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NITRIDING / ADDITIVE MANUFACTURING

CONTROLLING NITRIDED LAYERS AND ENHANCING PREDICTABILITY OF NITRIDING PROCESS WITH METALLOGRAPHY

COMPANY PROFILE ///

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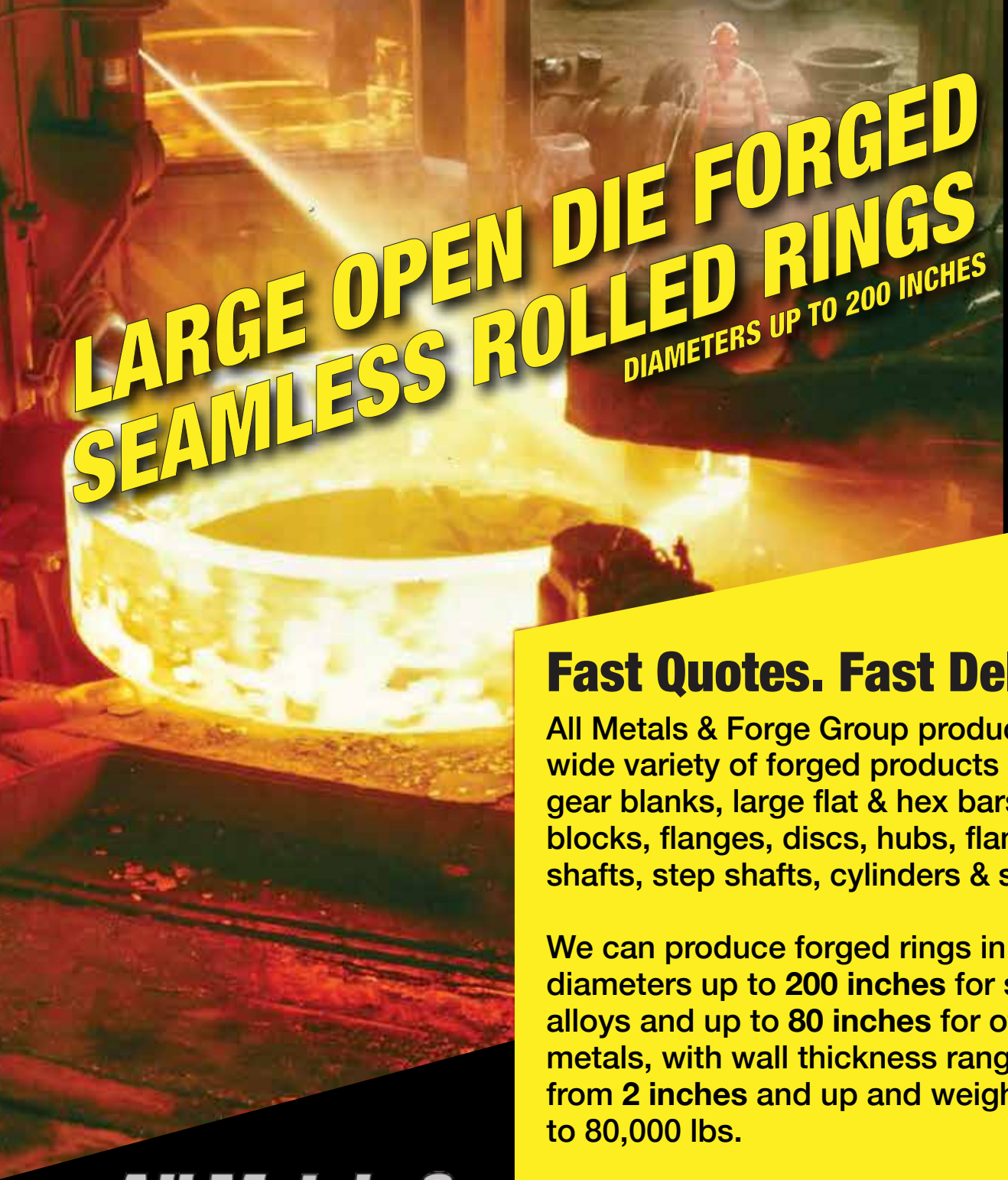

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FROM THE EDITOR ///

We're excited about Heat Treat 2023

Things are definitely heating up as we get closer and closer to Heat Treat 2023 in Detroit, Michigan, October 17–19. No doubt you're all excited about finally reconnecting with your colleagues in the industry.

Many companies and big names are expected to be there while hundreds of heat-treat exhibitors will crowd the floor of the Huntington Place Detroit Marriott at the Renaissance Center.

What makes Detroit the ideal city for the heat-treating industry?

According to Heat Treat sponsor ASM International, Detroit is where cutting-edge research meets real-world applications and innovation thrives. At the show, you can immerse yourself in a dynamic environment, where you can network with global influencers, connect with decision makers, and exchange ideas with like-minded professionals from around the world.

It is the largest gathering for heat-treating professionals, materials experts, and industry leaders in North America.

We don't want to miss out on this exciting city, either. *Thermal Processing* will have a booth at Heat Treat as well, so please drop by Booth #2238 and introduce yourself. I'd love to meet you and discuss editorial opportunities with the magazine. I'm always looking for new and exciting ways to pass on important industry knowledge and expertise.

So, consider this issue of *Thermal Processing* a primer to get you in the mood, because our September issue covers quite a few topics you will definitely find interesting.

Make sure you check out this month's feature articles that spotlight a variety of important heat-treating topics such as nitriding and additive manufacturing.

And last, but certainly not least, *Thermal Processing* is always thrilled to highlight the expertise all of our columnists bring to the heat-treating table. They continue to shine a light on all aspects of the industry.

I'm excited to bring you this issue, and I hope to see you at the show in October.

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
ASSOCIATE EDITOR | SOCIAL MEDIA

SALES

Dave Gomez
NATIONAL SALES MANAGER

Kendall DeVane
REGIONAL SALES MANAGER

CIRCULATION

Teresa Cooper
MANAGER

Jamie Willett
ASSISTANT

DESIGN

Rick Frennea
CREATIVE DIRECTOR

Michele Hall
GRAPHIC DESIGNER

CONTRIBUTING WRITERS

JESSE HYDER
D. SCOTT MACKENZIE
WILLIAM MARK MCVEA
JASON PEREIRA
EDWARD ROLINSKI
TONY TENAGLIER
MIKE WOODS

Media solutions

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Solar Atmospheres Eastern Pennsylvania facility now has Boeing BAC-5613 approval for the processing of titanium for Boeing aircraft. (Courtesy: Solar Atmospheres)

Solar Atmospheres Eastern PA adds Boeing approval

Solar Atmospheres Eastern Pennsylvania facility announced the addition of Boeing BAC-5613 approval for the processing of titanium for Boeing aircraft. With this approval, all five Solar Atmospheres facilities are approved to process Boeing end-use titanium components requiring vacuum heat treatment.

"We are proud to announce this addition to our scope of approvals for Boeing," said Mike Moyer, vice president of sales for Solar Atmospheres of Eastern Pa facility. "Solar has unique expertise and capabilities in the realm of processing titanium, and we are happy to gain Boeing's confidence in that regard. This new approval opens the door for Solar Atmospheres to better serve Boeing's suppliers in the Mid-Atlantic region of the U.S., as well as provide overflow capacity for other Solar facilities nationwide."

MORE INFO www.solaratm.com

Hydraulics company adds 4 Nitrex nitriding systems

Nitrex, a leading manufacturer of turnkey heat-treatment systems, has successfully installed a second set of nitriding/nitrocarburizing systems for a European hydraulics manufacturer. This strategic investment further strengthens the company's in-house heat-treatment capabilities and reaffirms its commitment to delivering quality components for hydraulic pumps and motors.

The customer has experienced prior success with UPC-Marathon (UPC), a Nitrex company, specializing in process control solutions. Leveraging UPC's Protherm 9800 SCADA, the customer boasts a well-established track record of automating heat-treatment operations with remarkable efficiency and success. With more than 30 furnaces integrated into this platform, including those for nitriding and nitrocarburizing, the facility has continuously improved productivity over the years. In 2022, the company integrated two Nitrex horizontal-type nitrocarburizing furnaces into their existing setup, paving the way for an additional two identical furnaces in 2023. These systems primarily serve to nitride/nitrocarburize components made from various steels and alloys, such as ductile iron, hardened steel, nitriding steel, and carburizing steel.

The four Nitrex systems are seamlessly integrated into the automated heat-treatment cell. Run by UPC's Protherm 510 programmable controllers, they interface with the Protherm 9800 SCADA, enabling precise management of process recipes and workloads, and providing real-time visibility of ongoing processes. Additionally, the furnaces are equipped with an ammonia dissociator for low nitriding potential. This feature allows for precise control of the compound layer thickness for products with tighter tolerances, contributing to optimal product performance and efficiency.

The decision to invest in new heat-treatment equipment was driven by the manufacturer's vision to expand its manufacturing capacity and meet the growing demand for hydraulic components. The partnership with UPC, along with their first-rate on-site customer service and the company's positive past experiences with UPC control solutions in other global plants, played a pivotal role in positioning Nitrex as the preferred supplier for these heat-treating furnaces.

The first set of systems was delivered in the last quarter of 2022, followed by the subsequent two furnaces in the second quarter of 2023, ensuring a seamless and efficient integration into their production processes. With the successful incorporation of the second set of turnkey Nitrex systems, the European manufacturer has built up its heat-treatment capabilities to align with the growing demands of the hydraulics industry.

"This collaboration exemplifies our commitment to empowering customers in their pursuit of operational innovation and efficiency through our comprehensive, end-to-end solutions in heat treating," said Mark Hemsath, Nitrex vice president of Sales,

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.

A European hydraulics manufacturer strengthened its in-house heat-treatment capabilities with a second set of nitriding/nitrocarburizing systems from Nitrex. (Courtesy: Nitrex)

Furnaces & Heat-Treating Services. "The nitriding/nitrocarburizing furnaces have demonstrated exceptional performance and reliability, integrating seamlessly into our customer's operations. As a result, the customer's heat-treatment planning team highly commends Nitrex for future investments, including a new greenfield factory in the Americas."

MORE INFO www.nitrex.com

Special fasteners to be processed in Vector furnace

A plant that produces highly advanced fasteners for the largest manufacturers in the aerospace industry, operating since the middle of the last century, ordered a Vector® vacuum furnace from Seco/Warwick. The furnace will be delivered in a standard configuration and will meet the global aviation industry's highest requirements.

The machine will process self-locking nuts, nut plates, barrel nuts, stud nuts, spline nuts, clamp nuts, as well as a wide range of washers and flanges. The Italian partner is an innovator in the field of comprehensive fastening solutions. The Vector furnace will become part of a modern production plant, increasing not only its efficiency, but also guaranteeing thermally treated fasteners of the highest quality.

The furnace on order is a standard solution perfectly suited to aviation industry needs. Thanks to a very refined design without any additional modifications, the furnace will perform at high operating temperatures, up to 1,300°C.

"This is Seco/Warwick's first contract with this client," said Maciej Korecki, vice president of the Vacuum Furnace Segment at Seco/Warwick. "Our Vector furnace is perfectly suited to meet the fastener heat-treatment challenges, while meeting all required aviation standards. The heating process for these materials requires extraordinary purity, which is why the presence of two gases is important: argon — used for partial pressure, and nitrogen — used mainly in the cooling process. The customer required a very short cooling cycle, which is achieved with a 15 bar abs gas blower. These are the Vector vacuum furnace standard features. Due to the fact that we did not have to adapt it to the Italian manufacturer's needs, it was also an economically beneficial purchase."

The furnace on order is equipped with a dew point sensor for each of the gases. It is a system solving one of heat treatment's very critical requirements, which is to control the quality/purity of the gas used during the process. Vector also features a partial pressure control system which helps prevent evaporation and sublimation of alloying elements from the load surface during the vacuum heat treatment.

The aviation industry expects finished parts of the highest quality. This is understandable, because in this area, the safety

An Italian plant producing highly advanced fasteners for the largest manufacturers in the aerospace industry has ordered a Vector® vacuum furnace from Seco/Warwick. (Courtesy: Seco/Warwick)

of human life depends on even the smallest component. Aviation boasts the lowest accident rate, and this is a direct result of implementing a number of quality standards and procedures. The AMS2750 standard was established in 1980 for the heat treatment of components for aircraft. Its main purpose is to better define pyrometry specifications. The AMS2750 standard includes guidelines for thermocouples, controllers, and recording equipment, as well as strict temperature specifications for furnaces and equipment for the manufacture of aerospace components. The latest version, the AMS 2750G, was published in 2020. Seco/Warwick supplies built-from-scratch vacuum furnaces that meet the standards set by the AMS2750G.

The vacuum furnace from Seco/Warwick will not only allow the user to fully control the production process, the systems will guarantee high quality and continuity of the finished work.

Vacuum furnaces use vacuum (vacuum created by air evacuation) as the protective atmosphere for the heat-treated part surfaces. The vacuum furnace's main advantage is its versatility and the ability to carry out processes traditionally carried out in atmospheric furnaces. Differences in the vacuum furnace construction as well as the method of conducting the processes minimizes both media consumption and emissions to the environment, making the vacuum furnace itself a SECO/ECO solution when compared to traditional atmosphere furnaces.

Vacuum heat treatment's eco-friendly features include:

- Perfect part surface quality (without additional operations).
- No intercrystalline oxidation (no additional mechanical treatment).
- No need to use protective gases (lower costs and emissions).
- Minimal consumption of process gases (cost savings).
- Minimum time for atmosphere preparation and conditioning (saving time and costs).
- Zero startup and shutdown time, work on demand (saving time, costs).
- No open flame, no risk of fire or explosion (safety).
- Clean process, no part washing required (reduced environmental pollution).
- Low heat and by-product emissions (limited global warming effect).
- Environmentally friendly (zero pollution).
- Zero CO_2 emissions (carbon footprint reduction).

MORE INFO www.secowarwick.com

JUMO offers reliable electronic transformer

The JUMO IPC 300 is an electronic transformer with amplitude control in the performance range up to 40 kW. It features a high degree of reliability and low operating costs, and was developed for the control of heating loads that previously required an additional transformer for power control.

Due to the integrated amplitude control, the mains current and the mains voltage of the JUMO IPC 300 are proportional to the required power of the heating element. The acquisition of additional compensation equipment is therefore no longer necessary.

In addition, the power converter reduces malfunctions such as flicker or harmonics so that it contributes to higher plant availability. Consistent energy demand decreases reactive power and reduces current peaks. This way, the JUMO IPC 300 lowers energy costs.

The integrated resistance limitation protects against overheating in the upper temperature range and thereby extends the service life of molybdenum disilicide heating elements. Low maintenance requirements combined with longer operating times

The JUMO IPC 300 electronic transformer features simple startup and low maintenance requirements. (Courtesy: Jumo)

reduce the operating costs.

An external current sensor monitors residual currents and detects housing shorts in the heating elements. Heating elements with large temperature coefficients change their heat output very strongly relative to their operating temperature. The power controller of the IPC 300 detects this and compensates for such an error.

