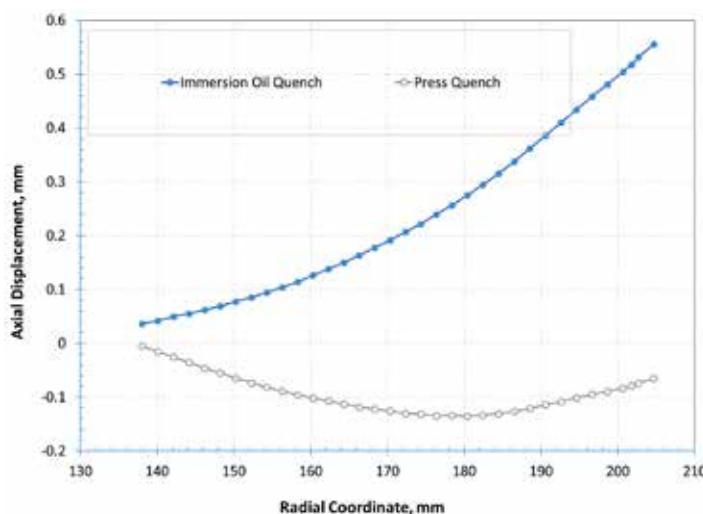


Figure 3: Final axial distortion of the bevel for a quench without tooling (Immersion Oil Quench) and the press quenching operation with the tooling originally used.

The modeling results are used to understand the causes of distortion, and further studies of the press quench models are used to improve the effectiveness of the press quench tooling design.

in controlling the bevel distortion within the specified tolerance. However, the simulation revealed that the tooling was not actually helping to reduce the shrinkage of the bore, as shown in Figure 2. A solution was therefore sought.

Through experience, it has been found that a plug can control the radial dimension much better than an expander. An expander was being used in this case, to no avail. There is generally an optimum oversize to the plug. That is, the plug generally works the best when it is larger than the room temperature size of the bore. Since the

part will expand when it is heated, the part will have no problem accepting the plug. After several modeling iterations, it was determined that a plug with an oversize of 60 micrometers reduced the distortion to a minimum amount. The plug used in the model had a straight profile, which led to a significant taper in the bore of the gear. To correct this, a plug with the inverse taper was developed and simulated. This reduced the radial shrinkage and taper to manageable levels, but the bore was still not completely straight. Sometimes it is possible to remove the contour of the bore by designing the plug with the inverse contour, just like taper can be removed with an inverse taper design. A model was developed that used an inverse contour plug design. The results showed a negligible effect, so it was determined that using a contoured plug was not worth the extra cost associated with manufacturing a contoured plug, but using a tapered plug was worth the extra cost. Figure 4 shows the results of the five cases modeled.

In conclusion, the DANTE heat-treatment software was used to effectively model the press quenching operation of a bevel gear. It was determined, through simulation, that the upper and lower dies were effective in controlling the axial distortion of the gear, including the bevel. The model did show, however, that the expander acting on both sections of the bore was ineffective in controlling the distortion of the bore. It did such a poor job controlling the radial distortion, that the same radial distortion could be realized by quenching the gear without constraints. Through simulation, it was determined that a plug with an oversize of 60 micrometers worked the best to reduce the radial shrinkage. A plug with a taper was then designed, using DANTE, to remove the taper caused by the straight plug profile. Heat-treatment simulation software can be used to successfully improve the rather complex press quenching operation of a bevel gear. ¶

ABOUT THE AUTHOR

Justin Sims is a mechanical engineer with Dante Solutions, where he is an analyst of steel heat-treat processes and an expert modeler of quench hardening processes using Dante software. Project work includes development and execution of carburization and quench hardening simulations of steel components and analysis of heat-treat racks and fixtures. He has a mechanical engineering degree from Cleveland State University.



Water quenching might sound like a straight-forward process, but there are plenty of guidelines and rules for using it.

Heat treatment of aluminum, part II: Water quenching

In the last article, we talked about the metallurgy behind quenching aluminum. Now we are going to discuss the available quenchants for aluminum.

INTRODUCTION

To achieve proper quenching of aluminum, the solute must be maintained in solid solution. This means that quenching must be rapid to prevent premature precipitation of solute. If this occurs, the solute will precipitate at grain boundaries, and be lost for any further hardening [1].

For aluminum heat-treating, quenchants are usually water (hot or cold, depending on the alloy and product form), or polyalkylene glycol (PAG).

WATER

Water quenching is the most readily available and most common quenchant for wrought and cast aluminum. Typically, quenching aluminum in water is conducted at either room or elevated temperatures (20-80°C). Water quenching has many advantages, including being readily available and inexpensive. There are no storage problems or health and safety problems associated with storage or disposal of water. It is nonflammable and nontoxic, and has no smoke or fumes. Cleaning is not required prior to subsequent processing. It is easy to pump and filter and is readily compatible with many different metals and polymers.

However, water quenching is not a panacea, and has disadvantages that restrict its use to specific applications. Often, if materials for the quench tank are not chosen properly, corrosion of the quench tank, fixtures, and fittings can occur. In addition, water supports biological growth. Corrosion inhibitors and biocide packages can be used to overcome corrosion and bacteria growth. However, the quenching characteristics of water can cause problems with distortion

and cracking. Water also shows significant variation in quenching characteristics depending on the hardness of the water. Hard water is much faster than distilled water (Figure 1), which can result in property and distortion differences.

The cooling rate of water quenching is independent of material properties such as thermal conductivity and specific heat. It is pri-

marily dependent on water temperature and agitation [2]. Water temperature is the largest primary variable controlling the cooling rate. With increasing water temperature, the cooling rate decreases. The maximum cooling rate also decreases as the water temperature is increased. In addition, the temperature of maximum cooling decreases with increasing water quench temperature. The length of time and stability of the vapor barrier increases, with increasing water temperature. This is shown in Table 1.

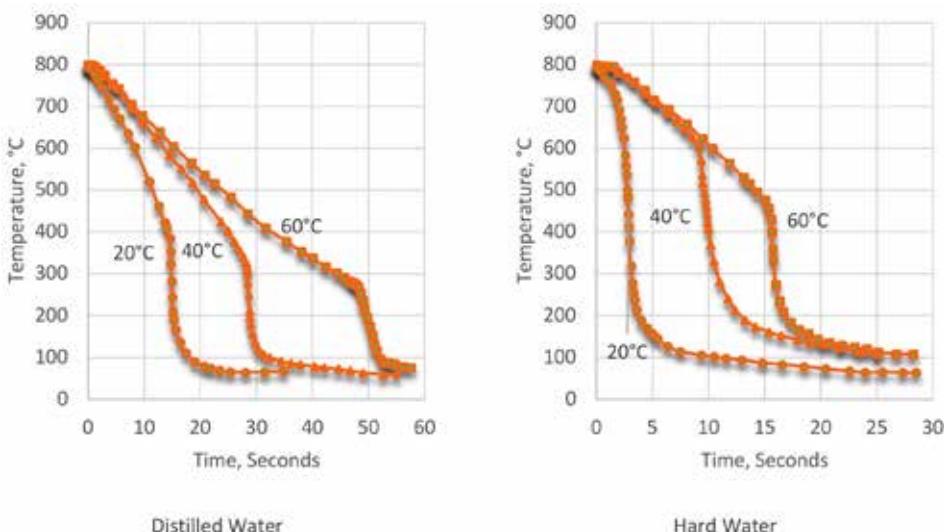


Figure 1: Comparison of the time-temperature curves of distilled water and hard water.

Water Temperature (°C)	Maximum Cooling Rate (°C/s)	Maximum Cooling Rate Temperature (°C)	Cooling Rate (°C/s) at T		
			704°C	343°C	232°C
40	153	535	60	97	51
50	137	542	32	94	51
60	115	482	20	87	46
70	99	448	17	84	47
80	79	369	15	77	47
90	48	270	12	26	42

Table 1: Effect of water temperature on cooling rates [4].

As water temperature increases, the vapor phase becomes prolonged, and the maximum rate of cooling decreases sharply. This can lead to soft spots, high conductivity, or locations of intergranular corrosion susceptibility in the workpiece.

The stability of the vapor phase is dependent on the surface finish of the component. The vapor film is extremely persistent on flat or

smooth surfaces. The vapor film is easily trapped on bottom surfaces, and in small pockets. Extremely rough surfaces can cause the retention of the vapor phase, and limit heat transfer. Adjacent parts can also cause film retention. This film breaks up readily with the onset of boiling at sharp corners, rough surfaces, defects, or other stress risers. This variation in stability will cause different cooling rates across the part, resulting in distortion and cracking.

Water also exhibits extremely high cooling rates in the convection phase. High cooling rates can help make sure that the part meets mechanical properties but can also cause excessive residual stresses or part cracking to form. The detrimental effects of temperature dependence and vapor phase stability can be minimized by maintaining the water at a low temperature through effective cooling, and vigorous agitation to disperse the vapor phase.

Cold water quenching is the most severe. In an early study using cooling curves [3], it showed that quenching into still water caused rapid heat transfer. This study showed that heat transfer at the surface of the part was very turbulent at the metal/water interface. This study also showed that there was a marked difference between hard water and distilled water. Distilled water showed an extensive vapor blanket that extended to low temperatures.

Quenching into water at < 50-60°C often produces non-uniform quenching. This non-uniformity manifests itself as spotty hardness, distortion, and cracking. This non-uniformity is caused by relatively unstable vapor blanket formation. Because of this difficulty, it was necessary to develop an alternative to water quenching. Polyalkylene glycol quenchants (PAG) [5] were developed to provide a quench rate in between that of water and oil. By control of agitation, temperature,



The average cooling rates of quenching aluminum in water have been measured for different plate thicknesses. A wide variation in average quench rates are observed when the temperature of the water is changed.

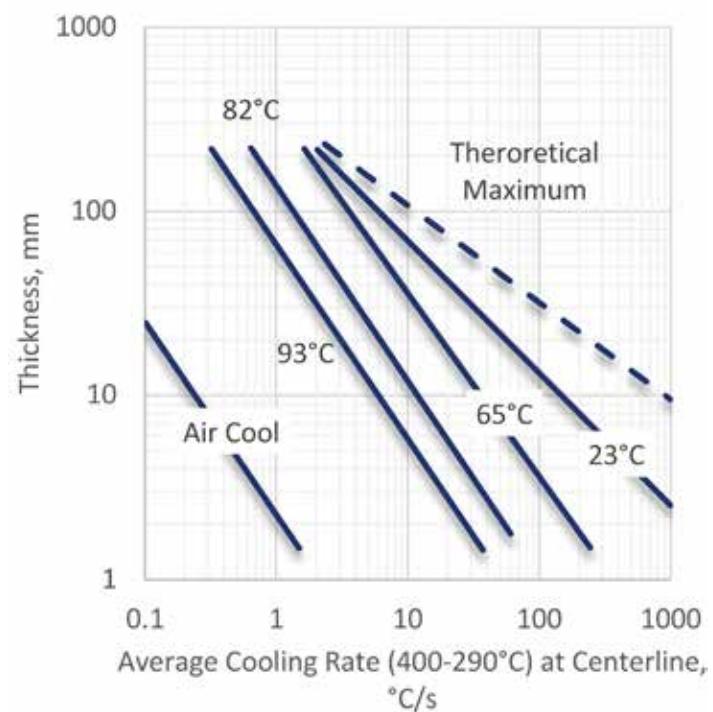


Figure 2: Measured average quench rates for water at different temperatures for different plate thicknesses, measured at the centerline of the plate [1].

and concentration, quench rates like water can be achieved.

The average cooling rates of quenching aluminum in water have been measured for different plate thicknesses (Figure 2). A wide variation in average quench rates are observed when the temperature of the water is changed. It is seen that the average quench rate at 400-290°C decreases as the water temperature is increased.

For very thick plates, it is not possible to obtain full properties because the cooling rate is not adequate to keep the solute in super-saturated solid solution. Some precipitation of the solute at grain boundaries will occur. This must be considered during design.

