Thermal processing

SELECTING INDUSTRIAL VACUUM PUMPS

COMPANY PROFILE:
Vacuum Pump Services Corporation

Technologies and Processes for the Advancement of Materials

JANUARY/FEBRUARY 2018
thermalprocessing.com


Change the Way You Work
Augmented reality (AR) has the potential to change the way we see and interact with the world around us. Imagine being able to send out a service technician to repair your heat-treating equipment, and with the addition of AR, he can see its past service history, as well as any notes left by other service technicians. He can also access step-by-step troubleshooting instructions and view a digital overlay of the equipment he will be repairing.
Discover the possibilities of AR at go.IpsenUSA.com/Augmented-Reality
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FEATURES

JANUARY/FEBRUARY 2018

LEGENDARY
PERFORMANCE

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

The BeaverMatic IQF's rugged design combined with a unique load transfer mechanism for high-production output is the reason for so many successful installations around the world.

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- Simplified designs for ease of operation and maintenance
- Reliable, performance proven equipment
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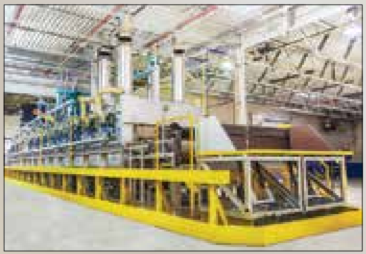
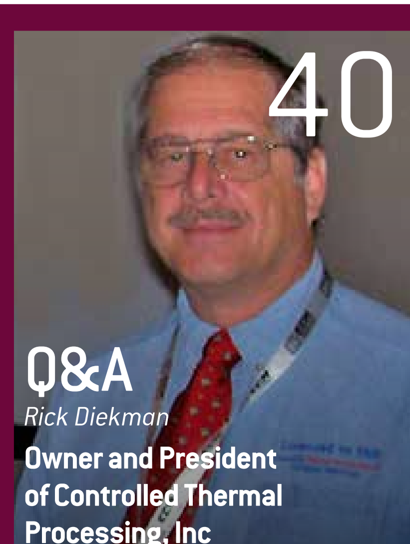



Premier Furnace Specialists, Inc.

BeaverMatic

DEPARTMENTS

JANUARY/FEBRUARY 2018
Volume 7 / Number 1



RESOURCES

Cover photo: Metallurgical High Vacuum Corporation

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LETTER FROM THE EDITOR

Exciting things planned for 2018

Since *Thermal Processing* magazine expanded its coverage of the heat-treating industry last year, we have continued to bring you the latest and best information surrounding the industry on a variety of topics.

And as we begin 2018, we will bring you even more ways to discover what is happening in and around the heat-treating world.

Beginning this month, we will expand our online coverage by offering digital newsletters and social blasts that will keep you in the know on what heat-treating businesses are up to via their Facebook and Twitter feeds as well as a newsletter spotlighting the latest events and news. Our sister magazines — *Gear Solutions* and *Wind Systems* — have been offering these digital bonuses for a while, and it was time for *Thermal Processing* to join in.

Other projects in the works to better serve you are a redesigned website that should be coming online very soon, and we plan to focus on the print magazine and give it an overhaul to enhance the overall look and feel of the important information we will continue to bring you.

And that important information begins in this issue, where you will find the expert advice from our contributing columnists, as well as an article from MHV on selecting industrial vacuum pumps and one from Busch Vacuum Pumps and Systems on finding a reliable vacuum supply for plasma nitriding.

Our Hot Seat columnist, Jack Titus, has graciously pulled double duty for this issue by writing an article on cryogenics and how it is the third parameter required to achieve maximum hardness in ferrous alloys.

And speaking of cryogenics, in our Q&A feature, I had the opportunity to speak with Rick Diekman, founder and president of Controlled Thermal Processing. He expects cryogenics to become an even bigger player in the industry with an exciting process designed to extend the life of parts by up to five times.

Exciting stuff, indeed.

So, it may be the dead of winter, but for the industry, things look like they're really starting to heat up.

I hope you enjoy this issue, and, as always, thanks for reading!

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OPERATIONS

Despite or perhaps because of the current good order situation it is necessary to constantly acquire clients. CastForge helps secure orders for the future. (Courtesy: Heunisch Foundry)

Industry welcomes concept of new trade fair with CastForge

A meeting of interested parties in Stuttgart provided valuable ideas as Messe Stuttgart presented the concept of CastForge, the new trade fair for castings and forgings as well as their machining, to interested companies within the framework of several rounds of talks. There was good feedback from the participants who unanimously welcomed the concept, date, and venue. Since its launch in 2017, CastForge has developed positively with about 60 registrations and more than 30 more commitments. The trade fair is June 5-7, 2018, at the Stuttgart trade fair center.