Other strengths of the JUMO IPC 300 include its easy operation, configuration, and startup. The compact device has a plain text display and a keypad. The communication will be done via an optional PROFINET interface. Configuration can also be handled via the interface. As an alternative, configuration parameters can be easily transferred using the USB interface. A voltage supply is not required. As a result, the JUMO IPC 300 is the right solution for mechanical and plant engineering, the process industry, and furnace construction.

MORE INFO www.jumo.net

Pomini Tenova roll grinders for Hoa Phat Group

A new project awarded to Tenova, a global company specialized in sustainable solutions for the green transition of the metals industry, confirms Pomini's leading role in Vietnam for roll grinders.

Tenova has been awarded a new contract by Hoa Phat Group, the leading industrial manufacturing group in Vietnam, for new roll grinders supplied by Pomini Tenova, a well-known Tenova brand and a worldwide leader in the production of roll shop equipment. The roll grinders are for Hoa Phat's new hot rolling mill in Dung Quat, Quang Ngai province.

The scope of work for the roll shop includes the full set of roll grinders for grinding work rolls and back up roll, with and without mounted on chocks. All machines are equipped with the most advanced and user-friendly Pomini HMI (human machine interface), the Pomini Inspektor3 with eddy current and ultrasound probes for roll inspection, the most referenced and reliable online roll flaws detection system available on the market. The roll grinders also mount the Pomini Process Monitoring (PPM) and the Continuous Profile Compensation (CPC) to easily achieve the best roll surface quality with the highest profile accuracy and the lowest stock removal. The digital package with Tenova Edge technology and Tenova adVisor will provide remote constant condition monitoring for each machine and all sorts of operational and maintenance support.

"Currently Hoa Phat Group operates in five sectors and steel production is the core, accounting for 90 percent revenue and profit of the Group. With the capacity of 8.5 million tons of crude steel per year, Hoa Phat is the largest steel producer in the Southeast Asia," said Hoa Phat Dung Quat team. "We chose Pomini for the reliability of its equipment

already in use at our hot plant. We are sure Pomini grinders will allow us to guarantee the supply of quality rolls also for the new hot rolling mill."

"Thanks to the proven reliability of our innovative technologies, we have now secured our biggest roll grinder contract in Vietnam, and our fourth with Hoa Phat Group," said Giuseppe Zanzi, Tenova chief representative officer, Southeast Asia and Oceania. "Vietnam is a very important market for Pomini and we're pleased that with this new contract, we have achieved the sale of 27 machines in the country."

MORE INFO www.tenova.com

Delta H Super DCAHT recognized for AOG support service

Delta H® was recently recognized by a major military aircraft support facility for the excellent performance and reliability of a Super DCAHT® furnace system supplied in 2018. The massive dual chamber furnace system features twin 30-inch wide, 16-inch high, and 120-inch-long work volumes, with both being capable of operation from 250°F to 1,200°F as Class 2. Both chambers feature the exclusive Aging Mode™ venting system that enables not only low temperature operation, but also rapid cooling. Both chambers are capable of aluminum solution heat treating, annealing, and aging, as well as PH stainless aging and stress relieving.

Delta H® Model DCAHT®-3016120-1200/1200-BAC provides tamperproof batch records, simple performance of the temperature uniformity survey (TUS) and the system accuracy test (SAT), and requires minimal maintenance. (Courtesy: Delta H)

The furnace system features a massive quench tank which is more than 12 feet long. The tank features a powered drive system, a heating system, auto-refill of water, a high-temperature external water pump, and electronic sensors for quench delay recording.

The model DCAHT-3016120-1200/1200-BAC has specific features for primary compliance to BAC5621, as well as now AMS2750G. The system provides tamperproof batch records, simplistic means of performing the temperature uniformity survey (TUS) as well as the system accuracy test (SAT), and the design requires minimal maintenance. The control and data acquisition features Honeywell instrumentation and customized software. All necessary compliance and operator training is provided by Delta H.

"This furnace system is, by far, the easiest system to maintain and has virtually 100 percent reliability," said Mike Lawrence, director – Lawrence Technical Services Company, LLC. "We especially appreciate the rapid technical support when needed from Delta H."

"The challenge with this project was to have both chambers be able to operate and qualify over the full range of the required temperatures for aviation grade aluminum heat treating," said Richard B. Conway, director/CTO – Delta H. "This is especially helpful with the long aging cycles relative to the solution heat treating cycles — either, or both chambers can be used for aging — which helps minimize bottlenecks. When it comes to support for an aircraft on ground (AOG), every minute is potentially costing thousands of dollars and this system has performed every time needed. We have now supplied additional systems of this design to the same client — as a standard model."

MORE INFO www.delta-h.com

Solar Manufacturing ships vacuum furnace for fasteners

Solar Manufacturing recently shipped a vacuum furnace to a U.S.-based aerospace fastener manufacturer. The furnace will be primarily used to age-harden various fasteners of high-strength alloys used in the aerospace industry.

This is the second Model HFL-5748-2IQ furnace purchased by this customer. Like the first furnace, the new furnace features a graphite insulated hot zone of 36" x 36" x 48" deep with a weight capacity of 5,000 pounds, a maximum operating temperature of 2,400°F, and a 100 HP quench motor. Solar Manufacturing's SolarVac® Polaris control system was customized to interface with the customer's in-house automation system for recipe control and data acquisition.

"Due to steady growth, our customer needed additional furnace capacity to keep up with demand," said Jason Davidson, Regional Sales Manager for Solar Manufacturing. "The quality and performance of the first furnace was enough to influence the customer to invest in the second furnace after two years of successful operation. We had proven our furnace technology was reliable and robust."

Solar Manufacturing designs and manufactures a wide variety of vacuum heat-treating, sintering, and brazing furnaces and offers replacement hot zones, spare parts, and professional service.

MORE INFO www.solarmfg.com

Heat treater adds NXK series furnace from Nitrex

Heat Treatments, a leading provider of commercial heat-treatment services in New

Zealand, has recently expanded its operations by adding another Nitrex nitrocarburizing system.

This marks a significant milestone in the company's long-standing partnership with Nitrex, which dates to 1992 when Heat Treatments purchased its first Nitrex system with Nitreg® nitriding capabilities. As operations grew, the company later added a second system in 2004 for nitrocarburizing and post-oxidation treatments. Contrary to the first two systems, which are identical pit furnaces, the latest addition, an NXK series, features the furnace and control panel mounted on an integral platform. Delivery, installation, and startup time and costs are reduced with this design. The NXK-812 model is designed to treat workloads weighing up to 1,200 kg, with a diameter of 800 mm (31.5″) and a height of 1,200 mm (47.25″). The system is equipped with advanced process technologies, including Nitreg®-C controlled nitrocarburizing and ONC® post-oxidation, which provide precise control and consistent results.

Heat Treatments' latest Nitrex addition, an NXK series, features the furnace and control panel mounted on an integral platform. (Courtesy: Nitrex)

"We are proud to continue our partnership with Heat Treatments, who has been a true ambassador of the Nitreg® brand in New Zealand," said Nikola Dzepina, Nitrex account executive. "With prior installations in operation between 20-30 years, our systems are a testament to their durability and reliability. We are confident that this latest Nitrex system will help Heat Treatments continue its growth and success, and we look forward to supporting the company in the future."

Heat Treatments is capable of nitrocarburizing a variety of materials and applications, including alloy steels, tool steels, high-speed steels for aluminum extrusion dies, and deep case nitrocarburizing for general applications. The system was successfully commissioned in the first quarter of 2023.

MORE INFO www.nitrex.com

Seco/Warwick Vector chosen by firearms maker in Brazil

Seco/Warwick has received another order for the supply of a Vector® vacuum furnace to a South American international manufacturer of weapons and military equipment.

The furnace will process various components including barrels, reels, locks, and firearm magazines, which are expected to be reliable, of the highest quality, and perform with outstanding resistance to negative external conditions.

The most versatile vacuum furnace on the market will be the second solution of this type in the South American defense industry leader's internal hardening plant. It is a single-chamber gas-cooled vacuum furnace that can be used for a variety of metal heat-treatment processes and applications. This solution has been adapted to the customer's requirements so that it is as effective as possible at delivering the precision heat-treatment results required for quality weaponry.

Thanks to the large working space (900 x 900 x 1,200 mm), the Vector system is designed to process quite large elements. A characteristic feature of the design is convection heating, which improves heat transfer efficiency when heating at lower temperatures, and directional cooling, which enables differentiated cooling of problematic parts in terms of shapes.

For this American manufacturer, it was a challenge to clean work post-heat treatment with their existing equipment. The old furnace, which will be replaced, caused undesirable load coloring, necessitating the need for post-hardening sandblasting. Vector technology eliminates this problem.

"This is our second delivery to this partner," said Maciej Korecki, vice president of the vacuum furnace segment in the Seco/Warwick Group. "The previous furnace was the fastest delivery in Seco/Warwick history. Due to the fact that we had the required product in stock, we were able to deliver it at an express pace. The Vector system met expectations, and today, this partner is ordering a second solution from this product family, only this time, larger and differently equipped.

"Working with the new furnace, the Brazilian manufacturer will be able to harden larger packages of components and carry out very clean hardening processes. The Vector is a furnace which eliminates the unfavorable load coloring effect, eliminating the necessity to sandblast parts after hardening in the production process. This significantly improves both work quality and reduces production costs."

This Partner is a world-leading manufacturer of small arms for the defense and private sectors. They are also a member of the Industrial Defense Base (IDB). The units produced are often used in very harsh conditions. They are required to be absolutely reliable, of the highest quality, and resistant to negative external conditions. Vector — a vacuum furnace that is consistently the sales leader in the Seco/Warwick portfolio – will fulfill these expectations.

Last year, Seco/Warwick delivered Vector furnaces to numerous military companies in the world. This is an industry apart from aviation and automotive, that is most willing to take advantage of the increased capacity offered by this vacuum furnace, whose performance is a real improvement in harden-

ing plant efficiency.

Vacuum furnaces use vacuum (vacuum created by air evacuation) as the protective atmosphere for the heat-treated part surfaces. The vacuum furnace's main advantage is their versatility and the ability to carry out processes traditionally carried out in atmospheric furnaces. Differences in the vacuum furnace construction as well as the method of conducting the processes minimizes both media consumption and emissions to the environment, making the vacuum furnace itself a Seco/Eco solution when compared to traditional atmosphere furnaces.

MORE INFO www.secowarwick.com

FPM Heat Treating receives Nadcap Merit status

FPM Heat Treating, LLC, Elk Grove Village, Illinois, has been awarded 24-month Nadcap® Merit status for Heat Treating.

"At FPM we strive to meet the performance expectations of our aerospace customers and pay attention to the details required to provide great quality heat treatment," said Bob Ferry, vice president Engineering and Quality at FPM Heat Treating. "Our employees are dedicated to being proficient with a quality mindset and this accreditation is a direct reflection of their performance. We are proud of them for this high achievement."

"We take pride in the opportunity to service various industries needing a Nadcap accredited heat-treatment supplier," said Jim Feltner, president and CEO at FPM. "Being awarded a 24-month Nadcap Merit is another leading indicator of our commitment to our customer base. Our Quality group is second to none and it shows with being awarded this monumental merit."

FPM Heat Treating has held Nadcap accreditation since 2007. Having demonstrated their ongoing commitment to quality by satisfying customer requirements and industry specifications, the Nadcap Task Group has determined that FPM Heat Treating has earned special recognition. This means that, instead of having their next Nadcap audit in twelve months, FPM has been granted an accreditation that lasts until August 31, 2025.

"Nadcap accreditation is globally recognized as a hallmark of quality and is a major accomplishment," said Jay Solomond, executive vice president and chief operating officer at the Performance Review Institute. "For many years, the aerospace industry has incorporated Nadcap into its approach for handling risk, as it demonstrates compliance to industry standards and customer requirements. I wish to congratulate FPM Heat Treating, LLC, Elk Grove Village, Illinois, which has gone a step beyond by achieving 24-month Merit status. This entitles them to a less frequent audit schedule which reduces audit-related costs and other associated pressures. PRI is proud to support the continuous

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improvement of quality at FPM Heat Treating, LLC and within the wider industry. Well done to everybody involved."

MORE INFO www.fpmht.com

Mazak MegaStir to display advanced joining technology

As a pioneer in friction stir welding (FSW) technology, Mazak MegaStir will display some of its latest developments for that advanced joining process at FABTECH 2023 in the Mazak Optonics booth A3502. Among those developments are the company's dynamic and intelligent FSW toolholders and its recently released line of diamond FSW tool tips. Dynamic holders support older legacy machines, while intelligent holders provide connectivity for process feedback, and the diamond tipped tools enhance FSW performance and extend tool life.

All are for use in HYBRID multi-tasking machine operations that combine subtractive processes with that of FSW assembly/joining. This hybrid platform provides the ability to join assembly components on the same machine with the same operator and consolidates factory floor footprints while decreasing capital expenditures.

For the Mazak MegaStir process, an intelligent FSW tool holder is pulled — via a normal tool change cycle — from the tool magazine of a Mazak vertical or horizontal machining center to perform FSW operations. The tool holder collects temperature, Z-axis load data, and other information to enable operators to manage the FSW process. FSW software available through Mazak's MAZATROL Smooth CNC allows real-time monitoring of FSW's three main processes — plunging, traversing, and extracting.

For older machines, Mazak MegaStir developed its dynamic FSW tool holder. While the holder is manual and does not connect to the machine CNC, it does allow shops to reap all the benefits of adding FSW capability to conventional subtractive machine tools.

Designed specifically for joining aluminum alloys, Mazak MegaStir-patented ultra-hard diamond tipped FSW pin tools deliver higher performance, longer tool life, and superior weld quality. With the strength of polycrystalline diamond, the tools provide effective thermal conductivity for improved weld surface finishes and allow for higher spindle speeds that boost FSW productivity rates. Key benefits include up to 150 times more tool life, lower operating costs and shorter ROI. The tips are available in standard and customized versions and are thermocouple ready.

MORE INFO www.mazakusa.com

From left: Ron Waligora, COO of Project Management, Engineering, Manufacturing, and Field Services, AFC-Holcroft L.L.C.; Tracy Dougherty, COO of Applications Engineering, Sales, and Aftermarket, AFC-Holcroft L.L.C.; Yuichiro Miura, president, Sanken Sangyo Co., LTD.; and Kosei Daida, chairman, Sanken Sangyo Co., LTD. (Courtesy: AFC-Holcroft L.L.C.)

AFC-Holcroft, Sanken Sangyo form partnership

AFC-Holcroft, a member of the Aichelin Group and global leader in the thermal processing equipment industry, announced a partnership with Sanken Sangyo Co. LTD., a Japanese-based leader in that industry.