CONCLUSIONS

In this short article, we have discussed the use of water for quenching aluminum. In the next article, we will discuss the application of polyalkylene glycol quenchants for quenching aluminum.

Should there be any questions regarding this article, or any suggestions for further articles, please contact the author or editor. ♣

REFERENCES

- [1] J. E. Hatch, Aluminum: Properties and Physical Metallurgy, Metals Park, OH: American Society for Metals, 1984.
- [2] A. Rose, Arch. Eisenhulles, vol. 13, p. 345, 1940.
- [3] K. Speith and H. Lange, Mitt. Kaiser Wilhelm Inst. Eisenforsch., vol. 17, p. 175, 1935.
- [4] G. Totten, C. Bates and N. Clinton, Eds., Handbook of Quenching and Quenchants, Metals Park, OH: ASM International, 1993.
- [5] SAE, "AMS 3025E Polyalkalene Glycol Heat Treat Quenchant," SAE, Warren, PA, 2018.

ABOUT THE AUTHOR

D. Scott MacKenzie, Ph.D., FASM, is senior research scientist-metallurgy at Quaker Houghton Inc. For more information, go to <https://home.quakerhoughton.com/>

QUALITY COUNTS //

JASON SCHULZE

METALLURGICAL ENGINEER /// CONRAD KACSIK



It is important for suppliers to perform a complete specification accountability review of the revisions to capture each requirement and plan for implementation.

AMS2750F contains key pyrometric changes

By now, most heat treaters should have had some time to read the new revision of AMS2750. The changes are extensive and, since it is considered a complete rewrite, there are no change bars to indicate specific changes.

In this article, I will explore some of the changes within AMS2750F. I will not be covering each and every change within the specification but will be focusing more on the major technical changes overall. For the most part, this article will be more of a technical listing and less like my usual articles, which may discuss how a particular subject affects thermal processing.

GENERAL CHANGES

AMS2750F has a total of 25 tables, an increase from the previous 11. The tables are, for the most part, placed adjacent to the subject matter to which they pertain. Certain changes to tables have been made, such as maximum permitted offsets are now in the tables associated with the TUSs and not the tables associated with SATs, as it previously was in AMS2750E. Numeric values are now expressed to the 10th of a degree as, in revision E, the resolution was to a whole number. It would be logical for heat treaters to begin expressing numeric resolution to the 10th of a degree as well if it is not already being done. Additionally, quite a few changes within AMS2750F are merely an integration of the Nadcap pyrometry reference guide requirements. This means that, for those suppliers who are Nadcap accredited, the institution of those specific changes should not have that great of an effect on their processing as they would have already been familiar with the requirements and hopefully already had it implemented as applicable.

SCOPE AND DEFINITIONS

Previously, AMS2750E had 79 total definitions. This has been increased to 87 total definitions. Definitions can play a key role not just in understanding AMS2750, but interpreting the requirements as they are being implemented and audited. It is important to understand the definitions as they apply to your operation. A good example of this is the definition change of expendable to nonexpendable thermocouples. I will get more into that subject as I progress.

One definition I would like to point out is paragraph 2.2.25 and its associated table on page five. The placement of this definition and table will help both heat treaters and auditors understand the frequency of testing in detail when examining due dates of testing. Previously, this had the potential to be interpreted in several different ways, whereas now it cannot be. This is one of the many positive changes within AMS2750F.

THERMOCOUPLES

Resistance temperature detectors (RTDs) are now addressed within AMS2750F. There are now specific limitations regarding permitted error and composition. While it does not seem RTDs are used as

Sensor thermal protection material	Sensor definition
Fiberglass or plastic	Expendable
Several individual ceramic beads	Expendable
Metal over-braid	Expendable
Shielded from process atmosphere by a tube	Nonexpendable
Metal sheathed	Nonexpendable

Table 1: Expendable vs Nonexpendable

Conrad Kacsik Instrument Systems, Inc.
Phone: 1-800-666-1165
Calibration
WO#: _____ Date Tested: _____
ID#: _____ Date Due: _____
Tech.: _____ "Applicable Limitations - See Cert"

Figure 1: Calibration sticker.

often as thermocouples, it is important for those who use RTDs to ensure their existing thermocouples conform to AMS2750F and that procedures address the new requirements.

A change that seems to have gotten attention is the elimination of standard limits for base metal thermocouples. Previously, TUS and load thermocouples (and furnace thermocouples for CL3 – CL6) had a maximum permitted error of $\pm 4.0^{\circ}\text{F}$ or 0.75 percent, whichever was greater, while SAT and furnace thermocouples (CL1 & CL2) had a maximum permitted error of $\pm 2.0^{\circ}\text{F}$ or ± 0.75 percent, whichever is greater. Standard limit thermocouples were defined as $\pm 4.0^{\circ}\text{F}$ or 0.75 percent, and special limit thermocouples were (and still are) defined as ± 2.0 or ± 0.4 percent, whichever is greater. Previously, quite a few suppliers would only order special limit wire, as having both standard and special limit wire in a production facility posed the risk of some thermocouples that met only standard limit error to be used for, say, an SAT test that requires special limit wire. For this reason, I cannot see this change posing too great a burden on the industry. In fact, it seems to make sense, considering the procurement of thermocouples in the last six years.

The next major change is the definition of expendable and non-expendable thermocouples. Previously, the definitions were as follows (simplified, of course): Expendable thermocouples are those that are covered in plastic or fabric insulation and nonexpendable were all others. This is not the case any longer (see Table 1 above). Now, an expendable thermocouple is one where any portion of the thermal element is exposed to the thermal process environment. Anything other than that is considered a nonexpendable. To get this

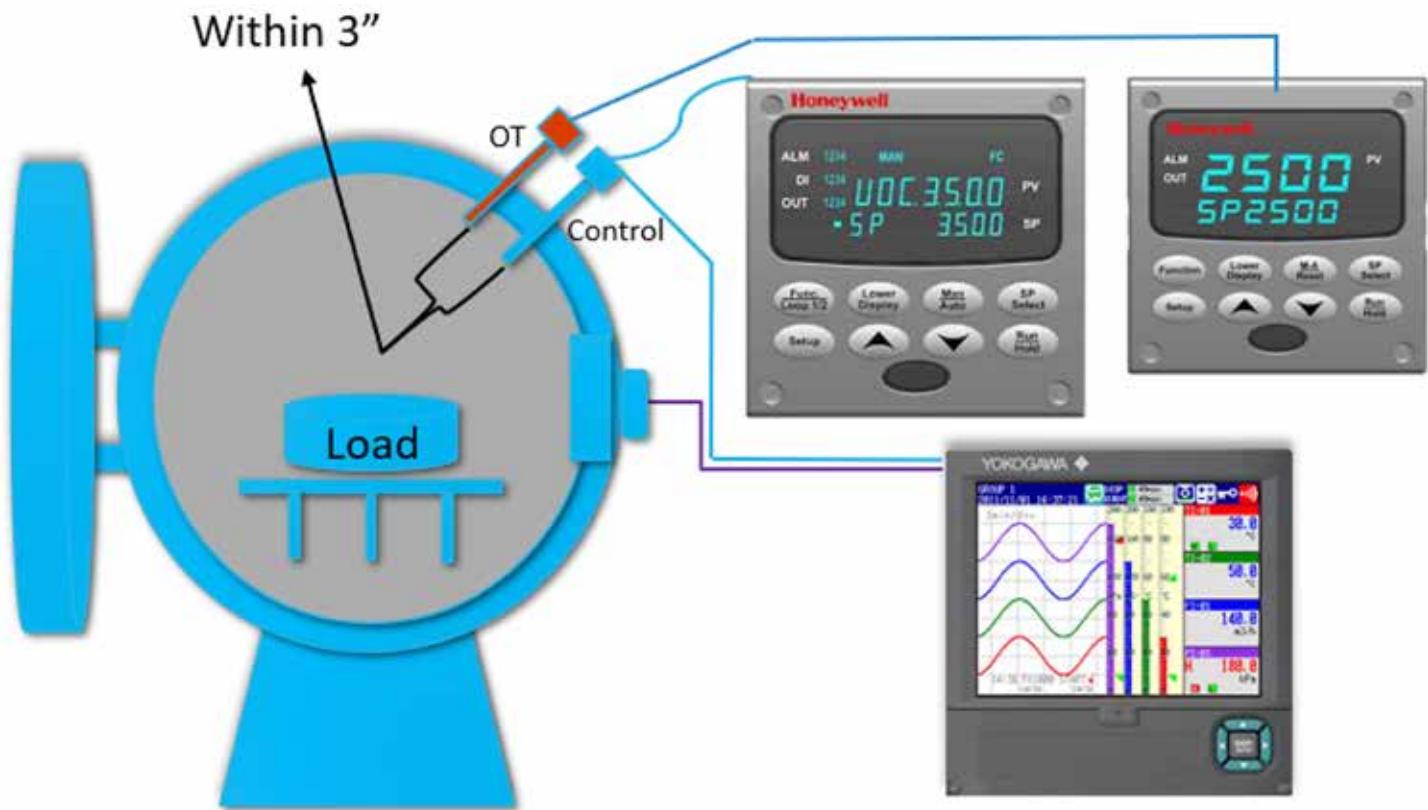


Figure 2: Type D+ instrumentation type.

new change into a more practical view, Table 3 has been inserted into AMS2750F. This table should be considered when suppliers begin to question whether the thermocouples currently in service apply to the new definition.

A change made that was based on Nadcap requirements is the inclusion of multiple methods to find a correction factor not stated on a thermocouple or test instrument certification. With AMS2750F, processors are now permitted to use either linear interpolation or selection of a correction factor based on the nearest test point. The key to this is potentially threefold:

- › Identify which method you choose to implement.
- › If not using the linear interpolation method, identify what you will do when the temperature being used falls directly in the middle of two test points.
- › Document which method will be used and use it consistently on both thermocouple certifications as well as test instrument certifications.

Additional items have been added to what is required to be on the thermocouple calibration report. These new items are extensive, and I will not be going into each one. For the most part, thermocouple suppliers already had these items on the certifications. The one item less likely to be on thermocouple certifications claiming conformance to AMS2750E is a statement of initial calibration or recalibration. As stated, the majority of the new items required on thermocouple certifications were already on most industry certifications, with the exception of initial or recalibration. Regardless, I recommend each supplier verify that, within their internal procedures (including any applicable receiving/quality review checklists), that each new requirement within AMS2750F, paragraph 3.1.11.1 is incorporated into applicable procedures. To shorten the labor, let's just state that paragraph 3.1.11.1 -A, B, D, E, F, G, (portions of J & K, L M, O, and P are new to AMS2750. The portions of J and K do not necessarily add up to anything new. They were already part of the pyrometry reference guide for AMS2750E, so those suppli-

ers who were Nadcap accredited before the release of AMS2750F should (ideally) already be in compliance.

INSTRUMENTATION

The changes within the instrumentation section of AMS2750F may have a bit more of an impact than those within the thermocouple section. For example, the removal of "monitoring" instruments seems more benign than the requirement that all recording instruments must be digital and have a readability of 0.1°F after June 2022. Test instruments must also have minimum readability of 0.1°F. Not all test instruments have the ability to accomplish this. Consider a test instrument that, when reading less than 1,000°F, some test instruments may have a readability of 0.1°F. Once that particular instrument receives a reading of 1,000°F or greater, the digit within the 10ths place may disappear. Suppliers should look for this.

Another major change within the instrument section is the calibration of clocks and timers within digital recording systems. We should all agree that this is a long time coming. Timing within heat treating, especially for more sensitive materials such as nonferrous metals, is critical. With this, there is also a new requirement that stopwatches must be calibrated every two years and be accurate within ±1-minute p/hr. It should go without saying that you cannot calibrate a furnace recording timer system with a stopwatch that is not calibrated. There are provisions within the recording timing system calibration requirements stating that if a supplier has a synchronized system linked to NIST via internet system that is verified monthly, and that will support the ±1-minute p/hr requirement, this will suffice. Of course, this will be up to the supplier to interpret, establish, and prove.