Gunnar Mey, department director for industrial solutions at Messe Stuttgart, is impressed with the high level of acceptance from the participants.

"After the presentations each time there was a dialogue which gave us, the event organizers, lots of valuable ideas," he said. "However, what we found most encouraging was the concept, date, and venue of CastForge were unanimously accepted."

One participant was Timo Richter, head of sales and marketing at Richter Formteile GmbH. "In our opinion, to date there has not been such a specific trade fair which addresses our products and services precisely — especially not in our catchment area. For us, it is a must-attend event in order to be present on the market. We expect to meet a customer base which is specifically looking for our services and wants to establish new contacts in the industry," he said.

In addition to the current registrations and commitments, mainly manufacturers from Germany and Italy, international industrial associations already have confirmed support for CastForge. The Czech Foundry Association Svaz Sléváren is also planning a joint stand for its members as is the Italian industrial association Confartigianato Imprese Varese.

Ulrich Kromer von Baerle, president of Messe Stuttgart. (Courtesy: Messe Stuttgart)

In addition, Messe Stuttgart is in talks with ASMET (Austrian Society for Metallurgy and Materials) about an involvement in the presentation program.

With CastForge, Messe Stuttgart showcases the entire value-added chain from the cast or forging blank to machining through to the final component and, for the first time, offers manufacturers an opportunity to present their range of cast iron, grey cast iron, and spheroidal graphite iron as well as non-ferrous castings and forgings to a wide audience.

For Ulrich Kromer von Baerle, president of Messe Stuttgart, the validation from the industry is not surprising: "With CastForge, we have launched a trade fair topic at the right time which strikes a chord with companies. Up to now for many companies there was only the opportunity to showcase products and services within the framework of industry and user trade fairs. Now, for the first time, their castings and forgings as well as their skills as processors take center stage at a trade fair."

FOR MORE INFORMATION: www.messe-stuttgart.de

Conrad Kacsik delivers cost-effective control panel retrofit

The thought of replacing costly systems on industrial furnaces can be daunting. Capital expenses can easily reach into the millions, and aging equipment is often made obsolete by process changes or lack of manufacturer support. Allied Machine & Engineering (AMEC) of Dover, Ohio, a manufacturer of hole-making and finishing tooling systems, was experiencing a number of issues with its vacuum furnace controls, which had become obsolete with the manufacturer out of business. AMEC had old controls on its four furnaces, and that was leading to considerable downtime — expensive equipment was idle due to control issues.

AMEC sought Conrad Kacsik to perform a comprehensive review of its systems. The company wanted to avoid overpaying for services it didn't need or want, but also wanted to ensure its systems were running optimally. While conducting preliminary research, Conrad Kacsik impressed AMEC by uncovering some unmet needs while speaking directly with AMEC furnace operators to understand how the company worked with its furnaces. AMEC ultimately chose Conrad Kacsik because the proposed control panel solution delivered ease-of-use and innovative features. Conrad Kacsik's experience, full-service capabilities, proven track record, and expertise — demonstrated by its Nadcap compliance consulting and other leading-edge work — helped AMEC make the final decision to hire Conrad Kacsik.

Conrad Kacsik did more than facilitate the installation of AMEC's new Honeywell HC900 control panel. The comprehensive job centered on the control panel but brought considerable automation and simplified a number of processes for AMEC.

Conrad Kacsik maximized value by using all of AMEC's viable equipment to create a reliable vacuum furnace system. AMEC had good starters, relays, and furnaces, so Conrad Kacsik built around that infrastructure to deliver all the benefits of a new system while using as much existing hardware as possible.

"We had four unreliable furnaces with old controls," said Bryan Cope, manager of heat-treating at AMEC. "Now, everything is more dependable. We have more uptime, and if there's a problem we can quickly understand what went wrong and resolve it. We record everything along the way."

The new control panel offers many advantages:

- Ease of use: Employees only need to learn one system, one time.
- Long-term support: Parts and factory support are readily available, and AMEC is not tied to Conrad Kacsik or any other vendor for that support.
- Improved features: Running, monitoring, and collecting data is streamlined, simplified, and made more reliable with the latest software.

Conrad Kacsik is a one-stop shop. The company is able to evaluate systems, provide training and consulting services, deliver engineering advice, and install systems. And everything they do is backed by deeply committed expert service.