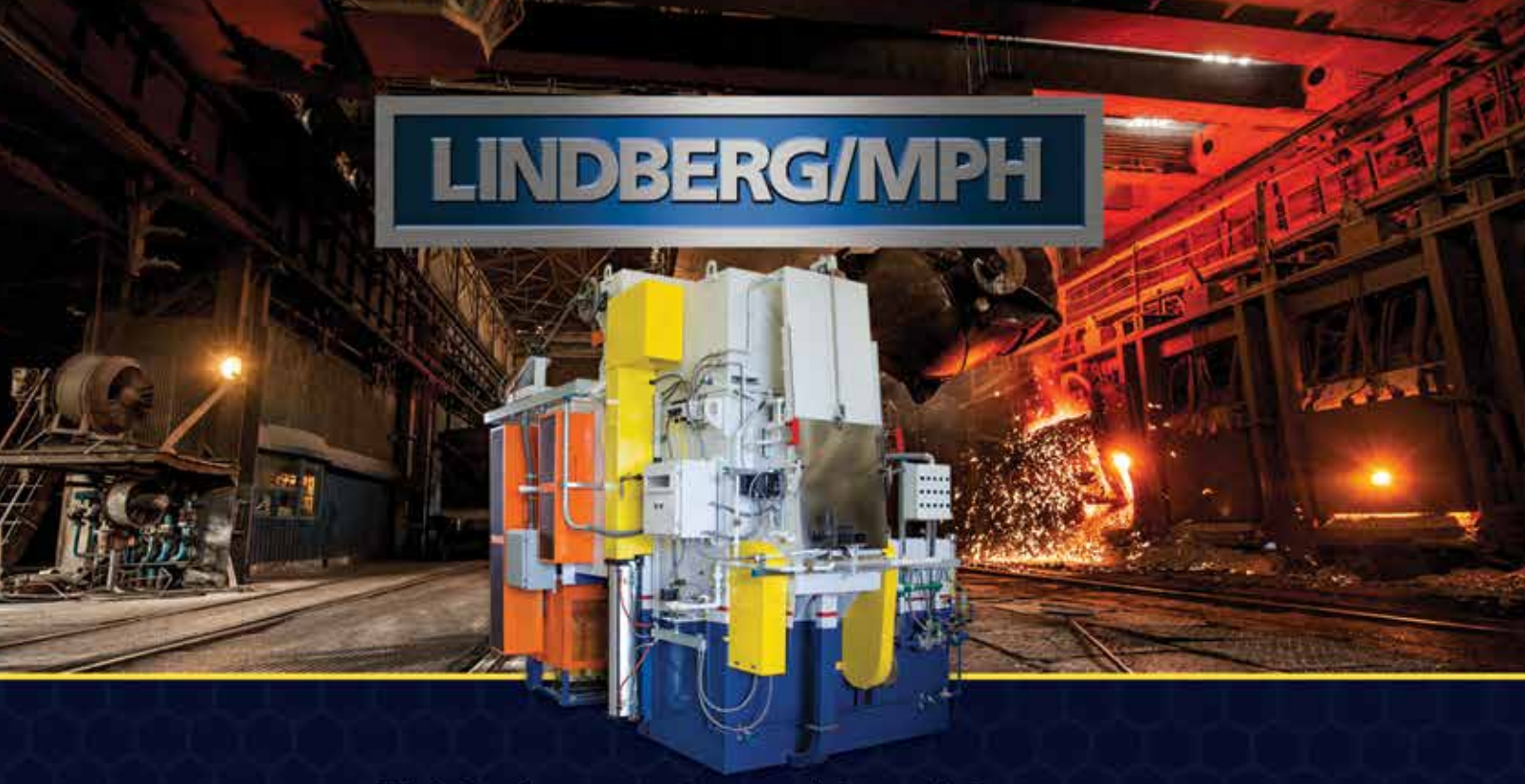
Under the terms of the agreement, Sanken Sangyo will provide their leading technology in rotary hearth aluminum heat-treating equipment to AFC-Holcroft in the United States and Canada to enhance the capabilities of AFC-Holcroft's product offering within a variety of industries. The partnership will enable AFC-Holcroft to offer customers a more sophisticated energy efficient design to what the market currently has available.

"We're excited to partner with Sanken Sangyo, a leader in the development of rotary hearth aluminum heat treating furnaces," said Tracy Dougherty, COO of AFC-Holcroft. "This partnership will allow us to continue our growth in the aluminum heat-treating market by complementing our current product offering (roller hearths, chain conveyors, pushers, mesh belts, etc.) with Sanken Sangyo's energy-efficient rotary hearth technology while reducing floor space, operating costs, and the carbon footprint for our customers."

"With AFC-Holcroft's history of over 100 years in the heat-treating industry and Sanken Sangyo's rotary heat treatment furnace technology, we are very excited and looking forward to making an enormous impact in the aluminum heat-treating market as a combined force," said Nick Maroudas, overseas sales officer of Sanken Sangyo.

The partnership signifies AFC-Holcroft's continued commitment to expansion into the growing aluminum heat-treating market.

MORE INFO www.afc-holcroft.com



High Performance Integral Quench Systems

The Lindberg/MPH Integral Quench Furnace System is highly productive and efficient. It is available as either gas-fired or electrically heated and features obstruction-free chambers and strategically located heated sources to ensure rapid heat transfer, low energy use, and excellent temperature and carbon uniformity. As a leading OEM supplier our aftermarket team is trained to provide parts and service support on any industrial furnace or oven regardless of manufacturer.

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Make plans to attend Heat Treat 2023

Heat Treat 2023 will be co-located with IMAT 2023 and the Motion+Power Technology Expo in Detroit, Michigan.

Heat Treat 2023 will be in Detroit, Michigan, October 17–19. This event will be co-located with IMAT 2023 and the Motion+Power Technology Expo and cover many topics of interest. This is the 32nd ASM Heat Treating Society Conference and Exhibition.

At the present time, about 125 papers from international heat-treating professionals have been submitted.

The conference is being held along with ASM's annual meeting, "International Materials, Applications and Technologies (IMAT)" Conference & Expo, providing Heat Treat attendees with access to 100 materials-related exhibitors and more than 400 additional technical presentations and workshops. Additionally, with the Motion + Power Technology Expo 2023, attendees will also have access to an additional 300 exhibitors.

Keynote speakers scheduled for this event include:

›› Dr. Leo Christodoulou, Chief Technologist, The Boeing Company, "Material in the Data-rich Age."

›› Dr. Jeannette M. Garcia, Manager/Global Lead for Quantum Applications in Chemistry and Science, IBM Research in Almaden, "Addressing Chemistry Challenges with Emerging Technology in Industry Research."

›› Dr. JT Kostman, Chief Executive Officer, ProtectedBy.AI, "Observations of a Myopic Futurist."

›› Dr. James A. Ruud, Senior Principal Scientist, GE Global Research, "Emerging Materials Technologies for Power Generation."

Core programming from ASM Affiliate Societies, including the Heat Treating Society, will serve as the backbone of IMAT technical sessions. More than 600 academic and industry presentations from leading scientists, researchers, and industry experts will share their knowledge on topics including additive manufacturing, materials behavior and characterization, phase stability, and reaction kinetics.

There are numerous student/emerging professionals initiatives, including free college student registration, Fluxtrol Student Research Competition, and the ASM Heat Treating Society Strong Bar Student Competition. This is an opportunity for young professionals and students to meet international heat-treating experts. Several courses by ASM HTS or AGMA will be available.

The technical program is available at www.asminternational.org/heat-treat/technical.

28TH IFHTSE CONGRESS

November 13-16, 2023 | Yokohama, Japan

This event is sponsored by the Japanese Society for Heat Treatment. This wide-ranging conference offers participants the opportunity to network and hear papers on a series of topics, including thermal processing of steel, surface hardening, additive manufacturing, and modeling and simulation of industrial processes.

The technical program is available at jsht.or.jp/ifhtse2023/IFHTSE2023Program.html.

The event venue, PACIFICO Yokohama, is one of the largest convention complexes in the world.

Deadline of full paper submission: September 29, 2023.

A special issue of JSHT will be published in March 2024 (scheduled). Applicants can submit a full paper (refereed) to the special issue. Only the presenters of the 28th IFHTSE Congress can submit full papers for this special issue.

IFHTSE FELLOWS TO BE PRESENTED IN YOKOHAMA

The following IFHTSE Fellows will be awarded at the 28th IFHTSE Congress:

›› Professor Yoshinao Mishima, formerly Tokyo Institute of Technology, Japan: "In recognition of his study for improving the mechanical properties of heat-resistant metal materials by microstructure control, and contribution to the development of heat treatment technology and IFHTSE."

›› Dr. U. Kamachi Mudali, Chairman and Chief Executive, Heavy Water Board, Department of Atomic Energy (DAE), Government of India: "In recognition of outstanding scientific contributions in corrosion and surface engineering of ferrous and non-ferrous alloys by innovative laser, ion beam, and chemical methods to achieve novel microstructures and improved corrosion resistance and development of high nitrogen stainless steels and high temperature ceramic coatings for aggressive corrosive environments."

2ND BOSPHORUS INTERNATIONAL HEAT TREATMENT SYMPOSIUM

April 25-26, 2024 | Instanbul

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

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

Important dates:

›› Abstract submission deadline: October 13, 2023.

›› Deadline for papers: January 19, 2024.

›› **Event information:** www.bhtsheat.com/en

29TH IFHTSE CONGRESS

September 30 – October 3, 2024 | Cleveland, Ohio

The Congress takes place in concomitance with IMAT, ASM's annual meeting. Planning for this event is in progress. More information will be coming soon.

SPOTLIGHT ON MEMBERS

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

The Austrian Society for Metallurgy and Materials

The purpose of the Austrian Society for Metallurgy and Materials is to support metallurgy, materials technology, and the associated processes in the scientific, technical, and business arena.

The organization has been in continuous operation since 1925 and has active committees in advanced surface engineering, metallography and microstructural analysis, furnace construction and operation, and powder metallurgy. There are also many other active committees.

›› **More information:** asmet.org.

INDUSTRIAL HEATING EQUIPMENT ASSOCIATION

Register for IHEA's Combustion and Safety Standards and Codes Seminars

IHEA will offer the Combustion Seminar and the Safety Standards and Codes Seminar over two days in October in Cincinnati, Ohio.

The IHEA fall seminars will be October 31 and November 1. This year, IHEA will offer the Combustion Seminar and the Safety Standards and Codes Seminar at the Embassy Suites by Hilton — Cincinnati RiverCenter, a convenient venue for the annual training courses. The concurrent seminars are led by IHEA member company representatives who are greatly involved in combustion technology and NFPA 86 working groups. There will also be a combined Tabletop Exhibition and Reception on the evening of October 31 for attendees of both seminars. The networking and after-hours learning are ideal for everyone in the thermal-processing industry.

SAFETY STANDARDS AND CODES

IHEA's popular Safety Standards and Codes Seminar will provide a comprehensive overview of NFPA 86, including the recent updates in the newly released NFPA 86 Standards for Ovens & Furnaces, 2023 Edition. The seminar covers critical safety information for those involved with a wide range of industrial thermal-process applications. Sessions will cover the required uses of the American National Standards governing the compliant design and operation of ovens and furnaces. Speakers are all involved in NFPA and serve on the technical committees, so they can bring the most updated information to attendees.

The two-day seminar provides a comprehensive review of the 2023 edition of NFPA 86, highlighting updated requirements for:

- Class A, B, & C furnaces.
- PLC based burner management systems.
- Safety shutoff valves.
- Safety equipment & application.
- Safety controls & devices.
- Safety shutoff valves.
- Thermal oxidizers.
- Gas line evacuation (purging) & charging.

For more information and registration details, go to www.ihea.org/event/Safety23.

The combined tabletop exhibition and reception gives attendees from both seminars the opportunity to speak with company representatives and learn more about the products and services discussed in the classroom.

The concurrent seminars are led by IHEA member company representatives who are greatly involved in combustion technology and NFPA 86 working groups.

COMBUSTION

For over half a century, the Combustion Division of IHEA has delivered quality education for those in the thermal heat processing industry. IHEA's Combustion Seminar continues to provide attendees with updated and relevant information from experts in combustion technologies. The seminar is designed for those responsible for the operation, design, selection, and/or maintenance of fuel-fired industrial process furnaces and ovens. With more than 12 hours of instruction from manufacturing professionals, attendees will learn from the best in the industry.

Topics covered in this seminar include:

- Fundamentals of Combustion.
- Burners and Nozzles.
- Practical Fluid Flow & Piping Practices for Combustion Systems.
- Radiant Tube Burner Concepts.
- Combustion System Safety.
- Flame Safety and Sequence Control.
- Fuel/Air Ratio Control.
- Enhanced Combustion Efficiency.
- Heat Application — Low Temperature.
- Heat Application — High Temperature.
- Combustion Troubleshooting.
- Optimizing Combustion Systems Performance.
- Furnace and Process Controls.
- Combustion Systems and the Environment.

For complete details and registration information, go to www.ihea.org/event/Combustion23.

TABLETOP EXHIBITION AND RECEPTION

There will be a combined tabletop exhibition and reception Tuesday, October 31. Attendees from both seminars will have the opportunity to speak with company representatives and learn more about the products and services discussed in the classroom. Member companies benefit by connecting with attendees from both seminars during the tabletop exhibition and reception.

Registration fees for the seminars include admission to one seminar, seminar materials, tabletop exhibition and reception on October 31, and lunch and refreshment breaks on October 31 and November 1. Upon completion of the course, seminar attendees will be issued a certificate documenting 15 Professional Development Hours (PDHs). There is a group discount available for two or more registrants from the same company who register at the same time. The first registrant will pay the full registration fee and each subsequent registrant will receive a $125 discount.

For more information on the seminar and registration, go to www.ihea.org/Fall23.

IHEA CALENDAR OF EVENTS

OCTOBER 31

Safety Standards & Codes Seminar

Cincinnati, Ohio I $800 IHEA members / $975 non-members

This seminar is designed for individuals involved in the design, manufacture, service or operation of ovens, furnaces, kilns, dryers, thermal oxidizers and a wide range of industrial applications. It is intended to help the attendee become better acquainted with the newly updated NFPA 86 – Standard for Ovens & Furnaces.

OCTOBER 31

IHEA's Annual Combustion Seminar

Cincinnati, Ohio I $800 IHEA members / $975 non-members

Long the industry premier seminar for industrial process heating professionals, this two-day event offers attendees the chance to learn the latest in combustion technology and visit with industry suppliers during a tabletop exhibition the first day. The IHEA Combustion Seminar is designed for persons responsible for the operation, design, selection and/or maintenance of fuel-fired industrial process furnaces and ovens. Seminar speakers are industry leaders in the combustion industry. Presentations will be non-commercial and promote the technology overall, not a specific product or company.

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

INDUSTRIAL HEATING EQUIPMENT ASSOCIATION

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DR. WILLIAM MARK MCVEA, P.E.
PRESIDENT AND PRINCIPAL ENGINEER /// KBE+

Pack (solid) carburizing is a cost-effective and relatively simple (comparatively) process. But it is not as accurate or controllable as liquid or gaseous carburizing.

Heat treatment techniques overview

EDITOR'S NOTE ›› This is the fourth in a five-part series.

In this fourth installment of my series on heat-treating techniques, I will discuss the pros and cons of pack (solid) carburizing. While it is not as accurate as liquid or gaseous carburizing, it is based on a robust procedure that is easy to manipulate and available to most facilities.

Carburizing is a thermochemical process in which carbon is diffused into the surface of low carbon steels to increase the carbon content to sufficient levels so the surface will respond to quenching and produce a hard, wear-resistant layer. Pack carburizing was in use in Europe as early as the 16th century and was in widespread use through the 19th century. Due to inherent limitations in the process, which I will discuss below, and the increasing demand for higher and higher performance from the steels being produced at the time, its viability rapidly decreased and now has been discounted as an efficient and cost-effective means to produce heat-treated steels today.