Instrument calibration sticker requirements have small changes, one being that the furnace or instrument number must be identified on the sticker (Figure 1). The other is that identification of limitations may be spelled out on the instrument calibration certification. This is not a new allowance; it was previously in the pyrometry reference guide.



The instrument calibration certificate contains quite a few new requirements. The more major changes are within paragraph 3.2.5.2.a, d and e. Portions of g, h, and i are new, although small additions have been made to those paragraphs. Nevertheless, it is important to read each paragraph in detail to ensure purchase orders and/or internal certifications contain the requirement information.

A new instrumentation type has been added – Instrumentation type D+. This new instrumentation type is simply Type D with the addition of a recording sensor that is within 3 inches of the control sensor and must be of a different sensor type (Figure 2). Those already familiar with AMS2750 will recognize that 3-inch requirement and relate it to an SAT thermocouple requirement. I have not seen too much feedback regarding suppliers identifying their equipment as Type D+ as there is no benefit to reduced testing frequency, although I am sure it will show up in the industry from time to time.

SYSTEM ACCURACY TESTING

The SAT section seems to have gotten the most attention so far. To start, paragraph 3.4.1.3 states that, if a sensor system has a single input into an electronic recording device that then splits that single input to multiple screens/menus, only a single view needs to be used for the SAT reading. This is a major step forward considering recording systems must be electronic two years after the publication of AMS2750F. Quite a few systems in the industry include PLCs, meaning, a single input can be routed to multiple menus within a system, so this new allowance is great for those suppliers.

A major change within both the SAT and TUS section is using recording instruments used for thermal processing as field test instruments as long as it can be demonstrated that the test channels of an integrated system are separated from the furnace recording

system, and meet the field-test instrument requirements. There is quite a bit packed into that statement. Let us, for a moment, focus on the word “separated”—a word that, in an auditing scenario, can be ambiguous. This wording is likely to be misinterpreted by suppliers and auditors alike. This allowance should be thought of as an at-your-own-risk convenience. It seems so much easier to just keep using a separate test instrument, although I am sure it will be attempted somewhere in the industry.

Previously, if you could not perform an SAT per the required frequency, a supplier could perform the SAT during the next production cycle (AMS2750E, paragraph 3.4.2.4). This is not the case any longer. If the frequency is not met, the SAT must be performed prior to the first production cycle (AMS2750F, paragraph 3.4.2.1). This is a new (albeit inconvenient) requirement I recommend all suppliers recognize.

For suppliers who process material in a furnace that has multiple qualified operating ranges, the SAT must be performed in each qualified operating range at least annually. As an example, if a furnace operates between 1,000.0°F to 1,600.0°F as a CL-2 ($\pm 10.0^{\circ}\text{F}$) and 1,601.0°F to 2,000.0°F as a CL-5 ($\pm 25.0^{\circ}\text{F}$), a SAT would have to be performed in each range at least annually. This change is logical and not very surprising that it has finally come to exist.

The section on Alternate SATs has changed significantly, although most of it was pulled from the pyrometry reference guide. One item to pay attention to is paragraph 3.4.8.2.3. If this is implemented in such a way, it may require the allowance of instrument offsets, which will also require offsets of that type (and any others permitted) are addressed within internal procedures.

The SAT report has a few new items. Portions of AMS2750F, paragraph 3.4.11.1.b and f have changed, as well as new requirements such as paragraph 3.4.11.1k, i and p. Nothing that should confuse

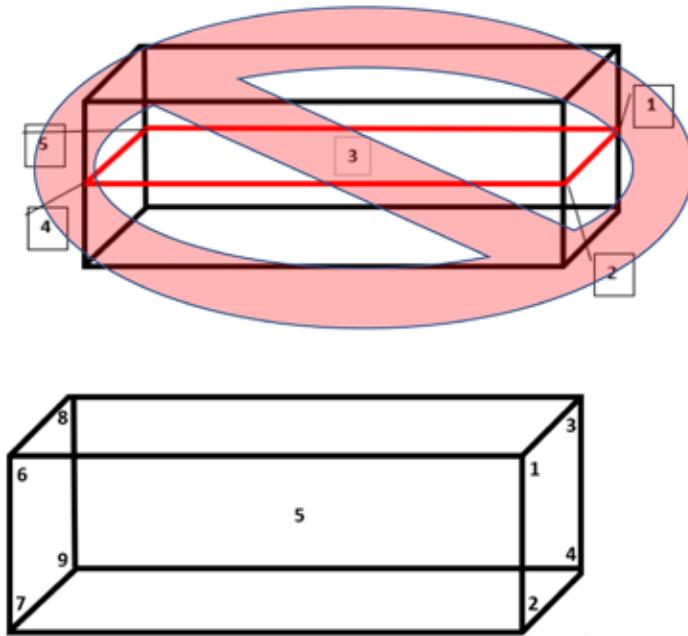


Figure 3: Select locations 1,4,5,7, and 8 or locations 2,3,5,6, and 9. Location 5 will always be the center.

suppliers; just pay attention to the portion about correction and modification offsets being identified. Even if neither is permitted per internal procedures, it is still better to identify a zero offset of any kind to an auditor instead of leaving it open to interpretation.

Paragraph 3.4.11.2 is new. It speaks to the required items on an Alternate SAT report. Most of the items seem logical and are straightforward. The challenge comes when a supplier wishes to take advantage of paragraph 3.4.8.2.3: limiting the error of the instrument calibration and/or sensors being used. If this is the method chosen, one of the two variables within the Alternate SAT has been procedurally eliminated. That being said, there would be no certification to go along with the Alternate SAT in this case, practically speaking. It would almost be a memo, less a certification/documentation. Nevertheless, AMS2750F requires “documentation” in any case, so we all need to follow the instructions/requirements given.

TEMPERATURE UNIFORMITY SURVEY

Temperature uniformity surveys, in my opinion, have the most significant impact on metallurgy (ask your current pyrometry service provider/auditor why and how). From nonferrous materials to brazing, TUS results can have a major impact on the metallurgical properties of materials. There are several changes within this section that, in all honesty, have no impact on the metallurgical materials. The changes are more clerical, and less engineering-related. For example, the verbiage within Tables 18 and 19 does not permit the initial TUS to be counted as part of the consecutive TUS's needed to go to extended frequency. This is not spelled out word-for-word within the specification but is apparent within the wording on Tables 18 and 19 and would have no practical impact on metallurgical aspects of materials.

Two changes I would say are more on the engineering end would be both paragraph 3.5.8.6 and paragraph 3.5.9.1, Table 21. Paragraph 3.5.8.6 requires that furnaces that operate at partial pressure must be surveyed at any temperature within the qualified operating range at the partial pressure used during production. One could argue that this should be treated as a radiation TUS; if nothing changes in the partial pressure system, why survey at partial pressure annually? Regardless, it is now a requirement and must be followed.

Paragraph 3.5.9.1, as it relates to furnace qualified work zones $\leq 3\text{ft}^3$, the thermocouple placement for TUS TCs has changed (Figure 3). The previous method was to place them on a single plane. This information, unfortunately, could only be gotten by attending certain training sessions and was not in the pyrometry reference guide. Fortunately, this has changed and the locations for TUS TCs in work zone volumes less than $\leq 3\text{ft}^3$ has changed and must be placed per Table 21. This is an important and significant change that should be recognized by suppliers having qualified work zone volumes $\leq 3\text{ft}^3$.

Previously, TUS data must have been collected before the first furnace or test thermocouple reached the lower end of the uniformity tolerance. Now, AMS2750F requires data collection of all furnace and test sensors to begin before the first furnace or test thermocouple is within 100°F of the setpoint temperature.

The next important change is the TUS documentation requirements. To keep it simple, the changes are within AMS2750F, paragraph 3.5.16.1.b, d, f, g, h, i, (portions of) l, o, r, s, and y. I hope this enables suppliers to nail down exactly what has changed with the TUS documentation requirements.

ROUNDING

When AMS2750E was released with the new requirement that suppliers had to round significant digits in accordance with ASTM E29, suddenly suppliers needed to understand a method that may not have been previously used. While AMS2750F still permits rounding, it states that it is now to the absolute method within E29 if E29 is chosen. The new revision also now permits suppliers to use the rounding method built into commercial spreadsheet programs. The key here is for suppliers to procedurally establish which option they choose and do it that way each time for all testing.

QUALITY REQUIREMENTS

The only item inserted in this section is that, for suppliers who use external pyrometry service providers, that those providers must be 17025 accredited in the discipline they are servicing. I can understand the logic behind this. If a service provider is 17025 accredited, they will have procedures that will be audited by a third party and, with that, the service providers' procedures will not need to be reviewed by the supplier (AMS2750F, paragraph 4.8.1).

SUMMARY

While this article does not list every administrative and technical change within AMS2750F, I have attempted to compile the changes that I think may have significant impact on suppliers. It is important for suppliers to perform a complete specification accountability review of AMS2750F to capture each requirement and find the best and most practical way to implement those requirements. Additionally, recognize that not all primes (i.e. GEAE, Rolls Royce, Honeywell, etc.) will accept the requirements within AMS2750F and may outline more stringent requirements. As always, I recommend repeat training sessions to ensure all requirements are realized and implemented correctly. ♫



ABOUT THE AUTHOR

Jason Schulze is the director of technical services at Conrad Kacsik Instrument Systems, Inc. As a metallurgical engineer with 20-plus years in aerospace, he assists potential and existing Nadcap suppliers in conformance as well as metallurgical consulting. He is a voting member with two AMEC Committees, including the one that governs AMS2750. He is contracted by eQualearn to teach multiple PRI courses, including pyrometry, RCCA, and Checklists Review for heat treat. Contact him at jschulze@kacsik.com.

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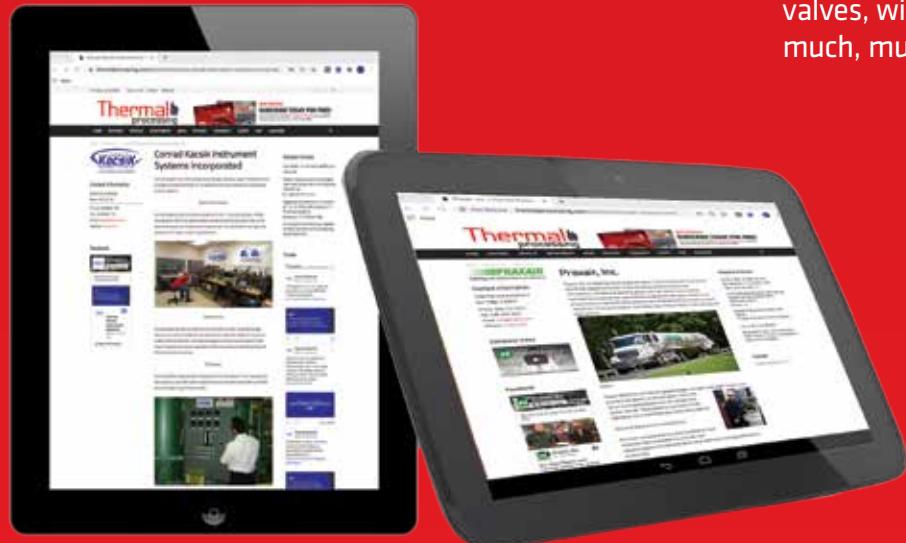
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AEROSPACE APPLICATIONS / CERTIFICATIONS

LOW PRESSURE CARBURIZATION MODELING WITH CARBIDE FORMATION AND DISSOCIATION

With the advent of high-strength steels for the aerospace industry, most of which contain substantial amounts of strong carbide-forming elements such as chromium, molybdenum, and vanadium, the LPC process can be extremely challenging to control.