FOR MORE INFORMATION: www.kacsik.com

Ipsen announces 2018 schedule for heat-treatment training

Ipsen will host another series of Ipsen U classes throughout 2018. Designed to teach heat-treatment fundamentals while also sharing best practices and new methods, Ipsen U is a three-day course where attendees can gain hands-on experience. Courses are available April 3-5, June 5-7, August 7-9, and October 2-4.

Throughout the course, attendees are able to:

- Learn about an extensive range of topics – from an introduction to vacuum and atmosphere furnaces to heat-treating, furnace controls, subsystems, maintenance and more
- View the different furnace components firsthand while learning how they affect other parts of the furnace and/or specific processes.
- Take part in one-on-one discussions with Ipsen experts
- Participate in a leak detection demonstration
- Tour Ipsen's facility

2018 Ipsen U classes offer an opportunity for hands-on learning at all experience levels. (Courtesy: Ipsen)

A forum where all levels of experience are welcome, Ipsen U instructors believe in using the participants' specific questions and interests to shape the hands-on class. Past attendees have appreciated the instructors' "incredible amount of knowledge, hints, tips, and real-world advice."

The Ipsen U classroom features comfortable seating for up to 36 attendees, as well as integrated technology with a large smartboard and two additional monitors for interactive presentations and demonstrations.

FOR MORE INFORMATION: www.IpsenUSA.com/IpsenU

Lindberg/MPH Ships hot stamping furnace to automotive supplier

Lindberg/MPH announced the shipment of an electrically heated three-chamber batch furnace to an automotive supplier. This multiple chamber furnace system will be used to preheat steel blanks to be used for hot stamping structural automotive components. The usage of multiple independent chambers means that multiple blanks can be simultaneously preheated resulting in reduced cycle times.

The three-chamber batch furnace has a maximum temperature rating of 1,920°F and work chamber dimensions of 102" diameter x 102" depth x 14" high. The furnace features inert gas atmosphere controls on one chamber, which will allow the customer to use a nitrogen gas atmosphere. Each chamber has three zones of heat to control temperature uniformity throughout the entire workspace. A cooling blower provides airflow between the three chambers and over-temperature protection is provided for each chamber.

The parallel arm doors actuate quickly to load and unload blanks, which keeps heat loss to a minimum. The refractory lining is constructed from vacuum-formed ceramic fiber modules that heat up quickly and have low heat storage. Five monitoring thermocouples will be supplied in each chamber to help profile the heat during the process development. A programmable logic controller performs temperature control, as well as logic and switching functions. The controller also offers Ethernet and Modbus-485 communication interfaces and is capable of archiving furnace time/temperature profiles.

"The three zones of hot stamping furnace have been tested for uniformity using multiple data points to ensure it is on par with our high-quality standards," said Jason Dobberstein, application engineering manager.

Features of this Lindberg/MPH electric batch furnace include:

- Vacuum-formed ceramic fiber modules with low-heat storage for fast heat-up rates .
- Three heating zones in each chamber.
- Independent parallel arm doors.
- Multiple heating chambers.
- Multiple point uniformity test..
- Inert gas atmosphere addition
- Raised pier hearth.
- Programmable logic controller.
- Exterior cooling blower.

FOR MORE INFORMATION:
www.thermalproductsolutions.com

500° F special cabinet oven from Grieve

No. 994 is a 500°F (260°C) special cabinet oven from Grieve, currently used for heating the end of long parts at the customer's facility. Workspace dimensions of this oven are a tapered 10" at front and 20" at rear wide x 20" deep x 21" high. 9KW are installed in Nichrome wire heating elements, while a 600 CFM, ½-HP recirculating blower provides vertical upward airflow to the workload.

This Grieve cabinet oven has 4" insulated walls and an aluminized steel interior and exterior. Features also include safety equipment for handling flammable solvents, including explosion venting door hardware.

Controls on No. 994 include all applicable NEMA 12 electrical standards and a tower light to indicate machine status.

FOR MORE INFORMATION:
www.grievecorp.com

Gruenberg Oven reports steady growth in 2017

2017 was a strong year for Gruenberg Oven, a division of TPS, in the pharmaceutical, medical, and lab animal science industries. Gruenberg has seen a steady increase in sales to the pharmaceutical industry of pharmaceutical sterilizers and granulation dryers used for drug manufacturing. Gruenberg's stainless steel, continuous weld design is ideal for the pharmaceutical industry as it mitigates cross contaminants to the products being sterilized. Another strong area of product sales were the Cleanroom systems used for sterilization of medical devices by the laboratory and medical industries.