The other two common case carburizing techniques, liquid and gas carburizing, can be used to provide surface hardness and case depth according to the part design requirements with a great deal of specificity and consistency. In comparison, pack carburizing involves a process in which steel items are loaded into a furnace in close proximity to high-carbon items. Carbon potential is not as easily controlled compared to normal gas carburizing, and this can limit consistency and specificity.

These high-carbon items in the furnace include everything from carbon powder to cast iron particles, as well as other sources of free carbon. The atmosphere in the furnace is then maintained as simple carbon monoxide released from the high-carbon items without the need to maintain a constant and uniform atmosphere velocity as typically required in the other processes. Pack carburizing is dirtier than atmosphere carburizing. Shallow case depths are not recommended, and the case depth is not consistent. For any real practical purposes, it is simply not possible to measure the carbon potential while pack carburizing. The uniformity of carbon potential in the atmosphere is a function, and very sensitive to the packing of the carbon material.

Pack carburizing differs from gas or gaseous carburizing because, in gaseous environments, the carbon monoxide (CO) gas is supplied to a heated furnace, and the reduction reaction of deposition of carbon takes place on the surface of the part. In pack carburizing, it is supplied by the high-carbon items.

During the process, carbon monoxide derived from a solid compound decomposes at the metal surface into nascent carbon and carbon dioxide. These compounds can be essentially pure carbon (charcoal) to any number of various levels of impurities, such as animal hooves, hide, fat, or even animal horns. This gives the process a great deal of versatility and applicability in regions without sophisticated facilities. Modern pack carburizing is normally carried out using a less-variable carburizing agent, such as charcoal, and an energizer, such as barium carbonate.

The components to be heat treated are surrounded by a carburizing medium / material and placed in a sealed box. The medium is usually coke or charcoal mixed with barium carbonate. The process is really one of gas carburization since, as previously noted, the carbon monoxide (CO) produced dissociates into carbon dioxide (CO_2) and elemental carbon (C), which diffuses into the surface of the component. Temperatures range from 790°C to 845°C for 2 to 36 hours.

Carburizing is a thermochemical process in which carbon is diffused into the surface of low carbon steels to increase the carbon content to sufficient levels so the surface will respond to quenching and produce a hard, wear-resistant layer.

Pack carburizing is the least sophisticated carburizing process and, as a result, remains a widely used method. Selective carburization

or partial carburizing can be done in order to mask or not carburize certain areas of the part. Copper is electroplated to a thickness of approximately 0.05 mm in regions where carburization is not desired. Alternatively, a refractory paste of fireclay mixed with asbestos, or other high temperature neutral material, can be applied.

Some of the drawbacks of this method, as mentioned earlier, are that it reduces the ductility of steel and requires long heating and cooling times. It also tends to produce parts with a little less ductility because it reduces the amount of free ferrite, which is capable of deforming without fracturing. It is the least reliable in terms of the finished part and specifically the surface effect. Granted, it does provide a means to infuse carbon into the part; this diffusion typically does not occur uniformly across an entire body of the part. It is very inefficient in that close control of the case depth and quality is difficult and quenching from the carburizing temperature is not possible.

ACKNOWLEDGMENTS

I would like to thank Maciej Korecki and Tom Hart of SECO/Warwick for their assistance and contributions to this article. Look for an article from Hart to be presented at the 2023 FTM conference in October.

I would also like to thank Michael Tekletsion Berhan (technical expert, Powertrain Gears and Bearings, with Ford Research and Advanced Engineering) who contributed the following addition to my July column, which addressed liquid carburizing:

"While anything with the potential for flexure-like thin bearing rings, toothed slewing rings, or long, skewed needle rollers can be risky with the brittleness in these ranges, classic through-hardened bearings are usually made with UNS G52986 / SAE-AISI E52100 steel at ~0.98–1.10% C. These are similar to the 100Cr6 1% C European nomenclature and the Japanese grade SUJ2. As long as they are loaded fairly evenly and not smashed by impacts to the point of fracture, these work quite well, hence their ubiquity. Fracture concerns did drive the tapered roller bearing field to carburized 0.2% C steels like UNS G86200/SAE-AISI 8620. These allow for greater robustness to high-impact loads with their more friendly softer cores. Low-impact risk tapered roller bearings can be made with the higher carbon through-hardened steels and are used where applicable and economical."

ABOUT THE AUTHOR

Dr. William Mark McVea, P.E., is President and Principal Engineer of KBE+, Inc. which develops complete powertrains for automotive and off-highway vehicles. He is the Principal Engineer with Kinatech, a joint venture with Gear Motions / Nixon Gear. He has published extensively and holds or is listed as co-inventor on numerous patents related to mechanical power transmissions. Mark, a licensed Professional Engineer, has a B.S. in Mechanical Engineering from the Rochester Institute of Technology, a Ph.D. in Design Engineering from Purdue University.

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

The formation of IGO strongly impacts fatigue properties and can severely shorten the expected life of carburized steels. Fast quench rates will reduce that formation.

Intergranular oxidation in carburizing steels

Intergranular oxidation (IGO) in carburizing steels is detrimental to carburized gear performance. It reduces fatigue performance and can contribute to surface spalling. This article discusses the causes of intergranular oxidation and methods to reduce it.

INTRODUCTION

Intergranular oxidation during carburizing has been known for at least 70 years [1]. Intergranular oxidation is caused by the precipitation of oxides of one or more of the alloying elements on grain boundaries. Alloying elements such as silicon (Si), chromium (Cr), and manganese (Mn) have a greater affinity for oxygen than iron. The presence of these internal defects strongly impacts fatigue properties and can severely shorten the expected life of carburized steels used in drive train or other loaded applications.

Near the surface, complex oxides of manganese and chromium dominate [2]. These oxides form as globules within grain boundaries, or within the surface grain. A short distance from the surface, oxides of silicon form a grain boundary network (Figure 1). These internal and surface oxides can act as initiation sites for fatigue, reducing expected life.

Figure 1: Unetched optical micrograph showing surface oxidation in a gas carburized SAE 4320 [3].

Vacuum carburizing, or an oxygen-free gas carburizing atmosphere will eliminate the formation of IGO [4]. Traditional gas carburizing is still widely used for gears, and other highly loaded parts. If gas carburizing is used, the problem of intergranular oxidation will occur.

During the formation of internal oxides, the matrix is depleted of alloying elements. This reduces the hardenability of the alloy at the surface and near the surface [1]. Because of the reduced hardenability, there may be non-martensitic transformation products such as pearlite, ferrite, or bainite formed, instead of the expected martensite. Due to the lower hardenability, increased quench rates are required to prevent the formation of non-martensitic transformation products. However, this can also lead to increased distortion. Increasing molybdenum (Mo) and nickel (Ni) content will increase the hardenability of the steel and reduce the depth of the non-martensitic transformation product depth [5].

EFFECT OF ALLOYING ELEMENTS

The partial pressure of oxygen in a carburizing atmosphere is on the order of 10-20 atm [6]. This partial pressure is reducing with respect to iron, but other oxides have much lower equilibrium partial pressures. The oxides of Si, Mn, and Cr have equilibrium oxygen partial pressures of 10-24 to 10-30 atm. This means that these alloying elements can be selectively oxidized during carburizing. This oxidation usually occurs along grain boundaries because this is a low-energy path for diffusion; however, internal oxidation within grains can and does occur. Additional oxidation can occur during loading or unloading.

Figure 2 shows the oxidation potential of different alloying elements in steel [7]. However, it does not consider the kinetics of reaction, nor does it indicate how much of a particular element is needed for the oxidizing reaction to occur. Parrish [1] considered that elements with a larger atomic number than iron tended to reduce internal oxidation, while those of a smaller atomic number promoted

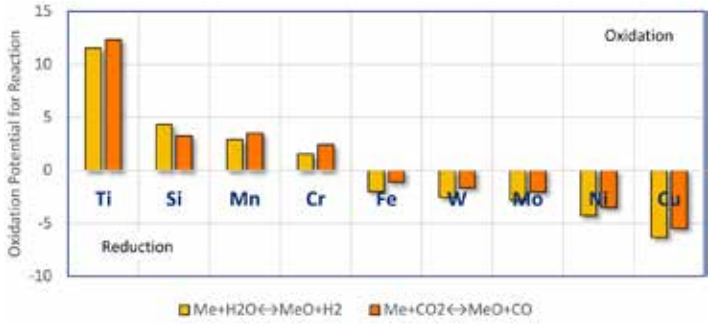
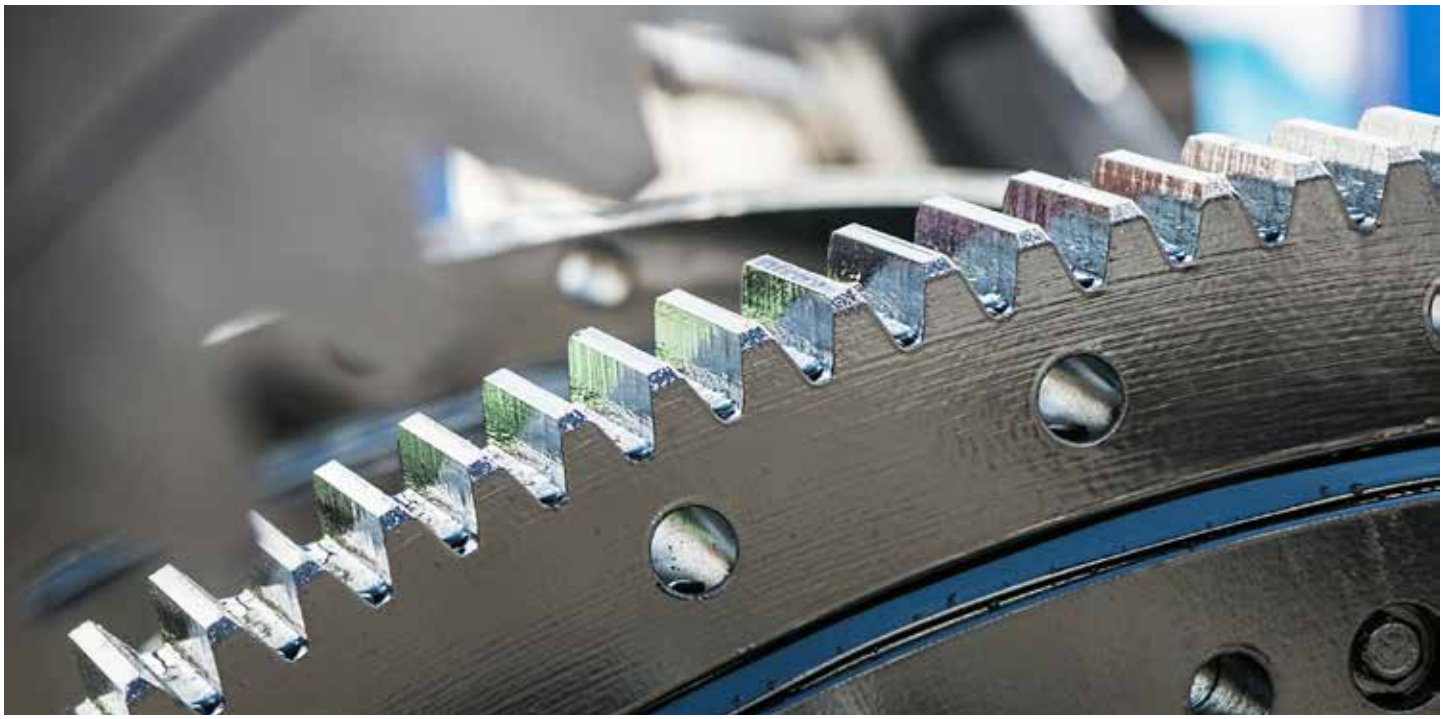


Figure 2: Oxidation potential of alloying elements in steel heated in an endothermic atmosphere [7].

intergranular oxidation. He found that as little as 0.1% was enough of a lower atomic number to cause IGO.In a study of many different alloys, it was found [8] that the internal oxidation depth correlated to the total oxidation potential:

$$P_{IGO} = 4.87[Si] + 3.7[Mn] + 1.47[Cr] - 3.24[Ni] - 1.82[Mo]$$

Another study [9] found that internal oxidation increased with increasing Si, Mn, and Cr content, until it reached a limiting value. Further increases in alloy content decreased the amount of IGO. The limiting value was found to be 0.5-0.6% Si, 0.8% for Cr, and Mn about 2.1%.



CARBURIZING PRACTICE

To minimize intergranular oxidation, it is necessary to minimize the amount of oxygen present. Chatterjee-Fischer [10] found that by increasing the carbon potential, reducing the CO_2 content, IGO was reduced. This was thought to be related to carbon reacting with O_2, reducing the free oxygen potential. For a 1% Cr steel, internal oxidation was minimized when the CO_2 content was no more than 0.2% maximum, while for a 1% Mn steel, the maximum CO_2 content was 0.1% [11]. Edenhofer [12] found that when doubling the CO content from a nominal 20% to 40%, the amount of IGO was doubled.

The time during carburizing has been found to increase with the square-root of time [10]. Increasing temperature increases the amount of intergranular oxidation.

When using nitrogen-methanol atmospheres, the purity of nitrogen matters. In-situ generated nitrogen contains greater amounts of oxygen than does cryogenically generated nitrogen. This means that more IGO will be created with in-situ generated nitrogen than cryogenic nitrogen. Direct injection of natural gas (CH_4) will help scavenge oxygen and reduce IGO.

CONCLUSIONS

In this article, silicon is the most significant alloying element causing intergranular oxidation. It has the lowest free energy of formation. Based on atomic size, Si is much smaller than Cr or Mn, and so has the highest diffusion rate. Higher carbon potential tends to reduce IGO, by carbon reacting with free oxygen. The formation of IGO tends to reduce the local hardenability of the steel, contributing to non-martensitic transformation products at the surface. Only fast quench rates, capable of overcoming the lowered hardenability, will reduce the formation of non-martensitic transformation products.

Should you have any questions regarding this column, please contact the writer or editor. Suggestions for new columns are very much welcomed.

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ABOUT THE AUTHOR

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

TONY TENAGLIER
QUALITY CONTROL MANAGER ///
HITCHINER MANUFACTURING

Beyond the science of rearranging atoms in metal, heat-treaters need to pay attention to the ever-changing variables affecting employee satisfaction and performance.

Transitions and transformations in the workplace

In the heat-treat world, metals are carefully ramped up to certain temperatures to allow for transformation of the microstructure. Temperature and time allow the atoms to energetically form more favorable energy states — atoms are "happy" and content where they are.

Job duties at a company can involve long hours working on a project, and the temperature of the room can sometimes rise with heated meetings over scrap or production efficiency. Time and this type of temperature can transform people as well. But the question is, what is that transformation? And are people really content with staying at a particular position or do they feel the need to "transform" and climb the corporate ladder to make them happy?

I have reflected on this while stepping from a process engineer to a managerial position. What, exactly, does it mean to transform? Does it truly mean to "climb the corporate ladder"? Or does it mean to fulfill one's fullest potential, which might mean being the best process engineer one can be in their career?

With materials that are heat treated in furnaces, the cycle design intent is to optimize a certain range of the material's properties for end use. Same, too, in an organization. Employees have certain talents and skills that, when optimized for a certain position, can result in improved results for the entire company. Not everyone needs to climb the corporate ladder to be a better employee. What people should think about is how they are growing in their current position. That growth isn't always upward.