By JUSTIN SIMS

Low pressure carburization (LPC) processes are becoming more widespread throughout industry due to the reduced cycle times and the control over the carbon profile through the case of the carburized component. Unlike gas carburization, which uses a constant carbon potential to maintain the available carbon on the part surface at a specific value, LPC uses boost and diffuse steps. A boost step involves the temporary addition to the furnace of a carbon-carrying gas, usually acetylene, to increase the surface carbon to the saturation limit of austenite. If not properly controlled, the carbon available for diffusion can well exceed the saturation limit, creating unfavorable carburizing conditions.

After a requisite amount of time has passed — generally one to several minutes — the carbon-carrying gas is evacuated from the chamber. The carbon that was deposited on the surface during the boost step is then allowed to diffuse into the part, reducing the surface carbon. These two steps are then repeated until the required case depth and carbon profile are achieved.

AEROSPACE CHALLENGES

For steel alloys that do not contain a significant amount of strong carbide forming elements, this process can be relatively easy to control. However, with the advent of high-strength steels for the aerospace industry, most of which contain substantial amounts of strong carbide-forming elements such as chromium, molybdenum, and vanadium, the LPC process can be extremely challenging to control. These elements bond with the carbon deposited on the surface to form primary carbides, which, if not properly dissolved, can damage fatigue performance. Long boost times, as well as very short diffuse times, can lead to the thermodynamic stabilization of these primary carbides.

While Fick's Second Law describes the diffusion of carbon through a low-alloy steel with reasonable accuracy, the same is not true of medium- and high-alloy steels. This is due to the presence of primary carbides forming and dissolving during the LPC process. When the boost step is occurring, the primary carbides take carbon away from the austenite solution, allowing more carbon to enter the solid solution from the surface. During the diffuse step, as the carbon that is in solid solution diffuses into the part effectively reducing the carbon in austenite, the primary carbides can dissolve to provide more carbon to the solid-state solution. If the primary carbides are not allowed to fully dissolve or shrink to a significantly small amount before the next boost begins, they will continue to grow.

PRIMARY CARBIDE FORMATION AND DISSOLUTION

In order to properly predict the carbon profile of medium- and high-alloy steels, the primary carbide formation and dissolution must be considered. The heat-treatment simulation software DANTE has this

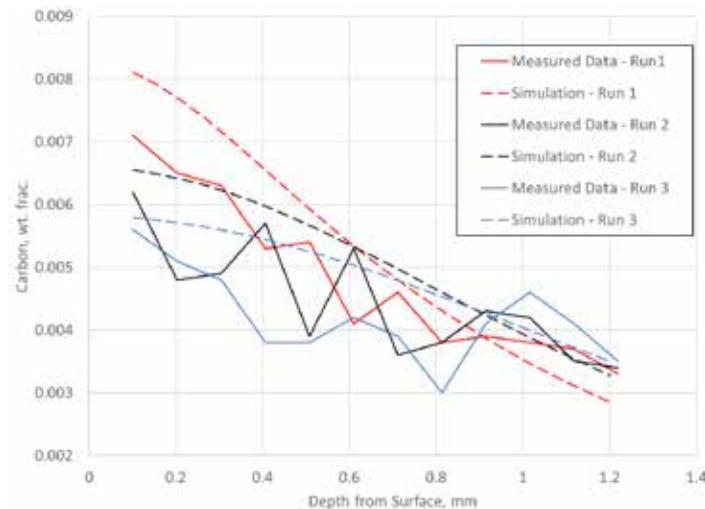


Figure 1: Experimental vs. prediction for Ferrium C64.

capability and was used to fit the diffusivity and primary carbide kinetics of Ferrium C64 steel alloy from LPC experiments.

LPC experiments were conducted whereby 4-inch diameter cylinders made of Ferrium C64 were subjected to three different LPC cycles with the only difference in the cycles being the final diffuse time. Each run used a progressively longer final diffuse time. Carbon measurements were made using a LECO burn. Unfortunately, this method of carbon analysis gives no indication as to the amount of carbon in solid solution and the amount of carbon in primary carbide form.

Regardless, the data was fit to diffusivity and primary carbide formation/dissolution kinetics parameters used in the DANTE carburization model and compared to the experimental data. The results are shown in Figure 1. As can be seen, the match between prediction and experiment is reasonable, with a significant amount of scatter in the experimental data. With the ability to predict carbon diffusion and carbide formation/dissociation, the DANTE model can now be used to predict and design LPC schedules for Ferrium C64 steel.

CASE STUDY

The following is a case study for the redesign of an LPC schedule for a ring gear using the DANTE heat-treatment simulation software. The original LPC schedule, consisting of six boost-diffuse steps, was producing too many primary carbides during the process, and, as a consequence, rolling contact fatigue performance was very poor. Since the carbon potential should act uniformly around the circumference of the gear and each tooth should behave the same with respect to carbon diffusion, only a single tooth was modeled.

Figure 2 shows the full CAD model of the gear (left), the single

tooth meshed model (center), and a closeup of the gear tip corner mesh (right). An extremely fine surface layer of elements is required to capture the steep chemical gradient that exists near the surface during an LPC process. Only the cross-section is shown, though the gear does have a height. The gear has a 5.5-inch outer diameter, a 4.5-inch inner diameter, a 0.60-inch height, and 40 teeth. The gear is made of Ferrium C64 with a base carbon of 0.1%. The model contains 233,850 hexagonal linear elements and 245,055 nodes.

The case depth was originally designed for 0.75 mm on the flank of the tooth, with a carbon value of 0.3% resulting in a hardness value of 50 HRC for Ferrium C64 when tempered at 495°C. Figure 3 shows a plot of the carbon in the austenite matrix (carbon) and the carbon in primary carbide form (carbon in carbide) from the surface of the flank toward the core. As can be seen, a great deal of carbon is tied up in primary carbide form — approximately 0.75%. These primary carbides, if not dissolved either during a reheating process to form austenite or at the end of the carburization cycle, can be extremely detrimental to fatigue performance. Figure 3 also shows that the case is deeper than it needs to be, at 1.1mm.

An added benefit of using simulation software like DANTE to design LPC schedules is the ability to witness the effect of each individual boost-diffuse step. It is therefore possible to know when to reduce the boost time to avoid large primary carbide formation and how long to diffuse to ensure the primary carbides are dissolved to a sufficiently small size. Most medium- and high-alloy steels will form primary carbides during the boost step, regardless of the time. So, it is important to allow enough carbon to enter the part before beginning the diffuse step.

Controlling the length of the diffuse step then becomes critical in ensuring the primary carbides have properly dissolved before beginning the next boost step. Figure 4 shows the predicted carbon in the austenite matrix (carbon) and the carbon in primary carbide form (carbon in carbides) at the surface of the flank for the baseline model over the total time of the process. As can be seen, the carbon in primary carbide form continues to increase as the process progresses. The long final diffuse begins to allow for decomposition, but the time is not long enough.

Figure 4 also indicates that the diffuse times are much too short, as the carbon in carbide does not dissociate back into the austenite matrix, but remains more than 1.0% for most of the process. The boost times seem reasonable, since the carbon in primary carbide form rises approximately 1.2%. This is reasonable for Ferrium C64, as the high level of chromium causes rapid formation of primary carbides. The important insight gained from Figure 4 is that the diffuse times are far too short to properly dissolve the primary carbides back into solid-state solution.

A NEW SCHEDULE

To ensure the primary carbides dissolve completely before hardening, a new schedule was developed with the aim of reducing the carbon in primary carbide form. To reach this goal, three boost-diffuse steps were removed, and the diffuse times increased substantially. This increase in diffuse time added approximately one-half hour to the schedule, which is acceptable given the positive results. Figure 5 shows the predicted carbon in the austenite matrix (carbon) and the carbon in primary carbide form (carbon in carbide) for the total process time at the same surface location on the flank as Figure 4 for the baseline LPC schedule.

As can be seen in Figure 5, the primary carbides now have time to dissolve during each diffuse step and are nearly eliminated by the final diffuse step. It is also interesting to note that the carbon in primary carbide form rises to 1.3% during each boost step before

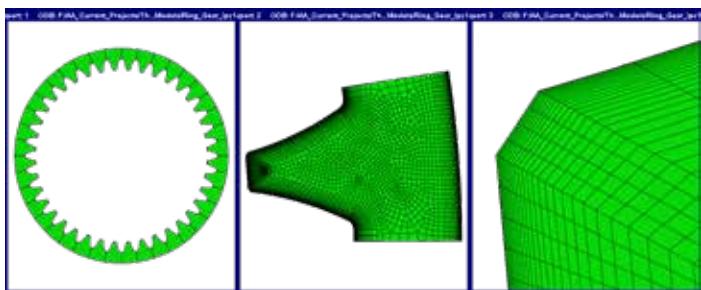


Figure 2: CAD model (left), single tooth meshed model (center), and close-up of tooth tip edge fine mesh (right).

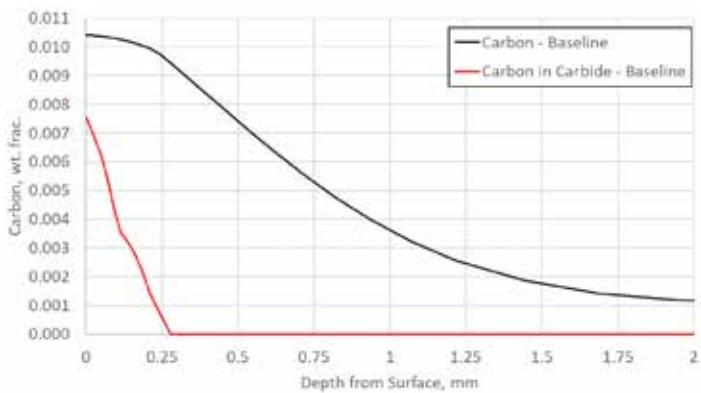


Figure 3: Carbon in the austenite matrix and carbon in primary carbide form for the baseline process from the surface of the flank.

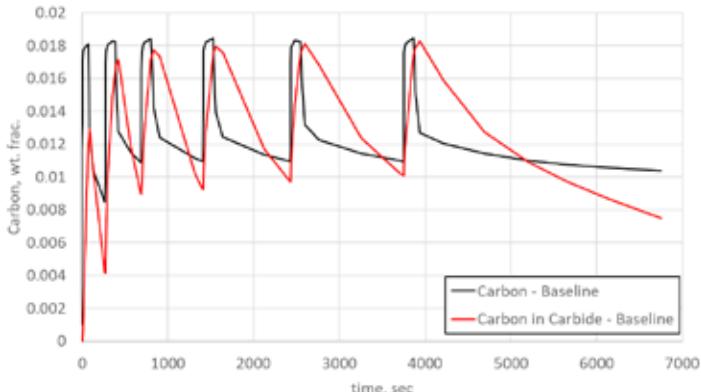


Figure 4: Carbon in the austenite matrix and carbon in primary carbide form for the baseline process on the surface of the flank for the total process time.

dissolving to a minor fraction of a percent. Comparing to Figure 4, this matches the first two boost steps, but the baseline carbon in primary carbide form contained 1.8% carbon in later boost steps. So, the redesign had a significant effect on primary carbide formation.

The baseline model also showed the surface carbon near 1.0%, which is much higher than what is needed to reach a hardness of 60 HRC. For Ferrium C64, a surface carbon of 0.55% is sufficient to reach a surface hardness of 60 HRC after tempering at 495°C. Therefore, the surface carbon was also reduced in the redesigned schedule. Figure 6 shows the carbon in the austenite matrix (carbon) and the carbon in primary carbide form (carbide) from the surface of the flank toward the core for the redesigned schedule. By reducing the surface carbon, this material was able to meet the required hardness, case depth, and avoid significant primary carbide formation during the LPC process. The carbon in primary carbide form on the surface can now be easily removed with a light finishing operation, whereas a significant amount of grinding would have been required to remove the primary carbide layer from the baseline process.