The Gruenberg SteriDry™ dry heat sterilizer series has seen year over year growth in the lab animal science industry as it provides a greener, more cost-effective solution than the traditional steam autoclaves used in years past for sterilization of animal cages. The SteriDry saves on utilities by requiring no water, saves on floor space with a minimal footprint, and offers ease of installation with a modular design. 2018 is expected to see continued growth for the SteriDry, as the demand for eco-friendly, space-saving equipment continues to rise.

"Gruenberg has seen steady growth throughout 2017. The experienced engineering team develops customized solutions for the most stringent specifications. These design capabilities play a key role in our success in the pharmaceutical and medical industries. Another area of growth is Gruenberg's dry heat sterilizer technology used in the lab animal sciences industry. This is a technology we expect to see continue to gain market share in the years to come," said Dave Strand, president & CEO of Thermal Product Solutions.

Gruenberg, a division of Thermal Product Solutions, LLC, is recognized as a leader in the design and manufacture of a comprehensive line of standard and custom industrial batch and conveyor ovens that accommodate temperatures up to 1,200° F.

FOR MORE INFORMATION: www.thermalproductsolutions.com

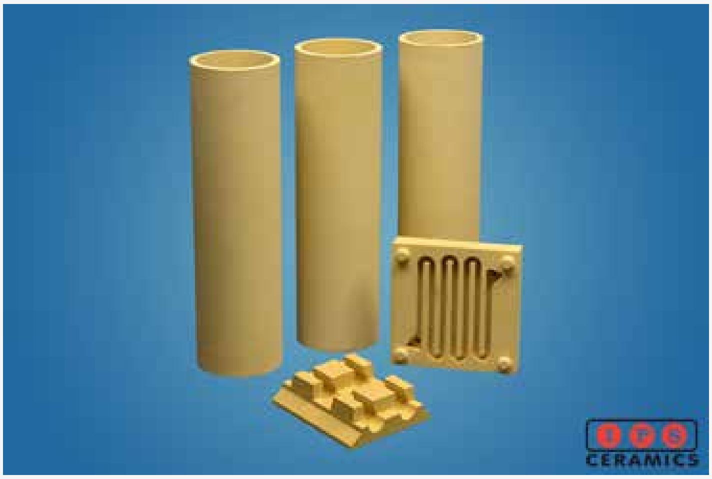
U.S. launch for specialty cordierite ceramics

IPS Ceramics USA has announced that one of the brand-new lines being launched at Ceramics Expo 2018 (May 1-3, 2018, Cleveland, Ohio) will feature two types of cordierite ceramic.

Cordierite ceramics are well known for their exceptional resistance to thermal shock. They are often used for components that are subject to rapid thermal cycling, in applications where other ceramic materials would quickly crack or break. This can include anything from high-performance kiln furniture to catalytic converter honeycombs.

Cordierite products are fired close to 1,400°C (2,550°F) to give a material that is volume stable in service (temperatures up to 1,300°C/2,370°F). Products are thermally and electrically insulating and are often used as lead-in tubes or as supports for wire heating coils.

IPS offers two grades of cordierite; porous cordierite (C520) is best for thermal shock resistance and use at higher temperatures, while non-porous cordierite (C410) is stronger and impermeable. The manufacturing processes (extrusion, pressing, and injection molding) allow a wide variety of shapes and sizes to be produced.



Examples from the new IPS cordierite ceramics range. (Courtesy: IPS Ceramics)

This offers the customer an attractive mix of design flexibility and high-temperature capability.

The team at IPS has 200-plus years of experience in the design, manufacture, and sale of cordierite ceramics and will offer its expertise to visitors from all industrial sectors. These products are supplied on a worldwide basis.

IPS Ceramics USA will exhibit at Ceramics Expo 2018 at booth 441.

FOR MORE INFORMATION: www.ipsceramics.com

Lindberg/MPH ships 1,200° C tube furnace

Lindberg/MPH announced the shipment of a 1,200° C single zone tube furnace to a manufacturer of electronic components. The 1,200° C tube furnace offers exceptional radial and linear temperature uniformity, process repeatability, rapid heat-up and response, and requires minimal maintenance. It is ideal for annealing, ashing, carbon firing, ceramic firing, hardening, sintering, solution treating, stress relieving, and other heat-treating applications.

The temperature range of this tube furnace is 100° C to 1,200° C and the work chamber dimensions are 3" to 6" diameter x 36" heated length. The tube furnace can be used for horizontal or vertical operation. The furnace shell is designed with two highly effective insulating air spaces, which results in lower exterior surface temperature than other designs. The 1200° C tube furnace uses a Eurotherm programmable controller that offers multiple programs and uses PID control and auto-tune for fast, efficient start up. The over-temperature control protects the furnace and load from over-heating.