THE IMPACT OF TIME

The rat race. The mostly unspoken discussion of reaching retirement. We run ourselves on the treadmill of work every day toward the march of retirement when we can eventually kick back and work on our golf game. However, this is a sort of sad way to view someone's life. Psychologist Erik Erikson broke down a human's lifetime into stages, and even then these stages aren't as defined as a working procedure with a statistical process control monitoring a person's true capability at meeting AS9100 requirements.

Time needs to be viewed instead as the opportunity for someone to do meaningful work. Work that helps them grow as an employee and even as an individual. Work that engages them such that it might even become play. I have explored this concept in my previous articles, "The paradox of work and happiness," "The 'why' in heat treating is important to operators," and "Employers need to expand on carrot-stick philosophy."

Therefore, when time is measured at work, it is not necessarily in the hours of work performed. Doing something eight times for eight years is different than doing something eight times a day for eight years. But very often we hear employees describing their work career as, "I've been doing this for 27 years." Really, the statement should be, "I have been trying to be the best process engineer or heat-treat operator or manager for 27 years." That is the true impact of time.

THE IMPACT OF TEMPERATURE

Heat treat doesn't take away from the initial properties in as-cast material; Rather, it transforms it into something new. But the process takes energy. The process is also controlled (thanks to Nadcap and the famous AMS2750 pyrometry spec) such that it allows for the transformation to occur. Allowing for temperature regulation in the work environment is critical at a personal level and among the team.

With materials that are heat treated in furnaces, the cycle design intent is to optimize a certain range of the material's properties for end use. Same, too, in an organization. Employees have certain talents and skills that, when optimized for a certain position, can result in improved results for the entire company.

Let's face it, each and every one of us has gotten angry over a mistake we have made, or a bad remark we received from our boss or even a customer. But there needs to be tolerances for acceptable behavior.

As in heat treating metals, there is a certain setpoint to when the metal simply melts. Hopefully, the workplace environment doesn't cause meltdowns among employees. Recognizing the internal temperature rising and falling was important to me as an engineer navigating the day-to-day of creating and developing the heat-treat process to meet aerospace requirements from the AS9100 and Nadcap requirements. Now, as a quality manager, it's about continual understanding of the temperatures in the team's rise and fall of energy in reaching their true "transformation."

TRUE TRANSFORMATION

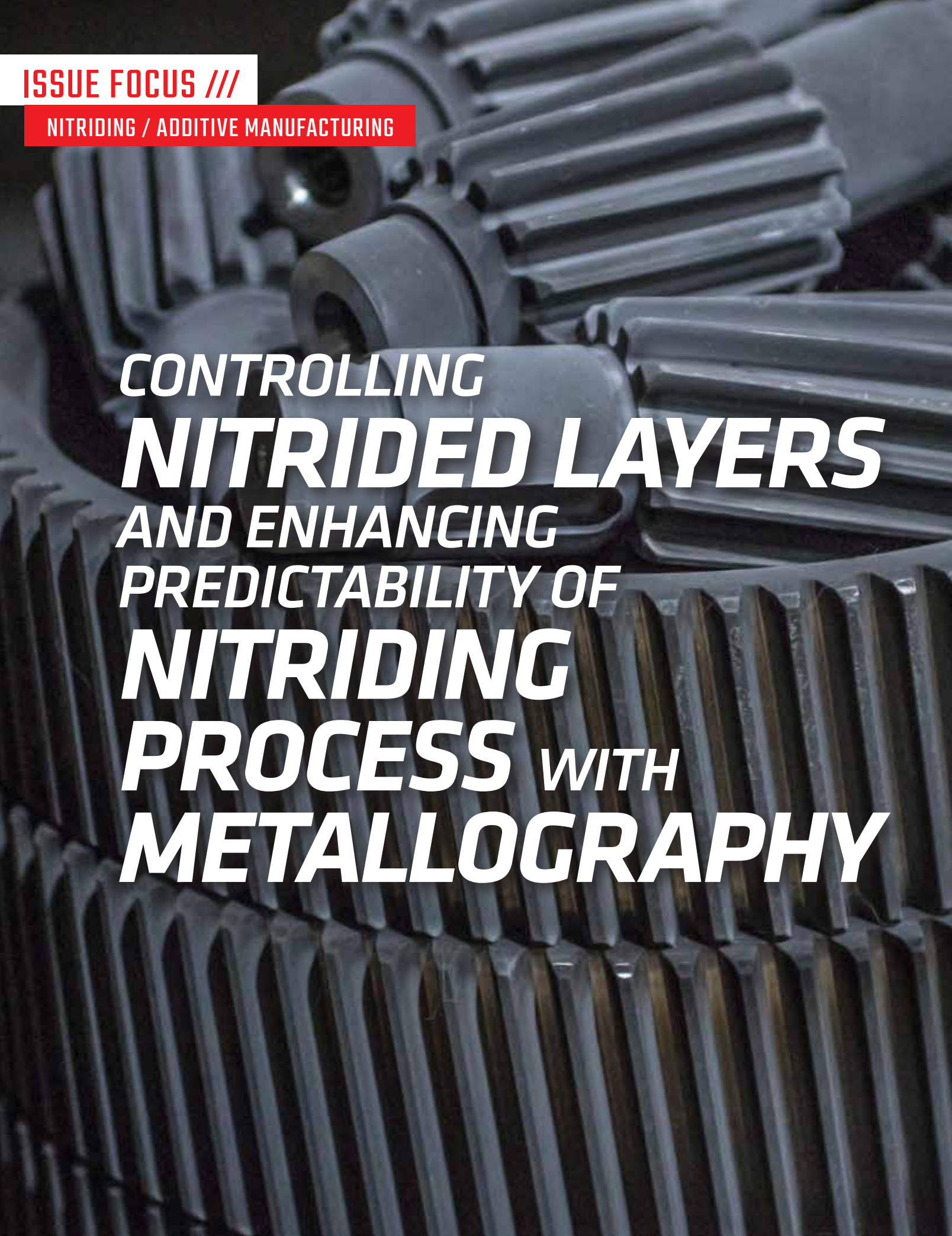
It is suggested in Maslow's Hierarchy of Needs, a psychological model for understanding human motivation, that every human being has the potential to be their fullest selves — to become self-actualized, similar to an acorn having the potential to become an oak tree. A planted seed can grow up in an environment that poses many threats to its growth such as hurricanes, loggers, wildlife, and so on. Constant upkeep is sometimes needed by way of trimming undergrowth or weeds or vines to protect the tree.

In the workplace, I have realized that the upkeep of myself and others is like a forest and the growth of the trees. I have to take care of my own growth as an individual, pruning bad habits and planting better ones in my schedule. As a manager now, I also have to look after the team. Their respective growth requires trimming the nuisance tasks from everyday work to do the work that counts. Peering above the tree line to see the direction the growth is actually going. Aligning the branches to grow toward the sun. Building the necessary walls to have the water flow around so the trees don't get washed away. Stepping up for the team in meetings and giving credit when credit is due.

As a manager, it's now about putting things in place so people don't quit and walk away from a company, to continually engage with them to make the work seem challenging and sometimes even fun so we can all grow together.

ABOUT THE AUTHOR

Tony Tenaglier is the quality control manager at Hitchiner Manufacturing. He earned both a B.S. in material science engineering and an M.A. in psychology. You can contact Tenaglier at tony_tenaglier@hitchiner.com.



CONTROLLING NITRIDED LAYERS AND ENHANCING PREDICTABILITY OF NITRIDING PROCESS WITH METALLOGRAPHY

Metallography of parts is extremely important for verifying results of nitriding and assessing the properties of the layer formed during this thermochemical process.

By EDWARD ROLINSKI, JESSE HYDER, and MIKE WOODS

Nitriding is the thermochemical process for producing surface layers in ferrous alloys, such as steels and cast irons used for making various mechanical components and tools [1]. Ferritic nitrocarburizing (FNC) is a process of nitriding doped with a small amount of carbon [1]. Producing the best nitrided layers for the given application requires a good cooperation between designers of the product and the manufacturing companies making it. Nitriding is a type of heat treating, which has a significant effect on the final properties of the product in improving its tribological properties. It reduces friction and enhances wear resistance of the surface as well as produces very good bending fatigue and corrosion resistance properties. All the above is decided by formation of the proper structure, thickness, and hardness of the nitrided layer. Metallography of the parts, or samples which run together with them, is extremely important for verifying results of this thermochemical treatment and assessing the properties of the layer formed, the data are also used for maintaining a good predictability of the process. It should be noted; however, that surface condition of machined parts may significantly affect the nitriding outcome and should always be taken under consideration [2-4].

METALLOGRAPHIC CHARACTERISTICS OF NITRIDED LAYER

Low-alloy steels

The typical nitrided layer formed in these steels has two sub-layers: the compound zone and diffusion zone. See Figure 1a and 1b. The compound zone increases wear and corrosion resistances, and the diffusion zone enhances the bending fatigue strength of the component.

As it can be noticed, the diffusion layer cannot be easily seen under the microscope in the low-alloying steels such as 4340, 4140, and others. Therefore, it is very useful to measure microhardness of the sample on its cross section to get the information on how deep the diffusion of nitrogen really was and also the hardness of this layer. See Figure 2.

Metallographic data like that above, are also very useful in making proper graphs used for predicting a cycle required for specific components. See example in Figure 3.

Data such as those presented above also can be used for making more sophisticated 3D graphs illustrating nitriding kinetics for various steels such Nit135M, 4140, and others. This information helps metallurgists at Advanced Heat Treat Corp. to write proper cycles for specific steels and the specific case depth requirements and properly set them for variously heat-treated steels with different core hardnesses. A typical kinetic graph is shown for Nit135M steel in Figure 4.

It should be noted that the effective case for this specific Nit135M steel was >50% of total case depth. See Figure 5.

However, it should be remembered that the relationship between the effective case depth's percentage of the total case varies depending on steel and its tempering temperature. Therefore, it is important to note the thickness of the effective case depth depends on the core hardness of the sample used for certifying the load, and it may be different than in the actual parts. As mentioned before, this depends on the tempering temperature of the steel. See Figure 6.

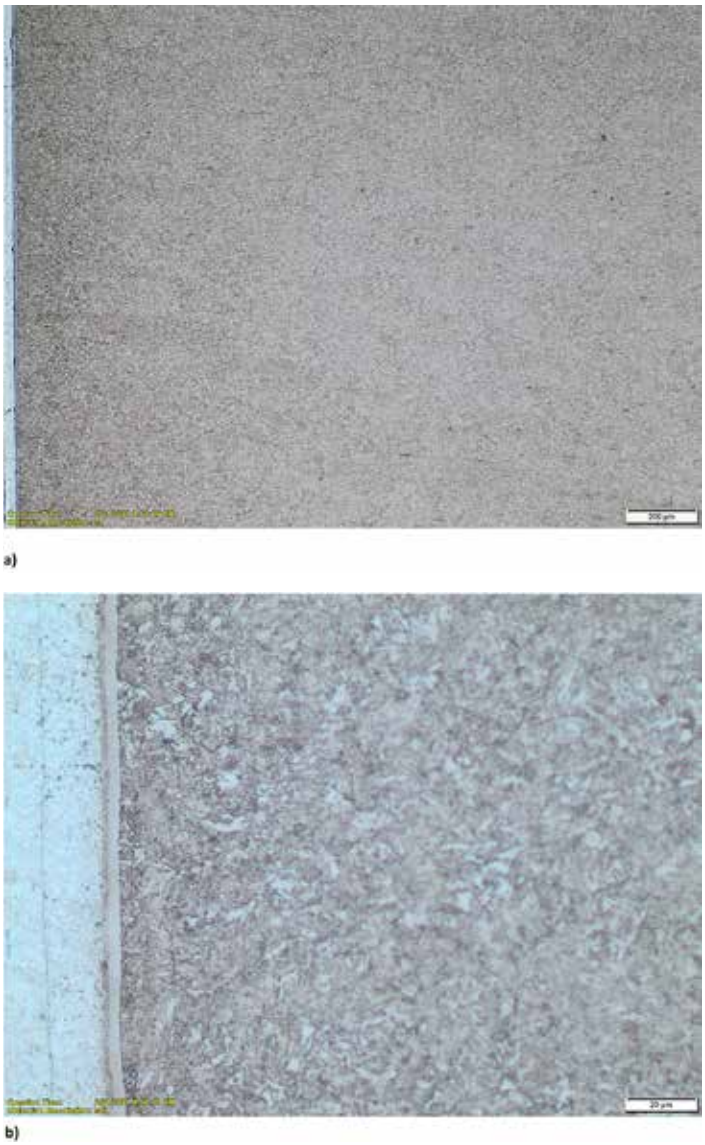


Figure 1: Nitrided layer produced in 4340 steel after the ion/plasma nitriding process at two different magnifications. Etched with 3% Nital. White layer on the left is a nickel foil used for better edged retention.

Plain carbon steels

Nitriding of the plain carbon steels such as 10xx, 11xx, 12xx and other similar carbon steels is oriented on formation of the compound zones

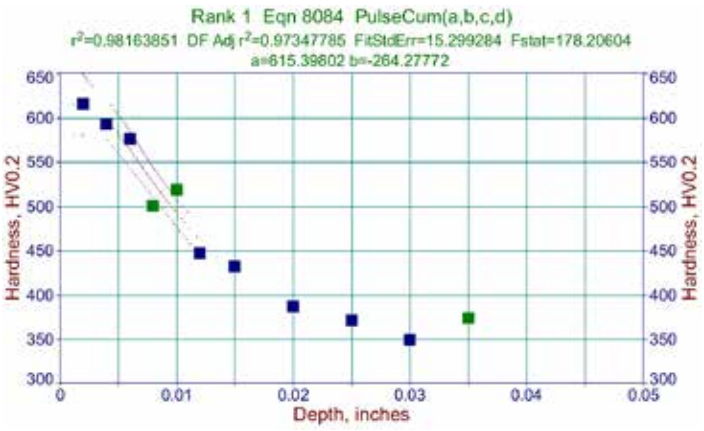


Figure 2: Hardness profile of 4340 sample after ion/plasma nitriding with a load of high-performance crankshafts.

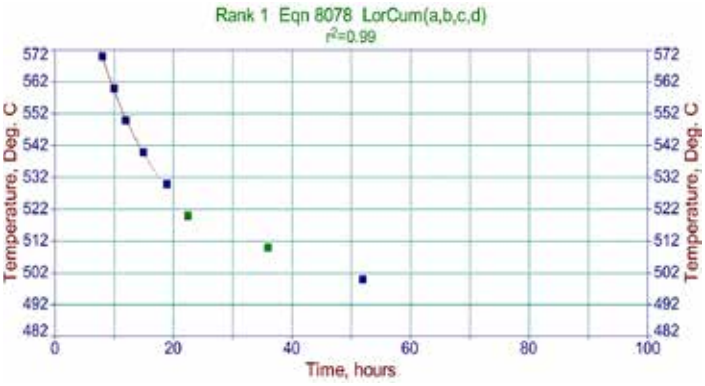


Figure 3: Effect of nitriding temperature and time for producing 0.015" total case depth in 4340 steel.