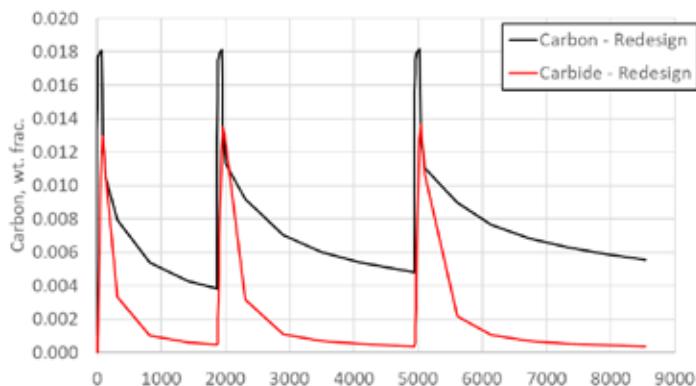


Figure 5: Carbon in the austenite matrix and carbon in primary carbide form for the redesigned process on the surface of the flank for the total process time.

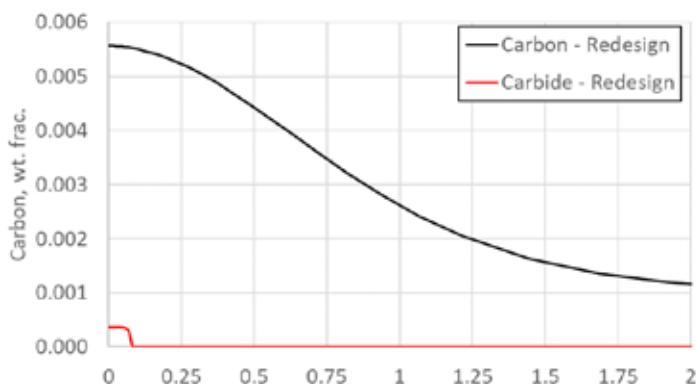


Figure 6: Carbon in the austenite matrix and carbon in primary carbide form for the redesigned process from the surface of the flank.

CONCLUSION

It has been shown that it is possible to model a low-pressure carburization process, including the formation and dissociation of primary carbides using the DANTE heat-treatment simulation software. The primary carbide kinetics can be determined through fitting experimental data to model parameters that include diffusivity of carbon in austenite and the formation and dissociation of primary carbides.

In this case, LPC experiments were conducted on Ferrium C64 cylinders, and parameters inside the DANTE carburization model were fit from the experimental data. The model was then used to redesign an LPC schedule for a gear component. It was shown, through modeling, that the original schedule was producing too many primary carbides and also had a surface carbon that was too high. A schedule was then successfully redesigned using DANTE in which the surface carbon was reduced to 0.55% and the primary carbides reduced to a small amount in a shallow surface layer. The same procedure of conducting LPC experiments and fitting the data to a model that includes carbon diffusivity through austenite and the formation/dissociation of primary carbides can be applied to any medium- or high-alloy steel. ♦

ABOUT THE AUTHOR

Justin Sims is a mechanical engineer with Dante Solutions, where he is an analyst of steel heat-treat processes and an expert modeler of quench hardening processes using Dante software. Project work includes development and execution of carburization and quench hardening simulations of steel components and analysis of heat-treat racks and fixtures. He has a mechanical engineering degree from Cleveland State University.

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CASE STUDY

INSIGHTS ON A NADCAP ACCREDITATION

Roy Adkins, corporate director of quality at Braddock Metallurgical and Nadcap Supplier Support Committee (SSC) Task Group representative for heat treating, describes his perspective and experience of Nadcap audits.

How did you first hear about Nadcap, and why did your company decide to pursue Nadcap accreditation in the first place?

Braddock Metallurgical was partnered with many aerospace suppliers. As Nadcap accreditation became more widespread, we were approached by our customers in 2004 to participate in the program and attain a Nadcap heat-treat accreditation. Braddock has always had a strong commitment to quality and to customer service. Participation in the Nadcap program has enhanced our robust quality system and continues our commitment to the partnerships with our customers.

How easy is it to find the information you need to help you prepare for a Nadcap audit?

Navigating www.eAuditNet.com can sometimes be challenging, but, once you get the hang of it, you will see that all the information you need is at your fingertips. I would highly recommend any auditee who wishes to get more familiar with eAuditNet, and how to use it, to attend the “eAuditNet Tutorial for Suppliers” session given at each Nadcap meeting. This session, along with other helpful ones such as “Keys to a Successful Audit,” is sponsored by the Supplier Support Committee and is given the Monday of each Nadcap meeting.

You can also find these presentations on eAuditNet, under Resources/Documents/Public Documents/Supplier/SSC Meeting Presentations as shown.

How long before the actual audit do you start preparing, and what do you do to prepare for a Nadcap Audit?

There is no specific time block that can be set aside for audit preparation. It should be an ongoing process as our Nadcap facilities must maintain a constant state of preparedness.

At Braddock, this is led by the plant manager and plant quality manager, and Nadcap checklists are an integral part of our internal audit system. Checklists for Nadcap and AS9100 are scheduled for review on a monthly basis through our internal audit schedule system. Audits are performed by plant personnel who are directly involved with the processes related to the checklist. The continual internal audit schedule rotation and involvement of plant personnel is critical to help ensure compliance at all times. It is basically an ongoing self-audit system that can be used as part of the required documentation to be submitted 30 days prior to the actual Nadcap audit.

Contract review and job audits also play a large role in staying prepared. All heat-treat processes are scrutinized against industry specifications and customer requirements and then double-checked for adequate flow-down prior to being released to production.

How do you find the audit scheduling process?

While I believe that the scheduling staff does a great job, I think there is always room for improvement. As with anything, the scheduling process is not excluded from improvement. I am sure it is not as simple as it may seem, and I don't really have proper suggestions

as to what could be done to improve it.

However, I can tell you that I have had a couple of issues in the past where I needed to contact the staff, and they were very helpful. Even though we actively participate in Nadcap, we are always trying to schedule customer audits around the Nadcap audits, and this can sometimes be very difficult for all parties involved in the process. As an aerospace and commercial heat-treating company, not all of our business is for the aerospace industry. Commercial customers expect and deserve the same level of customer service as our aerospace customers do.

Do you have much interaction with the Performance Review Institute's (PRI) staff before the Nadcap audit and how is it?

There is not much interaction with the PRI staff, in general, unless there is an issue with either a scheduled date or an auditor-change request. My experience with PRI staff has always been positive. However, with allotted time frames given and the high demand for auditors, I am sure scheduling audits to meet everyone's expectations and to keep everyone happy can become difficult at times for the staff.

What are your expectations of the audit and how do they compare with what actually happens?

I think my expectations are about the same as everyone else's. I expect a fair and thorough audit. And most of the time that does seem to be the case. I have had some issues with a couple of auditors over the years, but I think that PRI does listen, and I know that they do deal with issues as they arise. Overall, I would say that I am satisfied with the process.

What has been your experience with auditors and their way of conducting the audit?

I think it's fair to say that the majority of the auditors I have encountered are fair and open-minded and have good communication skills. Some auditors are better at managing their time than others. Each auditor is different, but time management is one of the keys to a successful audit. I believe that a course on time management as part of the Auditor Conference would be beneficial in order to avoid lengthy days and late-night sessions, which are not conducive to a good audit experience.

What are your thoughts on the opening session?

The opening session is fairly standard and consistent among the auditors. The auditor works with the quality manager, general manager, production manager, and myself—corporate director of quality—to establish a general timeline, review historical jobs, and in-process jobs that need to be witnessed. We also discuss any potential issues concerning availability of jobs and necessary personnel.

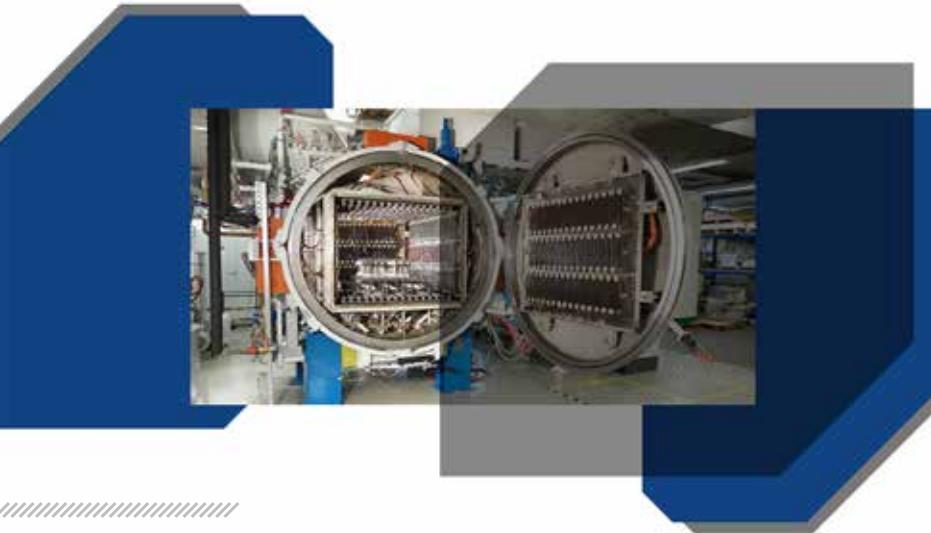
On the closing session?

The closing session, again, is fairly standard. It mainly consists of the

auditor having a meeting with the same team as during the opening session to ensure that we understand any/all findings as well as the eAuditNet non-conformances response submission process. I think a standard PowerPoint may be helpful for consistency of the material covered.

What did you find most challenging during the audit?

As mentioned earlier, I would say time management is the most challenging aspect. It is often difficult to ensure that there are enough in-process jobs available to complete the checklist requirements and to cover the ratio of historical jobs/in-process jobs within the time allowed.



Contract review and job audits also play a large role in staying prepared. All heat-treat processes are scrutinized against industry specifications and customer requirements and then double-checked for adequate flow-down prior to being released to production.

What could be done to improve the experience of going through a Nadcap audit as well as having an auditor on site?

This is a tough question, and I must be honest here: I really don't have a proper answer for this one. I do think that training must stress the importance of multitasking several checklists simultaneously by the auditor, which again can be linked back to time management. In addition, there should be a certain amount of flexibility when looking for objective evidence in order to satisfy task group requirements as we feel sometimes auditors are quite rigid.

What is the first thing you do once the Nadcap auditor leaves?

At Braddock Metallurgical, the first post-audit thing we do is to assemble the audit team, led by our quality manager, to discuss what we need to do in order to take care of any immediate actions related

to the findings to ensure compliance moving forward.

Once we review our action list, we set up sub-teams to perform root cause corrective action (RCCA) and assign responsibilities for actions to be taken. Assigning responsibilities is crucial to keep track of what is happening and ensure corrective actions are found and implemented within the right timeframe to get the Nadcap accreditation.

How does the outcome of the audit and your company performance compare to your expectations?

Although we usually do pretty well, the goal is always to receive zero findings for each audit that is conducted. In reality, however, there is always room for improvement. We have four Nadcap-accredited sites, and we apply lessons learned by each location across the board.

How do you go about responding to non-conformances (NCRs), if you have any?

We form a problem-solving team of people that have direct responsibility for the affected area(s)/ procedure(s) and are involved from a user standpoint. I do help facilitate the meeting, but the quality manager is ultimately responsible for closing all NCRs.

What tools do you find most useful in the RCCA process?

We tend to stick with the "5-Why Approach to Root Cause" method due to its simplicity and effectiveness. We use the final "Why" as our root cause and submit the objective evidence related to our action plan for closure of the related NCR.

I would also say, as a member of the Supplier Support Committee, I do work with many staff members on meeting-related issues, but I have never had any issues with any of the PRI staff members. In fact, I have always had a good working relation with both the staff engineers and the PRI support staff. I am aware of the importance and impact that this article may have on the Nadcap community, especially on SMEs who are new or who don't have much experience with the Nadcap program.

This is why I would like to share some advice to other Nadcap auditees as a conclusion:

➤ Audit preparation is key and must continue before and after the audit.

➤ Do not hesitate to contact a staff engineer if you have a question about a finding. They can be very helpful.