"The split-hinge design of this tube furnace allows for easy observation, fast cooling, and convenient placement of the process tube. It provides overall ease of operation for the customer and can be used for processing a variety of material such as ceramic, quartz, or alloy process tubes," said Shaina Scott, applications engineer

Features of this Lindberg/MPH 1,200° C single zone tube furnace include:

- Designed for horizontal or vertical operation.
- Patented Moldatherm® LGO™ heating element modules.
- Long-life, energy efficient elements.
- Unique cabinet design.
- Heat-reflecting element support assembly.
- Compact cabinet with high temperature resistant painted finish.
- Accepts interchangeable Moldatherm® tube adapters.
- Long-life Platinel® II thermocouple(s) with 10' compensated lead wire and polarized plug.

The Lindberg/MPH 1,200°C single zone tube furnace can be used for horizontal or vertical operation. (Courtesy: Lindberg)

FOR MORE INFORMATION:
www.LindbergMPH.com

Ipsen granted U.S. patent for advanced loader design

Ipsen was recently awarded U.S. Patent No. 9,719,149 B2 for the development of a new load transport mechanism that can move a load within a multi-station heat-treating system. Chief Engineer Craig Moller, Director of Engineering and Supply Chain Kevin Woerner, and Dr. W. Hendrik Grobler — the named inventors on the patent — began developing this design five years ago.

This newest patent joins a long list of patents dating all the way back to the time of Ipsen's founder, Harold Ipsen, in the 1950s. With nearly 100 U.S. granted patents, as well as numerous patents granted in countries around the world, the many advances and contributions Ipsen has made to the industry over the decades is clear. Today, Ipsen remains committed to innovation and finding new ways to improve heat-treating systems, ancillary equipment, and modes of operation.

With many of Ipsen's patents still used in some form, the advanced design and thinking behind each invention influences, and lives on in, everything Ipsen builds today. Ipsen is proud to add this newly patented loader design to its long list of reliable, innovative creations as it continues to engineer and manufacture advanced, highly technical equipment for special applications.

Ipsen has nearly 100 patents, dating back to the 1950s and founder Harold Ipsen. (Courtesy: Ipsen)

FOR MORE INFORMATION: www.IpsenUSA.com/Patents

Nutec Bickley acquires Olson Industries

Nutec Bickley (Monterrey, Mexico), the international leader in the design and manufacture of innovative and efficient industrial furnaces, ovens, ceramic kilns, and combustion systems, recently announced the key asset acquisition of Olson Industries (Burgettstown, PA, USA).

This major move will see Nutec Bickley complement its existing product range to offer more complete packages for the steel, aluminum, and alloy industries. As with the previous acquisitions of Bickley, GFC Kilns, and Dragon Kilns in the company's Ceramics Business Unit, bringing the Olson Industries' line of equipment on board will enable the Metals Business Unit to consolidate its position in the North American market and, at the same time, secure access to larger projects.

Olson Industries' large rotary hearth furnace. (Courtesy: Nutec Bickley)

To consolidate the acquisition and to maintain good strands of continuity, it has also been announced that, as part of the transaction, Bryan Kraus (president and owner of Olson Industries) will be engaged in Nutec Bickley's Metals BU, providing guidance and assistance in related activities such as technical sales and engineering.

Olson has been supplying industrial furnace and process heat-treating equipment to manufacturers throughout the world since 1945, and it enjoys a strong reputation for engineering and combustion design.

"We are very excited about Olson Industries and Bryan Kraus joining the Nutec Bickley family," said Nutec Bickley President Daniel Llaguno. "Olson's name and proven technology for the forging and heat treating of steel and alloys will perfectly complement our current range of products. We aim to make great strides as a result of this acquisition."

Olson's expertise encompasses everything from car bottoms, box, rotary hearth, steckel and roller hearth furnaces, in applications such as forging, heat-treating, continuous reheating, hot dip galvanizing, recirculation, and preheating. Great success has been achieved in major user industries such as steel, heat treatment, aerospace, automotive, and oil and gas.

"Applications such as large rotary-hearth furnaces, and peripheral equipment such as quenching systems, manipulators, robots, and conveyors will now be a standard offering from us," Llaguno said. "If you couple that with Nutec Bickley's state-of-the-art facilities, highly experienced staff, and constant focus on customer satisfaction, you can see that there is indeed a very powerful value proposition on offer to both existing and new customers."