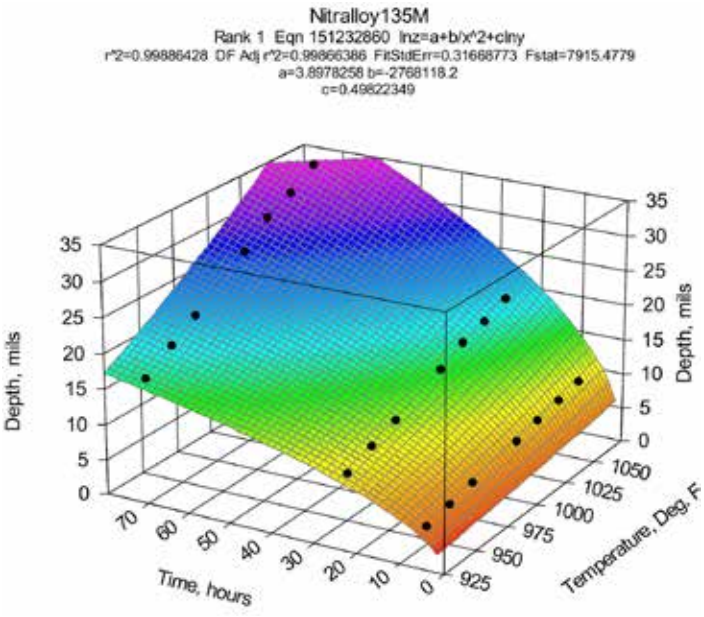


Figure 4: Kinetic data for formation of the total case depth in Nit135M steel processed in the range of 930-1,100°F.

of sufficient, larger than in the low-alloy steels, thicknesses. This is caused by the fact these steels do not form sufficiently hard diffusion zones and also that their typical applications do not require a high bending fatigue strength but rather wear and corrosion resistance. There is a variety of the compound zone structures formed in these

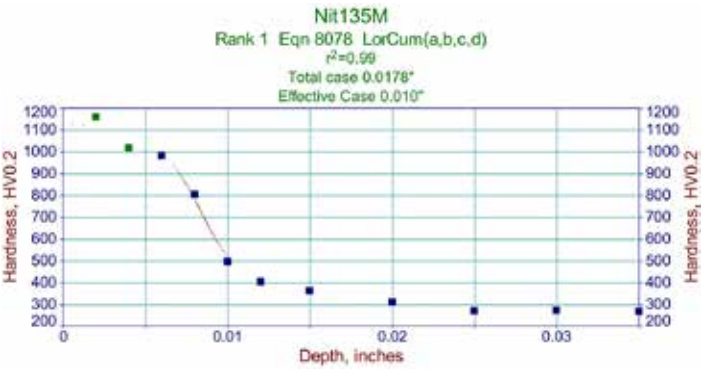


Figure 5: Typical hardness profile in nitrided Nit135M steel sample. The effective case depth was measured at 513 HV (equivalent of 50 HRc).

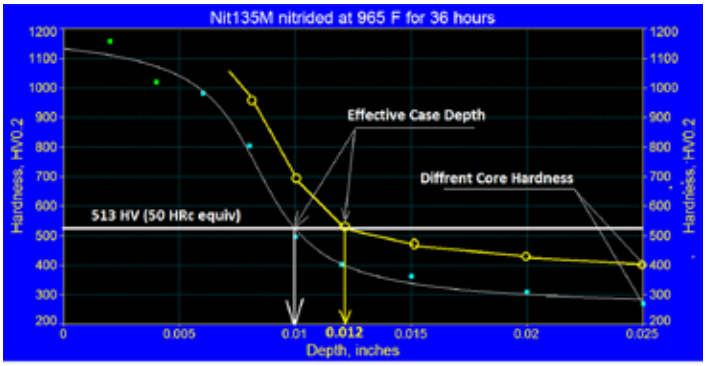


Figure 6: Schematic representation of the hardness profiles for two differently tempered Nit135M steel samples nitrided at the same temperature. Note the difference in the effective case depth.

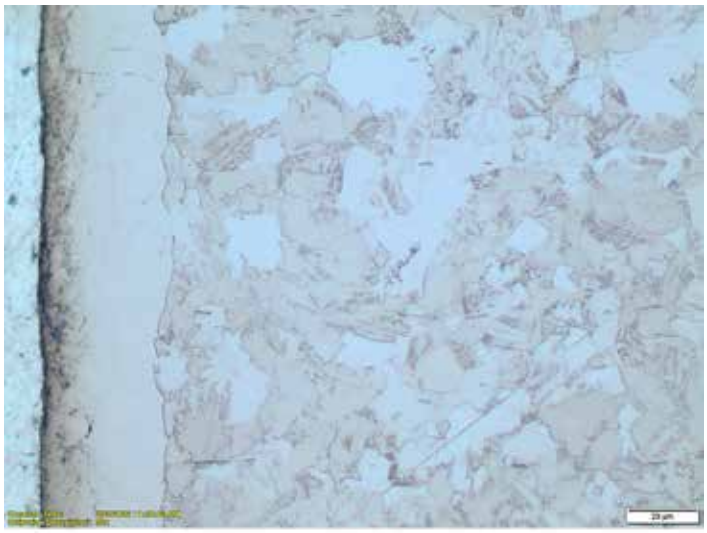


Figure 7: A thick compound zone formed by the gas Kn-controlled FNC process of 8620 steel. Etched with 3% Nital.

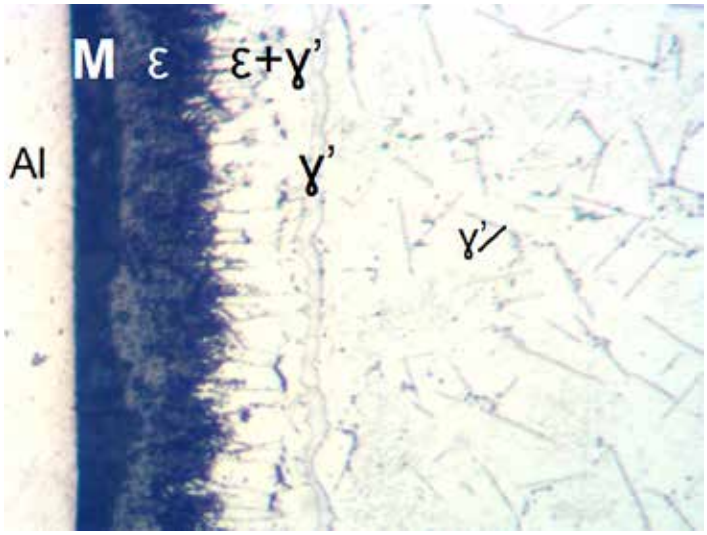


Figure 8: Structure of nitrided layer in the 1018 plain carbon steel after gas nitrocarburizing and post oxidizing. Sublayers from the left are: aluminum foil, magnetite oxide (M), Epsilon $\varepsilon(Fe_2N_xC_y)$ nitro-carbide, epsilon+gamma prime nitrides, γ'-gamma prime (final sublayer of the compound zone). Below there is a diffusion zone with the gamma prime (needles-like) and small $Fe_{16}N_2$ precipitates. Etched with Marbles. 1,000 X.

steels. Some of the examples are shown in Figures 7 and 8.

It also should be noted the total thickness of the nitrided layers in these steels can be assessed by microscopic evaluations without a need for the microhardness testing. Diffusion layer in the carbon steels has typically precipitates of the gamma prime, γ' (Fe_4N) or $Fe_{16}N_2$ nitrides visible in the structure, see Figures 9 and 10.

However, those nitrides might not be visible if a cooling applied after nitriding was sufficiently fast to cause supersaturation of ferrite.

IDENTIFICATION OF SOME OF THE SURFACE DEFECTS AFFECTING NITRIDING

Surface condition of steel parts has tremendous effect on their ability to accept thermochemical treatment such as nitriding or nitrocarburizing [1, 2, 3]. Too aggressive machining leading to distortion of the steel structure, its cold work, burnishing, or inducing tensile stress at the surface may completely stop or inhibit nucleation of nitrides at the surface [1-4]. The same, negative effect on nitriding can be expected from surface contaminations if the metalworking fluids

Figure 9: Structure of nitrided/diffusion layer in 1215 steel. Etched with 3% Nital.

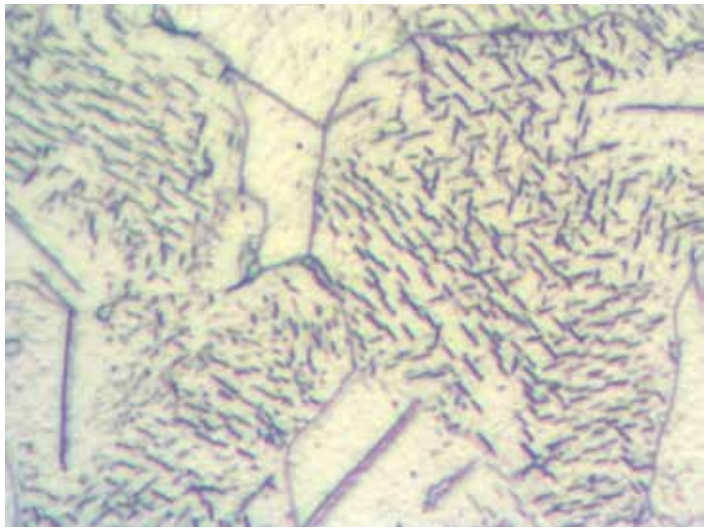


Figure 10: End of the diffusion zone of nitrided layer in 1215 steel. Etched with 3% Nital. Note large precipitates of Fe_4N and small $Fe_{16}N_2$ nitrides. Etched with 3% Nital. 1000X

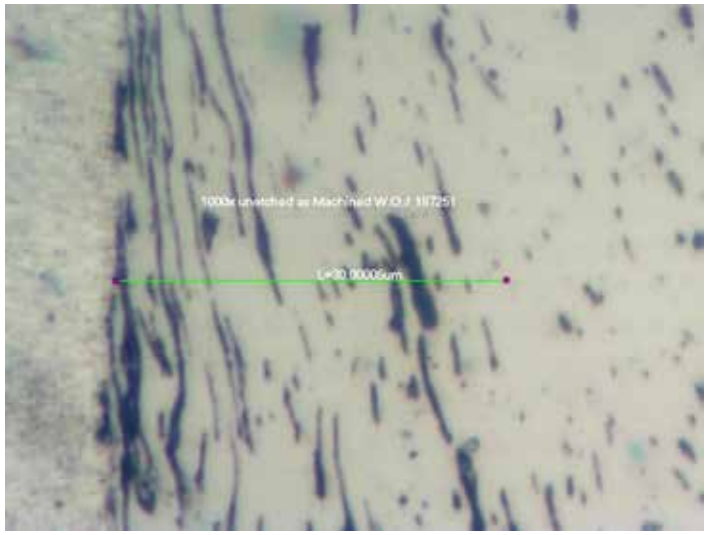
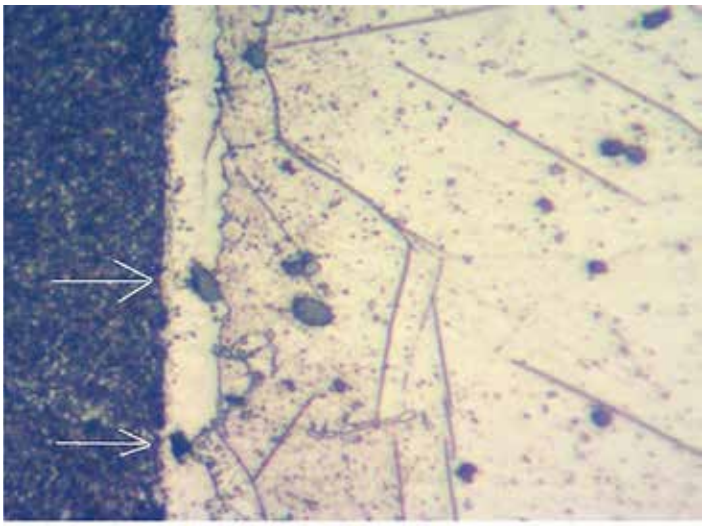
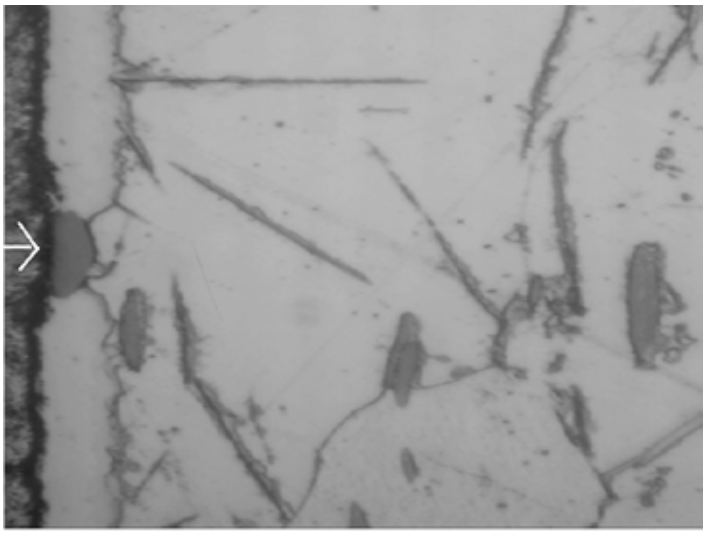


Figure 11: Cross section of as machined part made of 12L15 steel. Note disturbed distribution of sulfides and a possible delineaation of grains near the surface. Not etched.



a)



b)

Figure 12: Structure of the nitrided layer in 1215 steel after fast machining, recrystallize-anneal and gas FNC. Etched with 3% Nital. 500 X. See sulfides at the surface affecting locally thickness of CZ.

and coolants are not completely removed from prior nitriding or FNC [2-4]. On the other hand, compressive stress induced by machining or shot peening into the surface may have a very positive effect on formation of the nitrided layer [4].

The risk of producing unwanted stress condition by machining is very high, and, therefore, general industrial/heat-treating practice is to perform the stress relieving or recrystallize-anneal operation after rough, aggressive machining. After that, final machining should be applied to remove any remaining surface defects or conditions before nitriding or nitrocarburizing can be applied.

Machining operation affects the surface structure of 12xx steel components resulting in distorted grains and a possible smeared surface. Insufficient stress relief/recrystallization after that may result in a condition that affects nitriding or FNC processes resulting in waviness as well as insufficient thickness of the compound zone. Also, effects of sulfides present in the steel cannot be overcome easily. Sulfides are a physical barrier to the diffusion of nitrogen into the steel and, if they are present near the surface (and they are), they reduce effectiveness of nitriding, see Figure 11. Such voids are very likely to occur since the sulfides are present everywhere, and they may locally stop or limit diffusion of nitrogen. These phenomena cannot be controlled by any action of the machinists or heat treaters. Potential defects and surface imperfections of the steels affecting formation of the nitrided layers can be metallographically discovered and analyzed. See an example in Figures 11 and 12.

There is a clear negative effect of sulfides on formation of the compound layer and potential for a local imperfection in properties of it. Nevertheless, those inclusions have no practical effect on wear resistance of the steel but may have negative effects on their corrosion resistance.