➤ Understand the process. The Supplier Support Committee and PRI support staff are there to help you. Let them, or even ask them. ☺

ABOUT THE COMPANY

Braddock Metallurgical was founded in 1953 by William R. Braddock in New Jersey. It now has U.S. sites in Bridgewater, New Jersey; Charlotte, North Carolina; Atlanta, Georgia; Jacksonville, Florida; Daytona Beach, Florida; Boynton Beach, Florida; Riverview, Florida; and Bayamon, Puerto Rico. Four of the seven Braddock Metallurgical locations are Nadcap-accredited in heat treating, with its Boynton Beach plant in Florida also holding Non-Destructive Testing Nadcap accreditation. The Riverview site was the company's first Nadcap accredited location, with both certificates granted in April 2005. Three Braddock Nadcap heat-treating accredited plants have attained Merit status. This article appears courtesy of the Performance Review Institute. For more information, go to p-r-i.org.

LEGENDARY PERFORMANCE

WHEN JACK BEAVERS DESIGNED THE BEAVERMATIC INTERNAL QUENCH FURNACE (IQF) ALMOST 60 YEARS AGO, HE CREATED THE SIGNATURE TECHNOLOGY IN AN INDUSTRY WORKHORSE THAT STILL SETS THE STANDARDS TODAY.

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Today Premier Furnace Specialists builds the BeaverMatic IQF incorporating modern process controls and materials, keeping the legend alive and reliable as ever. The legend doesn't end there, Premier Furnace Specialists offers a complete range of furnaces to suit any industrial heating process.



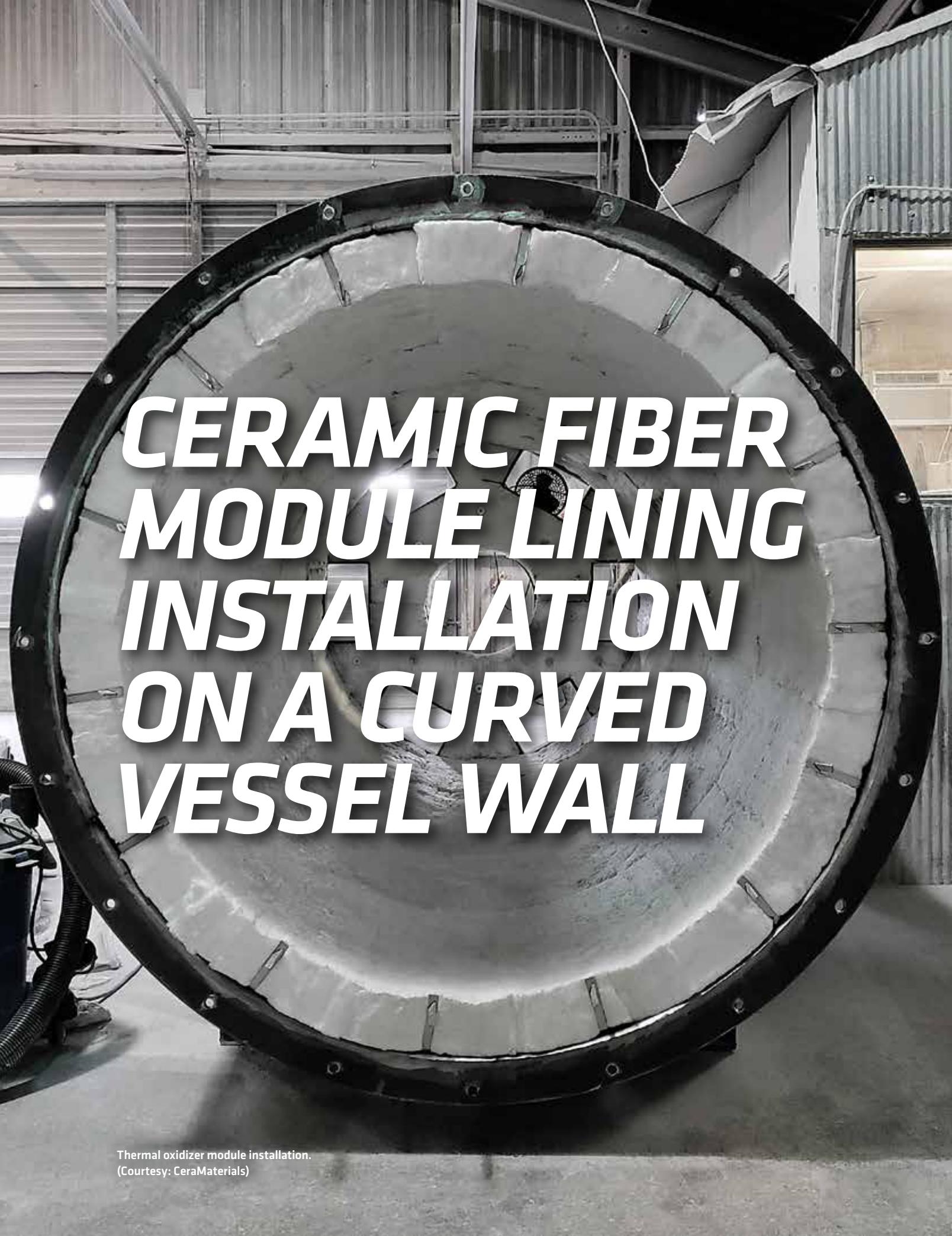
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Premier Furnace Specialists, Inc.





A black and white photograph showing a large, curved industrial vessel. The vessel's interior wall is being lined with a series of rectangular ceramic fiber modules. A worker wearing a hard hat and safety gear is visible inside the vessel, working on the installation. The vessel is situated in a workshop or factory setting with various equipment and structures in the background.

CERAMIC FIBER MODULE LINING INSTALLATION ON A CURVED VESSEL WALL

Thermal oxidizer module installation.
(Courtesy: CeraMaterials)

With their unique properties and versatility, ceramic fiber modules are often the go-to solution when it comes to insulating thermal oxidizer units.

By PHILIP KENT

C

eramic fiber modules have been implemented in thermal oxidizer units (TOU) and vessels for more than 50 years, and they have become ubiquitous as the only choice for insulation in TOUs.

A thermal oxidizer unit is a degasser unit that destroys volatile organic compounds (VOCs) through thermal combustion. The precise reaction yields the biproducts of water and carbon dioxide – two biproducts that are considered generally safe to be released into the environment. Essentially, it's a process that decomposes hazardous gases at high temperatures and releases heat. Therefore, it is also considered a HAP (hazardous air pollutants) reducer.

One example of a TOU CeraMaterials has worked on is an oxidizer at a plastics facility that collected solvents in the air and transported them through ductwork to its TOU, which then combusted and modified the solvent to an Earth-friendly fluid. The operating temperature of this particular unit was 1,400°F to 1,500°F.

THE VERSATILITY OF CERAMIC FIBER MODULES

Ceramic fiber modules are typically refractory blocks of ceramic fiber blanket that are banded together to form a thick piece of insulative material. Modules can generally range from very small handheld 6" x 6" x 4" modules with simple hardware all the way to 12' x 10' x 2' extremely large modules that need a crane to be installed on-site. Their density will range from 6 lb/ft³ (96kg/m³) to 15 lb/ft³ (240 kg/m³). Modules typically have a temperature range of 2,300°F (max rated for a blend of aluminosilicate fiber) to 3,000°F (mullite polycrystalline phase structure, or a 97 percent Al₂O₃ composition).

Because they can be extremely diverse in their applications, ceramic fiber modules are often the main choice when it comes to high-temperature insulation.

This is due to the nature of the ceramic fiber being easy to install, having the appropriate performance to reduce the internal temperature to something worker friendly and energy efficient on the cold-shell casing, and the fact that ceramic fiber blanket/modules can be obtained at a low cost compared to the rest of CeraMaterials' catalog of materials.

In addition, the ceramic fiber blanket, attached with stainless steel pins and washers, has diminishing returns as the thickness of the refractory lining increases.

WHERE DO THE MODULES GO?

Typically, you will see ceramic fiber modules in large diameter sections of the TOU and ceramic fiber blanket in the smaller, tighter sections. It is much easier to pin ceramic fiber blanket onto a wall casing with a stainless-steel pin and a washer than it is to install a large, bulky module when you have a 24-inch diameter exhaust pipe.

The parts of the unit that are greater than 48 inches are typically the hotter zones, and thus require four to eight inches of the module's thickness to achieve the required cold-shell temperature requested by the customer. Also, modules are more sought out than



Internal view of a module-lined thermal oxidizer. (Courtesy: CeraMaterials)



Thermal oxidizer unit assembly. (Courtesy: CeraMaterials)

the blanket due to the fact that anything thicker than two inches of ceramic fiber blanket – attached with stainless steel pins and washers – is extremely labor intensive as you increase the thickness of the refractory lining.

Lastly, modules are faster to install if they are welded on with a pyro gun compared to using blanket, pins, and washers. Most TOUs use 2,300°F fiber, and rarely will you see a requirement for 2,600°F ceramic fiber. It is very likely that a TOU will never need the expensive 3,000°F polycrystalline flavor; 8 lb/ft³ density is usually sufficient and specified; 10.6 lb/ft³ is prevalent for companies that have it specified into their plans historically. Folded modules vs. edge grain, along with cardboard slip planes, are based on customer

preference and provide little (or no) technical advantage to the overall efficiency of the TOU process.

INSTALLING THE MODULES

If your management (or engineers) has decided to install ceramic fiber modules and convert over from blanket and pins, there are specific guidelines one should consider before embarking on this journey. It is suggested that you only install modules with easy weld stud guns for concave walls. Spears, L brackets, and/or pre-welded studs are much too time consuming for curved surfaces and require extensive planning.

The specifications of the weld must include:

› **1.** A test piece of metal will be essential. It should be the same material as the TOU or vessel, preferably 12-gauge steel. This will be used for target practice to get the gun up and running to where your coworkers are comfortable. It's important that the gun operator gets in some practice before proceeding with the actual weld since multiple actions are happening within a short, arc burst. A piece of test metal should be as large as possible – 24" x 24", for example.

› **2.** It is essential that the chosen welder have a minimum of 300 amps with a DC voltage of 75 to 125. The welder also needs a "ground" cable.

› **3.** Since welding guns can be equipped with either a 110- and/or 220-volt capacity, make sure an outlet is available that can handle either.

› **4.** Don't forget to have proper welding and safety equipment available for anyone in the vicinity who might be working with the gun. Once the first test weld (on the test metal) is successfully completed, then the actual installation can proceed.

HELPFUL HINTS

› Make sure you don't paint yourself into a corner. Install the innermost modules first, so you aren't stepping over the floor modules later.

› Have a sawzall on-site to trim modules around tight corners.

› Prepare for welding misfires. Order approximately 10 percent extra hardware.

› Apply a rigidizer or ITC coating (after all modules are installed) for superior performance, lifetime, and safety. ♦

ABOUT THE AUTHOR

Philip Kent is the materials science engineer at CeraMaterials. He graduated from Rutgers University-New Brunswick and is responsible for all technical requirements relating to customer compliance, acquisition, and maintenance. He has 13 years of experience working on government, academia, public, and private sector projects that require problem solving techniques and technical support, specifically in a hub and spoke system dealing with insulation and refractories.

Ceramic fiber modules from CeraMaterials. (Courtesy: CeraMaterials)



AFC-Holcroft furnaces with integral salt quench systems:

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A large industrial forging press is shown in operation. A massive, glowing red-hot metal billet is being forged by the press's powerful hydraulic cylinder. Sparks and bright orange flames erupt from the impact zone, illuminating the dark, metallic interior of the press. The press itself is a complex assembly of steel beams, hydraulic hoses, and mechanical components.

BRINGING FORGING EQUIPMENT ONLINE

**TO MEET EXPANDING
PRODUCTION REQUIREMENTS**

Forgers weigh options such as repair, rebuild, remanufacture, or new equipment when considering options to increase capacity.

By DEL WILLIAMS

When forging operations need to expand production to meet increased demand for existing parts or to add new product lines, selecting from the available options to bring new equipment online can be challenging. Ultimately, the decision involves striking a delicate balance between fitting within budget constraints and accepting what can often be very long lead times.