FOR MORE INFORMATION: www.nutecbickley.com

Intercoat®Chemguard is a new type of corrosion protection

Permanent corrosion protection is more effective and less expensive than standard heavy-zinc galvanize. A leading coil coater and manufacturer of proprietary coating chemistries has recently introduced InterCoat®ChemGuard, a new type of corrosion protection for galvanized steel.

InterCoat ChemGuard uses a new type of coating technology that uses covalent bonds, enhances the effectiveness of zinc, and substantially improves corrosion protection on galvanized steel. Standard practice for protecting metal from corrosion for approximately the last 70 years has been to coat it with zinc. Heavier zinc coatings have normally been applied to provide longer protection. Until now, this was the industry standard practice.

InterCoat ChemGuard, instead, reacts with the zinc to form a permanent, covalent bond on the surface of the metal. The product is applied over a light layer of zinc, which reacts with the zinc to dramatically improve its corrosion protection properties. The bond formed at the molecular level cannot be washed or worn off. This is different and more effective than the typical barrier coating. This revolutionary process allows bending, stamping, post-painting, and even shearing, while providing self-healing characteristics that help protect newly exposed zinc that naturally occurs during secondary processing.

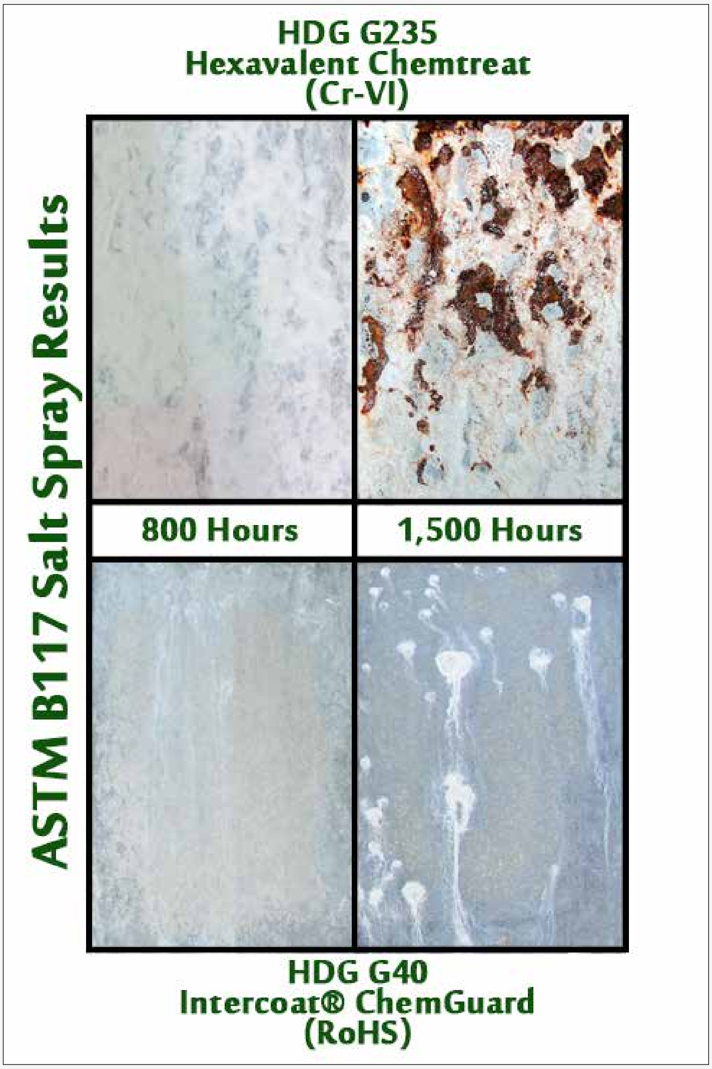
InterCoat ChemGuard is a major development for any user looking to extend the corrosion resistance of galvanized steel. The product is RoHS compliant and continues to protect during stamping, roll forming, shearing, and is weldable. With a low coefficient of friction, it actually enhances these processes. InterCoat ChemGuard is designed to be applied on the galvanize line or, for custom formulas, by the original coil coater and developer of this unique compound.

InterCoat ChemGuard offers significant cost savings because it allows for lighter zinc to form the bond. It is not necessary to apply heavy zinc; it reduces the need for zinc coatings heavier than G30, in many applications on the market today. The product also eliminates the need for temporary corrosion protection coatings, often used in shipping and materials storage, including hexavalent chrome, a known carcinogen, making it more environmentally friendly for all building, architectural, transportation, and consumer appliance applications.

It is applicable to many industries, including automotive, aerospace, construction, electrical conduit, wall studs, furniture, fixtures, appliances, outdoor and highway railing, agricultural, lawn and garden, and other products using galvanize.