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ABOUT THE AUTHORS

Edward Rolinski, Jesse Hyder, and Mike Woods are with Advanced Heat Treat Corp.

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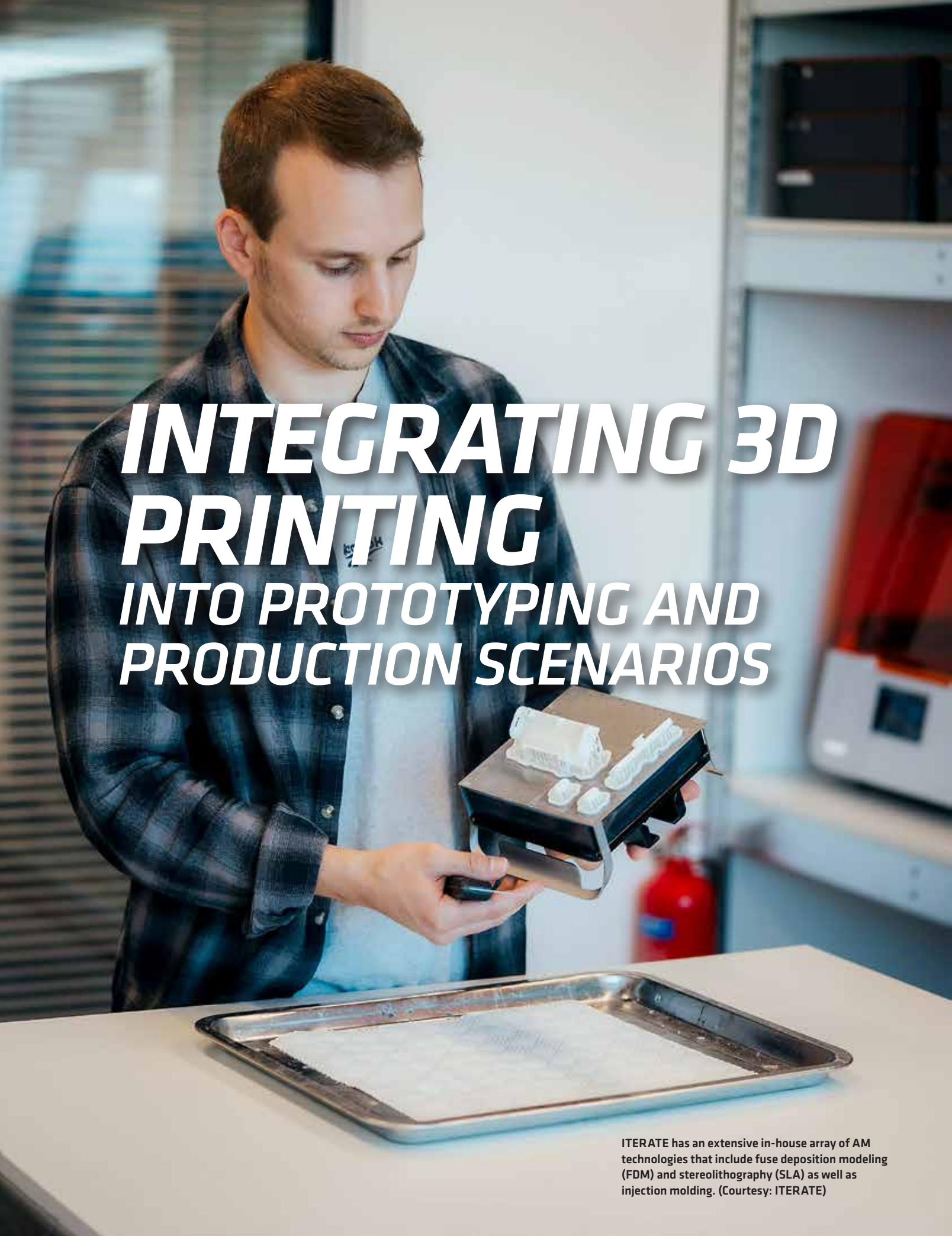

INTEGRATING 3D PRINTING INTO PROTOTYPING AND PRODUCTION SCENARIOS

ITERATE has an extensive in-house array of AM technologies that include fuse deposition modeling (FDM) and stereolithography (SLA) as well as injection molding. (Courtesy: ITERATE)

3D printing and additive manufacturing can be useful tools across many industries, especially when it comes to quickly designing parts.

By JASON PEREIRA

At the recent TCT 3Sixty event in Birmingham, England, 3DPRINTUK ran a competition offering vouchers to be used against the cost of future 3D printing work, which was won by leading design consultancy ITERATE Design and Innovation. Subsequent to this, 3DPRINTUK has worked with ITERATE to consider the use of 3D printing from the point of view of an eminent design agency, when it is a useful technology to be used in prototyping and production scenarios, and when it is best to bring 3D printing in-house, or to outsource to an expert 3D printing subcontract bureau such as 3DPRINTUK. In this article, all things 3D printing is discussed with Gethin Roberts, managing director at ITERATE, and a 20-plus-year veteran working in the rapid product development/3D printing niche.

Can we start by getting a feel for what ITERATE does, and sort of services you offer?

Well, at ITERATE, I guess we are what would best be described as a dynamic team of design engineers that blends creative and technical expertise in order to develop new products from a design concept right through to production. ITERATE is unique within the industry as we enable customers to be "first-to-market" through specialist knowledge of the discipline of Rapid Product Development. After studying a Masters degree in Rapid Product Development and spending a decade working in manufacturing I identified that many businesses are slow to respond to market demands as they take too long to conceive new products. As a result, I developed the "RPD Pathway," which focuses on removing many of the barriers that prevent new products from getting to market. By following this stage-by-stage process, ITERATE can create exciting product experiences within a compressed time-frame, which helps customers to better manage their risk. Using this proven approach, we have successfully developed an array of products for the technology, consumer, industrial, and healthcare sectors.

Within this rapid product development framework, how fundamental is 3D printing/additive manufacturing, and how do you, as a company, use it?

3D printing is at the forefront of our business. Every product we develop goes through an extensive phase of rapid prototyping in order to validate the design and prove every element, from its aesthetic appearance to its mechanical performance. We have an extensive in-house array of AM technologies that include fuse deposition modeling (FDM) and stereolithography (SLA) as well as injection molding. Each process offers different strengths and should be applied based on individual customer requirements. For example, FDM leverages engineering polymers such as ABS, PC, and PA6; however, surface finish is limited due to its layer upon layer bonding method. SLA utilizes light cured polymers that perform less like engineering polymers; however, its laser-based system enables a very high degree of accuracy to be achieved. Through a number of our production partners, we are able to offer additional processes such as vacuum casting, which is ideal for batch production of your product and will provide fantastic likeness to a fully manufactured item.

When you look at how you leverage AM in the product design process, what advantages does it offer over traditional manufacturing processes, and do you still use those, or is it now very much AM being the go-to technology when you're looking at prototyping and production runs?

Yes, we do still use traditional methods. It depends on the nature of the product we are working on. There are some really nice applications where we do actually use AM as the production method. But I think it is important to view AM realistically. It fits within a rapid product development process, just one of a number of tools and management processes that must work together to achieve timely and cost-effective new product introductions. Used in isolation, it can produce parts quickly. But unless you focus on streamlining the whole product development process, this may mean you just end up with a part sitting on your desk for weeks waiting for other process steps to catch up. At ITERATE, we do have in-house desktop SLA and FDM technologies, but these are only used for part validation, to check if parts fit together etc., but they are not suitable for volume production. For this step, we typically outsource to a qualified expert 3D-printing subcontract bureau.

As a company, we do a lot of work in the wearables sector. One customer we have been working with for five or six years, and during that time, their product has evolved massively, with maybe 20 or 30 iterations over the period. For this client, all production is via AM, as it would be financial suicide to retool every time a new iteration was developed. 3D printing is a perfect fit for product development in such dynamic sectors. It has afforded this company the ability to be able to introduce a small batch (maybe a few hundred), go to market, get customer feedback, and then respond with agility to changing customer or market requirements. Traditional manufacturing wouldn't have allowed this, so AM has really provided them with a competitive edge and has allowed them to enter new markets at low risk.

Obviously you're playing on the agility of the manufacturing technique there, but how about its ability to promote design freedom?

Absolutely, that's of huge importance. The wearables product I'm talking about could not be manufactured using traditional production methods. It just wouldn't have been possible because of the geometry and if using traditional processes, it would have to have been designed in a completely different way.

From your client's perspective, the ability to offer AM as a production process opens up all sorts of innovative possibilities for them, correct?

Yes, definitely. If you put the production time savings by using AM

Gethin Roberts, center, is managing director at ITERATE and a 20-plus-year veteran working in the rapid product development/3D printing niche. (Courtesy: ITERATE)

to one side, I think the design time to actually create something for AM requires less thought in many ways than if you are designing for say injection molding or casting. There are design rules for AM, but they are not so onerous. You can design, make a part, revise, make another part etc., etc., and so ultimately design time itself is considerably faster.

Do you find there are limitations to the technology as well?
Yes, surface finish is one. They often still look like printed parts in my view. You know, they're not looking as good as molded parts.

That plays obviously to a big issue at the moment in the sector, which is post processing. When you select a bureau, do you interrogate them about the post processing technologies they have?
Yes, we often have that conversation. It is vitally important now when we are using AM to produce end-use production parts.

What else informs your decision to choose one subcontract bureau over another?
I wouldn't underestimate the importance of delivery times, because that's been a huge problem for us lately. Particularly with Brexit. Some 3D printing agencies are sintering most of their parts in continental Europe. That's a pain as it adds hugely to the delivery time. For some of our customers, they require parts a maximum of 48 hours after design completion. Five days is impossible, but is increasingly what some prominent players are offering. Cost is also important, but I would argue today perhaps a close second to delivery times.

In general terms, what level of understanding of AM do customers have when they work with you? Do they see it as a magic bullet, or today, do they understand that its usefulness needs to be curated intelligently?
There are so many more of our customers today that have actually got 3D printers in-house. And so, they'll come to us, and they might have a proof of concept that they think is suitable, but in many instances, this is not enough. The wrong material may have been selected, for example, or the part is being built in a sub-optimal way in the 3D printer, causing it to fail in certain areas. I think that certainly people understand the benefits of AM more than they ever have, but beyond dabbling, they need the intervention of experts like us and 3DPRINTUK to optimize outcomes.

Finally, in terms of what you're doing, what would tip the balance for you to actually invest in the machines to fulfil AM production in-house?
I don't feel that we could be as efficient as a company that's doing it every single day like 3DPRINTUK. We use bureaus so we can focus on what we do well, designing products. And you know, by using bureaus, we don't have to worry about setting up the machine, optimizing parameters, getting into a whole load of things that we probably could if we wanted to, but we've got so many other things to be getting on with.

ABOUT THE AUTHOR

Jason Pereira heads the creative and marketing team at 3DPRINTUK. 3DPRINTUK are specialists in low volume production using state-of-the-art powder bed fusion (PBF) 3D printing systems with polymer materials. The company bridges the void that exists between prototyping and injection molding, such that if tooling costs are prohibitively expensive for an application that does not require the volume demanded by injection molding, 3DPRINTUK can provide a high quality, cost-effective and fast solution. 3DPRINTUK has mastered the process of 3D printing with polymer powders, with no need for support material, virtually no layer lines and short turnaround times.

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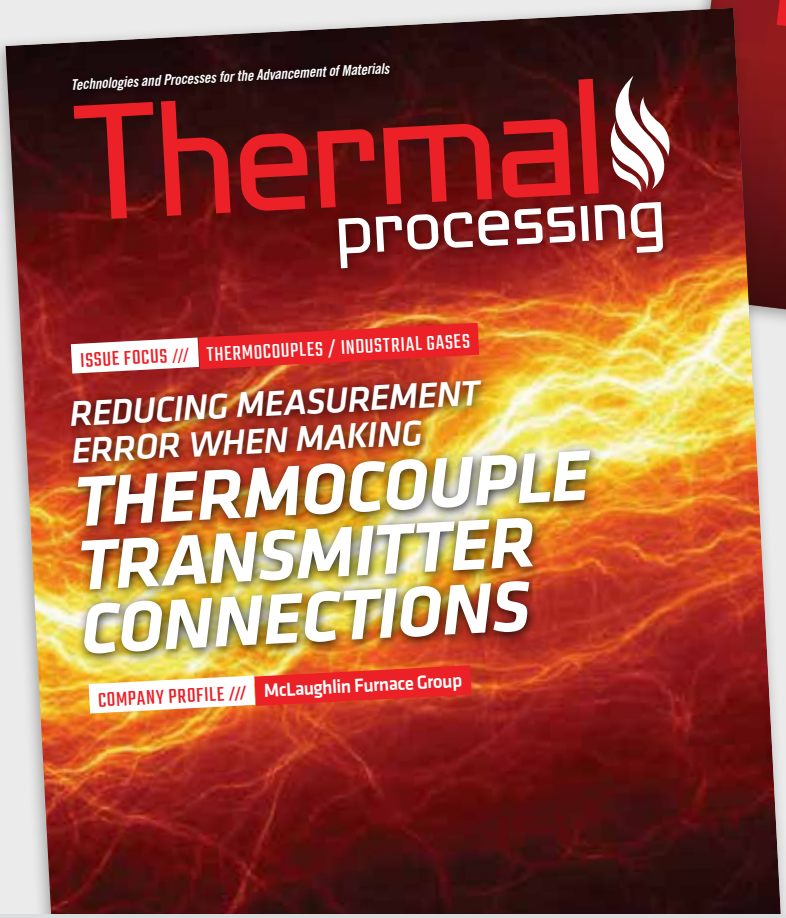

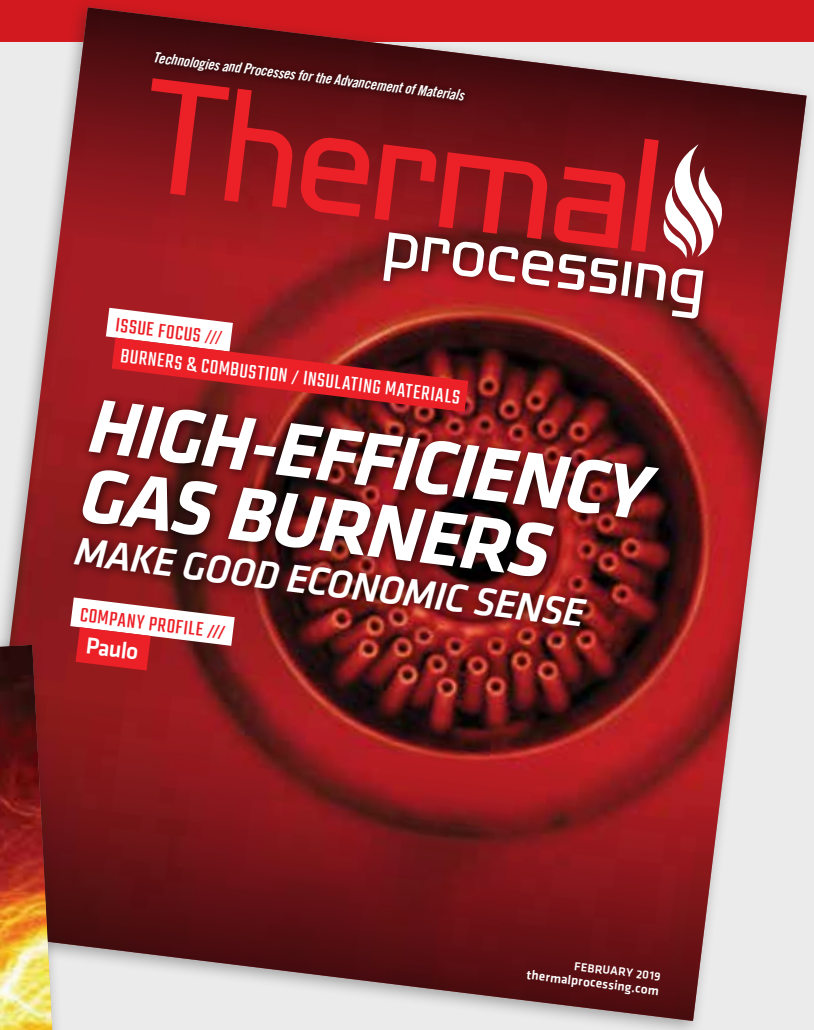

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COMPANY PROFILE ///

ECM USA

NOT JUST A LEADING GLOBAL INDUSTRIAL VACUUM FURNACE MANUFACTURER

ECM Nano Vacuum Furnace with automation. (Courtesy: ECM USA)

ECM USA offers high-quality, low-pressure vacuum carburizing, carbo-nitriding, brazing, sintering, and induction melting furnaces and automated systems for North, Central, and South America.