Forging machines, by design, are massive pieces of equipment that weigh between 25 and 300 tons and rise 10 to 25 feet above the production floor. Despite the violent nature of the forging process, the equipment is designed and built to last decades, and it is not uncommon to find equipment from 50 or more years ago still in use.

Unfortunately, this can be both a blessing and a curse when it comes to purchasing new equipment. The sheer size and complexity of the machine means that even items such as the massive cast steel frame can take six to eight months for delivery – not including the four to six months to install all the internal parts and components.

Given the longevity of the equipment, the other option is to purchase used forging equipment and have it rebuilt or remanufactured. This can speed delivery by as much as six months and reduces the impact on the budget, but the dwindling worldwide supply of used equipment is increasingly taking this option off the table.

The only other alternative is to simply repair out-of-commission units and/or to squeeze additional production by incorporating more automation in existing forging equipment.

Regardless of the choice, one thing is clear: Those in the industry are taking a closer look at each of the four options available – repair, rebuild, remanufacture, or new – as well as each option's advantages and challenges.

REPAIR

The most immediate option to bring forging equipment online is simply to repair existing equipment or out-of-commission units. This often comes down to locating adequate replacement parts, which can be quite difficult.

The tremendous longevity of horizontal and vertical forging equipment can create unique challenges for a forging operation when a part they need to replace was built decades ago. Is the original equipment manufacturer (OEM) still in business? Does a drawing of the part still exist? Can a local machine shop replicate it?

"Sourcing spare parts can be an ongoing problem," says Wade Ferguson, maintenance manager at Modern Forge Companies, LLC, a hot steel forging company in Blue Island, Illinois that operates five manufacturing facilities with more than 25 production forge units. "We probably run hammers tighter than what would ever be specified. And together with our high volume of forging, at times we are scrambling to make or find spare parts."



Sometimes only the cast steel frame of the forging equipment is salvageable, in which case all the internal components can be replaced in a full remanufacture of the equipment. (Courtesy: Ajax-CECO)

To produce engine valves and other motorcycle parts for customers like Harley Davidson, Modern Forge uses Chambersburg (CECO) die forgings that date back to the 1980s and weigh between 20 and 50 tons.

So, when Ferguson heard that Chambersburg was in bankruptcy many years ago, his first reaction was "what the heck are we going to do for parts?" Fortunately, he had some replacement parts in inventory and was able to salvage parts from two offline units. Like other forging operations, he also sent some parts out to be reverse-engineered and machined.

This comes with some unintended risk, however. Machine shops often do not have access to critical specifications about high-wear parts, including the material grade of the steel, the heat-treating process used, and tolerances that all were engineered specifically



The sheer size and complexity of forging equipment means that even items such as the massive cast steel frame can take six to eight months for delivery – not including the four to six months to install all the internal parts and components. (Courtesy: Ajax-CECO)

for that piece of equipment. The result can be parts that fail prematurely or wear much faster.

So, when Ferguson learned the Park-Ohio Company had acquired the intellectual property rights to all Chambersburg and Ajax Manufacturing equipment in 2005, he contacted them. Ajax-CECO, as the company is now known, is one of the oldest manufacturers of forging equipment, having begun operations in 1875. In its more than 140 years, the company has built and put into production more than 6,000 horizontal and vertical units of forging equipment.

Fortunately, the provenance of forging equipment for both Ajax and Chambersburg equipment has been well maintained, including the original drawings, bill of materials, and service manuals.

"They have very good, detailed information that Ajax-CECO carried over from Chambersburg, which is really advantageous for us," Ferguson said.

Most OEMs today also stock replacement parts using MRP systems that monitor inventory levels and track historical trends for common wear items such as friction plates, driving plates, piston heads, piston rods, rings, and packings.

In addition, some OEMs like Ajax-CECO offer stocking programs for long lead time items such as main gears, centric shafts, rams,

frames, and anvils that most customers will not stock due to the cost. In this type of program, the part is held in inventory for the customer. The customer pays a percentage of the cost and then the balance when they take possession of the part – even if years later.

"Ajax-CECO is good about putting a spare part on the shelf for me and not charging [the full price] for it," Ferguson said. "It is in their inventory until we need it, and then we pay the balance. I'm talking about expensive parts, too."

REBUILD

A step-up in order of magnitude from a repair is a rebuild of the forging equipment. In a rebuild, all high-wear items such as bearings, bushings, seals, and liners are replaced to get the machine in good working condition. The frame is inspected and repaired, if necessary.

Given the extent of the work involved, however, this approach represents a significant investment in time. Rebuilds can take six months, depending on the number of components involved in the project. While this is a significant amount of time, a rebuild can save an operator six months or more in comparison to purchasing new equipment. This approach also reduces the overall cost to bring

Rebuilds can be approached several different ways. The forging equipment can be sent to the OEM for rebuilding; the OEM can send repair personnel to the manufacturer's facility to rebuild equipment on-site; or the OEM can supervise a rebuild by maintenance staff. This allows the in-house staff to ask questions and better understand the operation of the equipment they are maintaining.

the equipment online.

Rebuilds can be approached several different ways. The forging equipment can be sent to the OEM for rebuilding; the OEM can send repair personnel to the manufacturer's facility to rebuild equipment on-site; or the OEM can supervise a rebuild by maintenance staff. This allows the in-house staff to ask questions and better understand the operation of the equipment they are maintaining.

At the Eaton Corporation forging operation in Kearney, Nebraska, the company operates 26 Ajax-CECO 100-ton to 1,300-ton forging presses. Eaton remains one of the top producers of engine valves and precision gears in North America.

Although some Eaton plants purchase rebuilt equipment from companies like Ajax-CECO, the lead maintenance manager at Eaton, Randy Kreutzer, sees the value in rebuilding the equipment in house with components sourced from the OEM.

"I like the experience the maintenance staff gets from rebuilding the equipment," Kreutzer said. "That way, when future repairs are required, the time frame to complete them is much shorter."

In addition, Eaton often incorporates automation upgrades that speed production in rebuilt equipment. Today, many of these manual tasks are instead being replaced with the mechanical "hand" of a robot or by integrating servos that can lift, insert, and deposit materials. Even tasks such as automated tooling changes can be completed with the push of a button.

By doing so, tasks that were once performed manually — such as moving heavy steel rods, pipe, and other stock in and out of equipment — are now automated to improve worker safety. Not only does this create a safer environment for forging operators, but productivity is increased.

REMANUFACTURE

Sometimes only the cast steel frame of the forging equipment is salvageable, in which case all the internal components can be replaced in a full remanufacture of the equipment. Given the extent of the work required, a remanufactured forging unit can still cost 85 to 90 percent of new equipment, but delivery time is reduced by about six months. However, when it is finished, a remanufactured machine comes with a new machine warranty.

In essence, a remanufacture saves the cost and the time of acquiring a new cast frame. The frame on a 3-inch upsetter press weighing 55,000 pounds, for example, could take six months, plus another month for shipping from overseas.

"With a remanufacture, all the internal parts are built to factory specs," Kreutzer said. "With a remanufactured unit, you don't need the man-hours to rebuild it. It can just be set in place, hooked up, and is ready for forging."

As with a rebuild, a remanufactured forging unit can include a

variety of automation option upgrades.

NEW

While the "buy new" option may offer a forging operator the most confidence in long-term performance and the most tailored solution to their forging needs, it also has the longest lead times. Moreover, a manufacturer will need to plan on approximately one year to take delivery of a new piece of forging equipment.

However, if the new equipment option is affordable, the decades of value that will be generated from the new equipment mean the return on investment will be significant.

When it comes to new forging presses, Kreutzer cautions quality can sometimes be an issue when sourcing from overseas sources.

"We like Ajax-CECO presses for their quality, and even prefer to rebuild that equipment instead of pursuing some other options out there that will not perform or last as long," he said.

New equipment also gives forgers the opportunity to take advantage of the most advanced automation options available today. For example, entire forging line "cells" can be created that include sophisticated communications that report production rates and machine performance back to company networks.

CONCLUSION

Some forging operations even hedge their bets by using more than one strategy. Given the shortage of available used equipment and the lead times, some customers order a new machine while another is being remanufactured. Others get quotes on new equipment while continuing to seek out used equipment opportunities as they arise.

Regardless of the approach, forging operations have a lot to consider when attempting to meet increasing production demands. Whether repair, rebuild, remanufacture, or new, bringing forging equipment online requires careful consideration and foresight, as well as a more complete understanding of the options.

"You have to constantly keep a look-out for equipment, worldwide, and do your price comparisons to ensure you stay within the budget," Kreutzer said. "Usually, when we are acquiring new equipment, it is well into the future, so we have adequate time. But there are always timelines that must be met. So, as a company, we have to consider all the available options." ♦

ABOUT THE AUTHOR

Del Williams is a technical writer based in Torrance, California. He writes about health, business, technology, and educational issues, and has an M.A. in English from C.S.U. Dominguez Hills. For more information about Ajax-CECO, call 440-295-0244, email info-sales@ajax-ceco.com, or go to www.ajax-ceco.com.

COMPANY PROFILE //
HARROP INDUSTRIES, INC.

**A COMPLETE
ENGINEERING, OPERATING,
AND TECHNICAL
SERVICE TO
THE CERAMIC
INDUSTRY**

View of electric- and gas-fired kilns
for development and toll firing.
(Courtesy: Harrop Industries, Inc.)

For more than a hundred years, Harrop Industries has designed industrial kilns that can be constructed on-site or delivered pre-built and installed at its clients' facilities.

By KENNETH CARTER, Thermal Processing editor

Industrial kilns are an important component in the heat-treat industry, so it's imperative that they are designed and built to exact specifications.

Ceramics is the quintessential building block of many industries, and Harrop Industries, Inc. has been supplying kilns and other ceramic products to a wide range of areas for more than a century.

"We are strictly a kiln designer and kiln builder for the ceramic industry," said Dr. Jim Houseman, CEO of Harrop Industries, and the third in the company's storied history. "Our primary product line, if you want to call it that, or services, is we're a design-build contractor of industrial kilns for commercially producing ceramic products. We want to be a high-class supplier of application-engineered kiln systems. We've been a supplier to the industry for over 100 years, and we enjoy the partnerships we've developed with established traditional companies as well as new startups."

KNOWING CERAMICS

The company prides itself in knowing everything possible about drying and firing ceramics, and Houseman said that has sparked an organic growth through the years.

"Our growth has really come from the different application needs of our clients," he said. "We don't profess to be a materials research company. We leave that to the scientists, but we've evolved in our designs as we've seen the need of more nontraditional ceramic products being developed around the country."

Metal heat-treaters, according to Houseman, are a big part of the industries that Harrop serves.

"All those furnaces they use are lined with ceramic refractories," he said. "And we count refractory manufacturers as some of our best clients. They need to develop new refractories to handle these exotic alloys and processing areas in the metals industry. They need better refractories to line ladles and heat-treating furnaces and whatever. And we are a supplier of these engineered kilns that go to the refractory manufacturers."

CUSTOM BUILT, EVERY TIME

Harrop doesn't have a product catalog, according to Houseman. The company's goal is to build to specs exactly what its customers need.

"First, we have to ascertain what their end goal is, and, for us, we're beyond R&D, but the typical application will come when a company has developed a product that they've taken out of the laboratory successfully and is looking to scale up to make a commercially available product," he said. "This can, a lot of times, start in building prototypes or getting into pilot plant development. A number of these companies — in the past 20 years anyway — are not traditional ceramic manufacturers and know very little about how to process ceramic products. So, we work with them to mutually educate each other in how ceramics behave and how they may have to be handled as well as the firing process to make viable products."



426-foot-long tunnel kiln gas-firing clay paving brick at 1,175°C. (Courtesy: Harrop Industries, Inc.)