FOR MORE INFORMATION: www.lowerzinc.com

G40 bare, left, after 144 hours and G40 with InterCoat®ChemGuard, right, after 2520 hours. Test: ASTM B117 salt spray. (Courtesy: Chemcoaters)



G235 treated with Hexavalent Chemtreat, top, vs. G40 treated with InterCoat®ChemGuard, bottom. Test: ASTM B117 salt spray test on hot dipped galvanized. (Courtesy: Chemcoaters)

Ceramaterials adds Industrial Furnace Specialties

Ceramaterials recently announced the signing of its newest representative, Industrial Furnace Specialties (IFS) providing coverage for Texas and the bordering states of Louisiana and Oklahoma. IFS is a family-owned business out of Justin, Texas, started 13 years ago by owner and founder Randy Rowland. Rowland has 34 years of experience in the industry, providing service and sales focused on heat-treating, aerospace, and energy industrial areas. IFS specializes in industrial furnace repairs, inspections, and maintenance installations.

Ceramaterials President Jeff Opitz said, "We are very excited to have Randy and his team on board representing CeraMaterials. Randy brings a wealth of experience and expertise to our key market areas of heat treating and manufacturing. We share many core principles: customer satisfaction, unwavering quality, and timely execution. We have already partnered on several successful projects and look forward to a long and prosperous relationship with IFS."

Ceramaterials is an international designer, supplier, and distributor of graphite and ceramic insulation, carbon composites, machined graphite, performance ceramics, and molybdenum products focused on heat-treat and processing furnace refurb supplies.

FOR MORE INFORMATION: www.ceramaterials.com

UPC Pro app designed as heat-treater's reference guide

UPC Pro is a go-to app for calculations relating to alloy factor, carbon/oxygen, endo generator, nitriding, nitrogen-methanol, resistance thermometers, shim test, thermocouple conversion, and Waukee Flo-meter. The app is intended to serve as a reference in the course of a heat-treater's daily work, whether developing heat-treat recipes or corroborating process data.

What's possible with UPC Pro?

- Calculate various parameters such as alloying factors for carbon uptake in steels, gas composition, and potentials for endo generators, carburizing, nitriding, and nitrocarburizing furnaces
- Set flows for direct injection of nitrogen and methanol, but also for conversion of signals from thermocouples and RTDs to temperature
- Calculate carbon potential from shim weight
- Select the right Waukee flow meter for your application, and more

FOR MORE INFORMATION: group-upc.com/publicationsdownload/upcpro

Automotive parts manufacturer brings nitriding in-house

Nitrex Metal installed and commissioned an NX-1230 potential-controlled nitriding system for processing automotive springs. (Courtesy: Nitrex)

Nitrex Metal successfully installed and commissioned an NX-1230 potential-controlled nitriding system for processing automotive springs. The customer, Daewon Corp., based in Korea, is a high-volume automotive parts manufacturer supplying global automakers such as Hyundai, Kia Motors, GM, Chrysler, Volkswagen, and others.

Daewon previously used an outside supplier to nitride springs, but the company recognized that its interests would be better served by implementing this capability in-house. This new project is the result of Daewon's past experience with a Nitrex-approved heat-treater and their satisfaction with the reliability of the Nitreg® nitriding process that was key to the application's success. Nitreg nitriding of springs allows fatigue resistance to be improved for longer service life in automotive use. The technology also maintains tight dimensional tolerances (no distortion), excellent uniformity from part to part, and excellent repeatability between production runs. The system is capable of processing a load capacity up to 11,570-pound (5250-kg) and complies with the nitriding requirements laid out by AMS2759/10A.

FOR MORE INFORMATION: www.nitrex.com

TPS ships Blue M mechanical convection oven

Thermal Product Solutions (TPS), a global manufacturer of thermal-processing equipment, recently announced the shipment of a Blue M Mechanical Convection Oven to a manufacturer of consumer products. This DC-256 model Blue M oven includes a NIST Certificate of Calibration at 300°F. The temperature range of this Blue M convection oven is 100°F to 600°F and has work chamber dimensions of 25" W X 20" D x 20" H. The mechanical convection oven features a pneumatically actuated vertical lift door with a safety door switch and light curtain to detect any obstruction prior to allowing the door to close. A 550 CFM powered exhaust was included for faster cool down time.

Custom programming was also included to link the oven controller system to the customer's automated PLC controller. This programming allowed the signals from the door, shelf sensors, limit switches, locks, light curtains, and oven controls to be communicated to the customer PLC. An over-temperature controller is included as a standard to prevent over-heating.