By KENNETH CARTER, Thermal Processing editor

Due to its ability to adapt to a more environmentally conscious industry, vacuum heat treating has become a linchpin to thermal processing across many sectors.

For the past 25 years, ECM USA has been supplying vacuum heat-treating furnaces and providing leading-edge technology for all industries needing its services, especially for automotive and aerospace.

"Our philosophy is to provide advanced turn-key technology, and that includes environmentally conscious equipment and eco-friendly solutions," said ECM USA General Manager Dennis Beauchesne. "We offer several different products to address these requirements to keep our customers on the leading-edge. It's also very important for us to provide equipment that's maintainable throughout its lifespan."

BROAD RANGE OF EQUIPMENT

The types of equipment offered by ECM USA includes vacuum heat-treatment furnaces, vacuum carburizing, and high-pressure gas quenching up to 20 bar in a cold chamber, according to Beauchesne.

"We have typically supplied large systems that are for continuous batch operation," he said. "Our systems utilize either a tunnel or a vacuum transfer module that bring loads from carburizing cells to gas quench or oil quench cells, and then they exit into external automation with washing equipment for oil-quenched parts, as well as tempering or any other post operations like cryogenics, cooling, or loading-unloading mechanisms."

ECM USA's furnace systems have continuous batch operations that come in fairly standard modules that can be customized based on a customer's needs, according to Beauchesne.

"They're individualized, basically set-up for the specific building layout," he said. "Whether you need something long and lean or something rectangular, we can set it up in different fashions. We also offer a complete line of robotics operations for loading and unloading the heat-treat fixtures, whether it's CFC or alloy."

Automation and robotics are a recent development for ECM USA, and Beauchesne said it has become a big deal for customers with a 1-2-3 furnace or a batch furnace system.

"They seem to be going toward robotics because of the reduction in availability of personnel in the marketplace," he said. "As their prices are being reduced, robotics has become more mainstream. We're seeing more and more applications for them and more requests for robotics integration into heat-treat systems, so that's what we're offering in addition to providing our leading-edge technology so heat treaters obtain a higher quality product."

ECO-FRIENDLY

Part of ECM USA's operating procedure has not only been to offer state-of-the-art equipment, but also to make sure that equipment meets the demand to be eco-friendly, according to Beauchesne.

"We feel like we've been way ahead of the trend, because, in Europe, it's been a big thing," he said. "We have countries that are spending money to buy capital equipment with companies to reduce their carbon footprint. We're seeing it more now in Mexico, too. And there will be carbon taxes, we believe, in Canada coming up soon. I think it's just a matter of time before the U.S. will follow suit. It's starting to be something that any European-owned company in North America is focusing on today."

One of the more fascinating ways ECM USA is evolving to attract the next generation of workers is by shaking up the status quo of not just how equipment functions, but how it looks, according to Beauchesne.

"With vacuum carburizing furnace technology, everything is water cooled, and the furnaces are painted white," he said. "It's a very different look for the heat-treat operation, and it's more attractive for, let's say, the newer generation coming into the work environment."

SYNERGY CENTERS

As ECM-USA thinks outside the box to bring more workers into the industry at large, the company also has developed innovative ways to help its customers, according to Beauchesne.

"We're one of the few companies in the world that has an in-house testing lab or Synergy Center," he said. "We've also developed Synergy Centers within ECM around the world."

These synergy centers are available for demonstrating ECM furnace systems as well as dimensional CMM systems. The centers also contain a full laboratory for metallurgical analysis for part quality and testing, according to Beauchesne.

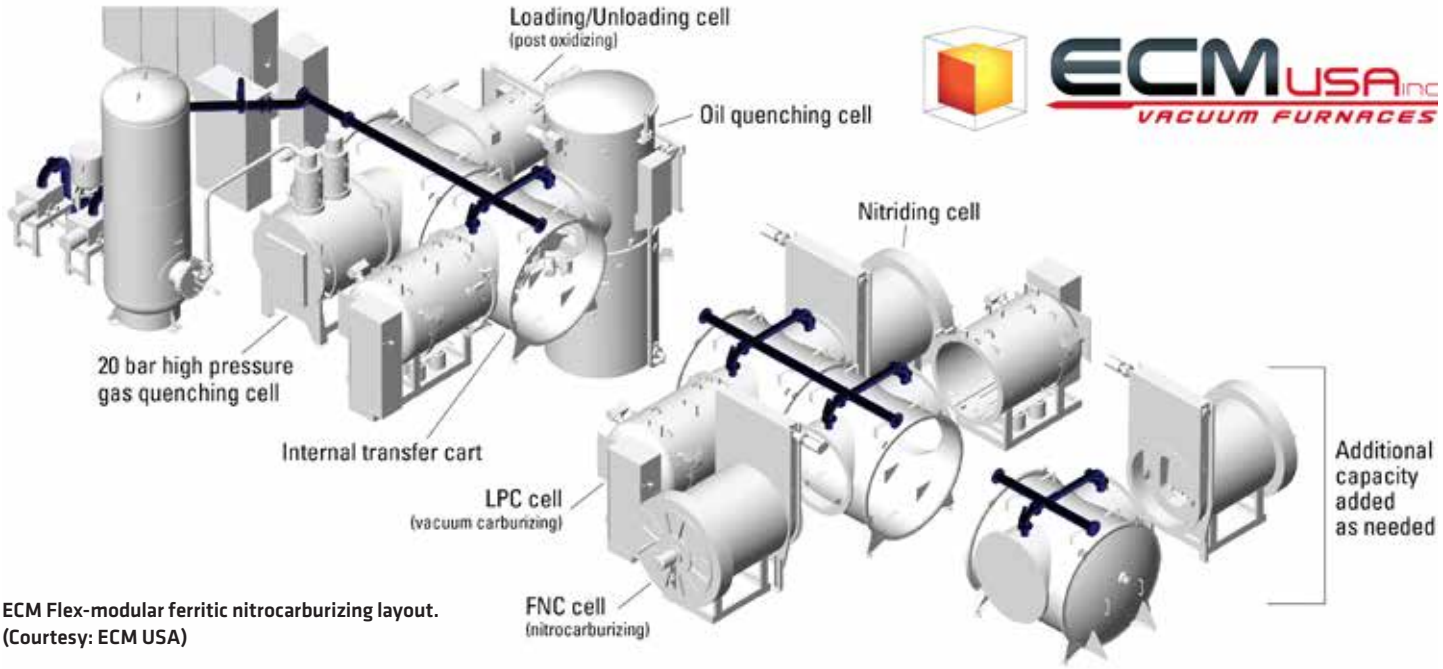
"Customers come to us with distortion, metallurgical, and heat-treating needs with requirements that are very detailed," he said. "That's especially important with what we're seeing in the current market with EV electric vehicles and NVH requests for a much finer tooth and quieter gear. Distortion plays a factor in that, and with our equipment, distortion is key with gas quenching and low-pressure carburizing. We can prove efficiency and suggest process improvements in the Synergy Centers. We have one here in Wisconsin, and one in Grenoble, France, that lets us step up to the challenge with customers."

These services are available for whatever the customer may need, whether it's part of a project or part of a test before a project begins, according to Beauchesne.

"Whichever way they want to do it — we can do the CMM analysis and testing here and share that data," he said. "Of course, we also like to use some of that data for presentations and whitepapers to promote ECM technology, if permission is given by the customer. We can do this type of testing or their specified heat-treat process and send it back so they can do the analysis. There are many different ways."

25TH ANNIVERSARY IN THE U.S.

ECM USA is a French-owned company that is a subsidiary of ECM Technologies, which has been in business since the 1920s. It created its first vacuum furnace in 1964, perfecting its low-pressure vacuum carburizing method in the 1990s. It was around this time when ECM



ECM Flex-modular ferritic nitrocarburizing layout. (Courtesy: ECM USA)

Technologies decided to offer its expertise in the U.S. Through a partnership with Midwest Thermal-Vac, a heat treater in Kenosha, Wisconsin, a joint venture was formed, and ECM USA was born.

ECM USA has been a big influence on many industries over its history, but the company's expertise has had quite an effect on the automotive sector, according to Beauchesne. This year, during the company's 25th anniversary of doing business in the U.S., it can boast the fact that it has sold more than 220 vacuum carburizing cells and more than 45 systems in that short time. A point of pride for Beauchesne during that time has been how much ECM USA has influenced the automotive industry.

"In 2001, our equipment processed the Corvette axle gears, and it was a great pleasure to know that our process was part of that car," he said. "Now, 25 years later, I think you can go on any street or any parking garage and find a car that's been vacuum carburized and has vacuum carburized gears in it. There are many brands, many programs, throughout the world now that use vacuum carburizing through the ECM systems."

ECM Flex system. (Courtesy: ECM USA)

LOOKING TO THE FUTURE

As ECM USA moves forward, Beauchesne said the company will continue to expand and perfect its eco-friendly processes.

"We see ourselves leading that technology to bring heat treaters into a clean environment, an eco-friendly environment, with equipment that will reduce their carbon footprint by over 90 percent and decrease their energy consumption up to 40 percent," he said. "Those are some factors that we know are happening today, and we'd like to keep bringing that technology to everybody — heat treaters, captive and heat-treat shops."

As automation becomes more in demand, Beauchesne said ECM USA will be there to make those transitions as smooth as possible for its customers.

"We want to add more integration into the entire production line of the heat-treat operation — not just at the back of the plant operation anymore, but we're becoming much more involved with streamlining the machining operation," he said. "And with that, we want to make sure that the carbon footprint is lowered while maintaining the high-quality heat treating expected and achieved from our equipment. That's what we want to do."

MORE INFO www.ecm-usa.com

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Q&A /// INTERVIEW WITH AN INDUSTRY INSIDER

JEFF RISSMAN /// SENIOR DIRECTOR, INDUSTRY PROGRAM /// ENERGY INNOVATION

"A transition to clean and modern industry is underway and is going to be increasingly important for businesses going forward."

You're the lead author on the report, "Thermal Batteries: Decarbonizing U.S. Industry While Supporting A High-Renewables Grid." What is your background, and what were your key findings?
I'm the senior director of the industry program at Energy Innovation. We're a nonpartisan clean energy and climate think tank that looks at technologies that can affordably reduce greenhouse gas emissions and promote industry. My report on thermal batteries is a work that I and one co-author, Eric Gimon, did on a new and emerging technology for industrial heating.

Thermal batteries are essentially a way to store thermal energy or heat. They charge using electric resistance and then they discharge by pumping a gas through the storage medium, which is graphite bricks or silicon dioxide sand. The gas absorbs heat from the hot storage medium and then is pumped into an industrial facility where it's used to heat equipment, parts, and materials for processing. Thermal batteries can operate either grid-connected or off-grid.

One key finding of the study was on cost reductions. We found these thermal batteries, inclusive of all costs (so, including their capital costs, levelized over their lifetime, and the energy costs), they can output heat in the locations we studied at $35 to $62 per megawatt-hour thermal, which is roughly one-half to one-third the cost of buying electricity from the grid and is broadly competitive with natural gas pricing. The biggest hurdle to electrifying heat is cost, and this is a technology that can help.

What drove the need to focus emissions challenges to industries other than power and transportation?
Industry is extremely important and has been somewhat overlooked in the past. The industrial sector, or manufacturing, is responsible for about a quarter of the world's greenhouse gas emissions directly. And if you count electricity and steam purchased by industry, it's responsible for about a third. So, if industry is responsible for a quarter or a third of all human emissions, you need to address industry in order to achieve our climate goals and stabilize Earth's climate.

What processes are the most challenging for the heat-treating industry?
Thermal batteries usually are delivering their output in the form of a hot gas. Anything that accepts bulk heat without fine precision is a good fit, like heating a furnace or if you want to treat an entire part, like you're tempering or annealing the entire part. There are other electrical solutions like plasma torches, plasma cutters, or lasers that are excellent at applying heat precisely.

How can your research benefit heat treaters as they look toward the future?
A transition to clean and modern industry is underway and is going to be increasingly important for businesses going forward as policymakers and purchasers of industrial products start to pay attention to the need to decarbonize industry and the need for clean industrial processes. A lot of these technologies haven't been pursued as much in the past, so they're still early in their learning curves, but we'll have cost declines in the future. This is meshing nicely with a policy environment that is increasingly valuing clean production.

For instance, Europe is implementing a Carbon Border Adjustment Mechanism where they're going to be looking at the emissions that went into making certain products. It's the efficiency not of the product itself, but of the process that was used to make the product. If emissions were too high, there will be a tax on the product in order to sell it in the European market. That's a large market, and that's just a start. There are other proposals elsewhere for policies that incentivize clean production — both carrots and sticks. One reason our work has value for industry and for the heat-treating industry is it helps point out these opportunities.

What kinds of technology will be needed to help smooth this transition to decreasing emissions?
There are a wide range of electrical technologies that can provide industrial heating. Thermal batteries are just one. There's electrical resistance heating. There's dielectric heating. I've already mentioned lasers, plasma torches, and plasma cutters. There's also electromagnetic induction and infrared.

Those are just a few technologies that can power industrial processes and deliver heat from electricity.

After addressing these emissions challenges, where do you see the heat-treating industry in the next 10 years?
I think the heat-treating industry is going to be using more electrified processes. It will be more common because the electrified technologies will be more cost-effective. In the U.S., there are federal programs helping with this transition, and they present some great opportunities. The Department of Energy's Industrial Efficiency & Decarbonization Office, the Office of Clean Energy Demonstrations, and the Loan Programs Office all have programs to provide money to help with adoption of new technologies. Certain provisions are in the Inflation Reduction Act also provide support, including the Advanced Energy Project Credit, the Advanced Industrial Facilities Deployment Program, and for firms producing certain energy-related products, the Advanced Manufacturing Production Credit.

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