To help customers accomplish their goals, Harrop maintains a 12,000-square-foot developmental and testing laboratory in its Columbus, Ohio, facility, according to Houseman. This laboratory has about 19 different types of kilns used for prototyping work and test firings for clients to help them develop the profile or the process needed to make products on a commercial scale.

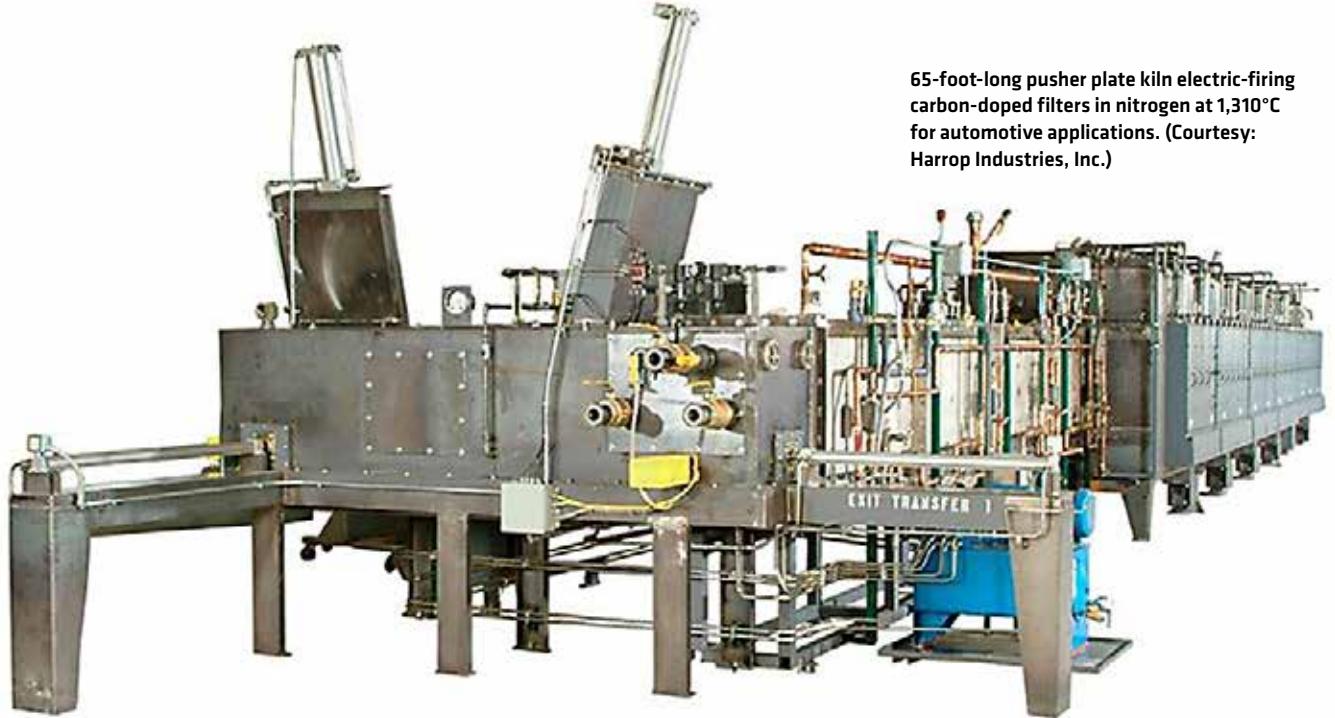
"Once we go through that, we then will — from our overall experience in this business — develop an industrial size kiln concept for them," he said. "Then we go through a bidding process and write specifications for it. That's how we approach our potential clients. We have no catalog. We have no price lists. It's all application engineered."

Harrop's technicians can conduct standard ASTM compliance testing or customized thermal testing of raw materials and ceramic components. The thermal and physical behavior of ceramics can be evaluated using such techniques as thermal analysis, psychometric drying, thermal gradient testing, dilatometry, and sintering studies. Harrop offers a broad range of firing services from bench-scale testing to pilot-plant production to evaluate the drying and firing behavior of industrial ceramics.

PUSHING THE ENVELOPE

The experts at Harrop are always pushing the envelope of the world's ceramic needs, and the company has been supplying kiln systems for firing high-purity ceramic powders used in lithium ion batteries for electric vehicles as well as other types of storage batteries, according to Houseman.

"We worked with clients who, instead of needing two pounds of this material a month, they need 75 pounds an hour," he said. "You really have to get involved in the materials handling aspect of feeding the kilns and taking material away. A lot of our work is



65-foot-long pusher plate kiln electric-firing carbon-doped filters in nitrogen at 1,310°C for automotive applications. (Courtesy: Harrop Industries, Inc.)



Elevator kiln electrically heated with Microwave Assist firing structural carbon foams to 1,620°C. (Courtesy: Harrop Industries, Inc.)



138-foot-long tunnel kiln gas-firing alumina substrates and cylinders to 1,600°C for power control applications.
(Courtesy: Harrop Industries, Inc.)

really how to integrate a high-temperature process into an integrated manufacturing process. These applications must make economic sense for the client."

Houseman is quick to point out that Harrop is not only well established, but it is consistent and reliable on many levels. It's been a private company since the beginning, and its roots have been in the same city, but he said Harrop's best accomplishments rest in having satisfied clients and repeat business.

"Probably 85 to 90 percent of our revenue is on repeat business, but being in heavy capital equipment, our current clients today may not be a client again for five years," he said. "We have a number of clients that we've dealt with for 40, 50, 60 years. Their needs have changed. Their requirements have changed, but we've had the opportunity to do business with them as their market needs have changed."

As the markets have changed through the years, it was imperative that Harrop changed with them in order to stay viable as it enters its second century of business.

OPENED ITS DOORS IN 1919

Harrop Industries began life in 1919 as Carl B. Harrop Engineers when it was founded by Carl Harrop, a professor in the ceramic engineering department at The Ohio State University.

In 1918, Harrop was granted a patent on a new type of car tunnel kiln, a device for firing ceramics in a continuous process that saved substantial energy over the traditional batch firing methods.

"Due to his travels during World War I to Europe, he discovered that the Germans were processing ceramics in a much more energy-efficient manner than we were doing here in the United States, and that was by continuous firing of ceramics," Houseman said. "He came back and started promoting this within the ceramic industry and it just took off like wildfire."

Nine years of successes later, the company incorporated as Harrop Ceramic Service Company, with Harrop as president until his death

in 1934. In 1936, Harrop's second CEO, George D. Brush, a civil engineer who had worked for Harrop since 1923, took over. When Brush retired in 1978, Houseman stepped in. The company officially changed its name to Harrop Industries, Inc. in 1981.

Along with its testing facility, Harrop's current location in Columbus, Ohio, boasts 17,000 square feet of office space and 36,000 square feet of fabricating shop.

CONTINUED ADVANCEMENT

Harrop continues to look for ways to advance the field of ceramics, and in doing so, commercialized a firing process called Microwave Assist Firing that can be used to more uniformly heat materials, according to Houseman.

"Microwave energy, of course, is a way to impart thermal energy into materials," he said. "And typically, ceramics are heated from the outside in just as metals are. But with the use of microwave energy, we can actually start heating materials from the inside out."

Many ceramic products made today have complicated geometric shapes, so traditional methods of heating those products from the outside in would often cause unwanted temperature differentials, according to Houseman.

"What we've found is that we can use microwaves on certain materials to heat them from the inside and keep the temperature uniformity a lot better, and the quality of the product can be much higher using it," he said.

Houseman expects Harrop's kiln designs to be at the forefront of many industries as more exotic materials are developed, particularly in the transportation and energy sectors.

"We're biased of course, but we think ceramics have got a growing place in the industrial field," he said. ☜

MORE INFO harropusa.com

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Q&A // INTERVIEW WITH AN INDUSTRY INSIDER

SHLOK SUNDARESH // ENGINEERING MANAGER // TS USA (HEF GROUP)

"Our liquid nitriding and PVD equipment are manufactured to very exacting standards to meet repeatability and process control demands"

What is your role at TS USA?

I joined TS USA, HEF Group, in 2014 as a process engineer for its Springfield, Ohio, facility. As our footprint in the U.S. grew, my responsibilities included other nitriding facilities as well across diverse applications. In 2018, I was promoted to the role of Senior Process Engineer, leading process development activities for the U.S. organization. In 2019, I was promoted to the engineering manager position responsible for all process engineering activities of the company in the U.S. along with supporting the North American side of the business. Part of my responsibility includes providing technical support, not just to our customers in terms of developing applications and the use of surface treatments, but also on the licensing side of the business where we provide some technical assistance to nitriders who purchase chemicals from us.



What is your organization's background?

HEF Group, which stands for Hydromécanique et Frottements (Hydromechanics and Friction)—is a French-based company. HEF Group's global HQ is located south of Lyon, France, and it primarily started as a tribology company working on wear, friction, and corrosion reduction applications. We've been in business for more than 60 years, and we are the leading global provider of surface treatments and coatings primarily. Our two primary surface technology options are liquid nitriding and physical vapor deposition or PVD, specifically diamond-like carbon coatings (DLC). We are the only supplier that offers both technology options worldwide. We also offer a range of other surface treatments to meet customer-specific needs. All of our facilities provide surface treatments and coating jobbing services to local customers. It can be applications ranging from automotive to oil and gas to aerospace, as well as hydraulic and pneumatic equipment, construction and mining equipment, material handling equipment, or even power generation. TS USA – Techniques Surfaces USA – is a subsidiary of HEF Group. HEF does the manufacturing, and TS offers the processing for our customers.

Does HEF design and manufacturer its own equipment?

HEF manufactures its own chemicals and equipment for liquid nitriding side of the business. We also manufacture our own equipment for PVD vacuum coatings as well. In short, we are a vertically integrated organization offering value-added surface engineering solutions. Our liquid nitriding and PVD equipment are manufactured to very exacting standards to meet repeatability and process control demands for a diverse range of industrial segments. Our nitriding chemicals are the new generation technology that is environmentally friendly

and can yield metallurgical properties superior to the other nitriding processes and platings.

Your website www.hefusa.net mentions processes that are not common in traditional heat treatment. Can you elaborate?

Liquid nitriding and salt bath nitriding are used interchangeably in the industry. We offer different variants within the same technology, and MELONITE®, TUFFTRIDE®, and ARCOR® are all trademarked processes of HEF Group called as CLIN—controlled liquid ionic nitriding. These trade names are used primarily for differences in the nitriding chemistry and the secondary processing steps (if any). ARCOR® (V, N, C, DT, etc.) represents a family of liquid nitriding processes based on customer-specific applications and our chemicals. They provide a more robust compound layer, which are operationally easier to control and environmentally friendlier than other liquid-nitriding treatments.

Could you explain some of the advantages of your processes over conventional gas nitriding and chrome platings?

Nitrocarburizing uses different media such as liquid, gas, or plasma and, in some cases, fluidized bed, which is not as popular. However, all methods are intended to accomplish similar, but not identical results. Liquid or salt bath technologies are typically considered the benchmark for uniformity with more flexibility in terms of tailor-made innovative solutions. ARCOR® and MELONITE® liquid nitriding provides the best combination of both wear and corrosion protection. But the key advantage here is its much shorter processing times (few hours) as compared to the very long 12 to 24 hours for gas nitriding. The benefit with HEF's liquid nitriding services is it provides that added option of impregnation with proprietary oils that can enhance the corrosion resistance of the nitrided part. The customizable surface porosity that's generated with this process is very effective in retaining the impregnated fluid and increasing the lubricity and also beneficial for breaking applications. In the past few years, gas and plasma nitriding were default processes because parts with large dimensions of more than 60 inches long couldn't be done in those furnaces. However, at our TS USA Chattanooga, Tennessee, facility, we're able to offer our treatments for applications such as oil and gas, large and heavy, hydraulic or pneumatic applications, and high-volume automotive components. HEF's environmentally friendly liquid-nitriding technology, along with its enhanced performance, has been the go-to process, replacing a lot of hard chrome plating, which has environmental challenges with hexavalent chrome. ¶

MORE INFO www.hefusa.net



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