"The oven is provided with two special 12-gauge non-tip stainless steel solid shelves mounted on telescopic slides designed to accommodate customer's automated loading system," said Alec Francisco, applications engineer

Features include:

- NIST Certificate of Calibration.
- Safety Door Switch.
- 550 CFM powered exhaust for faster cool down time.
- Pneumatically actuated vertical lift door.
- Light curtain.
- Cabinet-style floor stand.
- Over-temperature protection.
- Motorized exhaust damper.
- Two stainless steel shelves.

FOR MORE INFORMATION: www.thermalproductsolutions.com

Thermal Product Solutions ships Gruenberg granulation dryer

Thermal Product Solutions, a global manufacturer of thermal-processing equipment, recently announced the shipment of a granulation dryer to a manufacturer of specialty pharmaceuticals. This granulation dryer will be used for curing tablets or granulation and is designed with the capability to produce 330 kilograms per batch. The granulation dryer is designed to process a 330-kilogram load on four stainless steel trucks per batch cycle.

The maximum temperature rating of this pharmaceutical granulation dryer is 180° F, and the work chamber dimensions are 92" W x 81" D x 74" H. The granulation dryer body is constructed with 304L Stainless Steel and is designed with a continuously welded, sealed liner and ¾" radius corners for ease of cleaning. A high volume horizontal airflow system was used for optimal air distribution and uniformity. The tablet curing/granulation dryer is designed to maintain a temperature uniformity of ± 5° F at a test temperature of 160° F.

"At TPS, we understand that in the pharmaceutical industry, preventing contamination is of the utmost importance. This tablet curing and granulation dryer has a continually welded and sealed liner, as well as HEPA air intake and exhaust filters to keep out contaminates,"said Denny Mendler, Gruenberg product manager.

Features include:

- High volume 10,400 CFM horizontal airflow system.
- Steam coil with a 425,194 BTUH capacity.
- Touch screen programmable temperature controller with Ethernet communications.
- High limit thermostat to prevent overheating.
- Temperature uniformity of ±5°F at 160° F.
- Partlow MRC9000 VersaChart, two-pen, four-color, 12" circular chart recorder.
- Magnehlic Differential Pressure gauge.

FOR MORE INFORMATION: www.thermalproductsolutions.com

Evaluating furnace atmospheres for proper gas composition is the key to desired performance results

By Jim Oakes

HEAT-TREATING PROCESSES UNDER ATMOsphere drive desired metallurgical results to meet part performance. When it comes to gas atmospheres for neutral, protective, or carbon-rich atmospheres, there are many assumptions that are made about how the parts are being treated metallurgically, based on the equipment being used for monitoring the atmosphere or incoming gases.

One aspect of understanding what is happening to a part is to consider the surroundings that the parts are exposed to at heat-treating temperatures. You can make many assumptions about the atmosphere based on gas flows and the sensors being used to continuously measure. Temperature and time are, of course, significant to how parts are ultimately heat-treated, but here we will review the gas composition for certain heat-treating atmospheres.

Most atmosphere furnaces operating at slightly above atmospheric pressure with a continuous supply of a carrier gas have some sort of in-situ monitoring. Common applications for this would be annealing, neutral, or a carbon-rich atmosphere. An oxygen sensor is commonly used for in-situ measurement and, with the assumptions of the carrier gas (endothermic gas for example), a carbon potential for the atmosphere can be determined. Carrier gas mostly consists of two variations: nitrogen methanol or endothermic gas.

Nondispersive infrared (NDIR) analyzers are the "go-to" tools for the evaluation of furnace atmospheres. Other tools can be used when trying to evaluate if the atmosphere is correct to achieve a neutral or carbon-rich atmosphere, but NDIR provides an evaluation of three components of the atmosphere that can drive consistency and troubleshoot equipment and gas atmosphere delivery issues.

The consistency of the carrier gas makes the process of control at the furnace achievable. Although the carrier gas can vary between nitrogen methanol and endothermic gas, the desired theoretical makeup can typically be found as 40 percent hydrogen, 40 percent nitrogen, and 20 percent carbon monoxide. Maintaining these percentages will result in a carburizing atmosphere that is conducive to best carburizing practices.

Endothermic atmospheres are produced by mixing air and natural gas (methane) or air and propane, heating them to elevated temperatures and reacting them in the presence of a catalyst to form a specific percentage of carbon monoxide, nitrogen, and hydrogen. The reaction is shown using air with an approximate composition of 80 percent nitrogen and 20 percent oxygen.

$$2CH_4 + 4N_2 + O_2 \rightarrow 2CO + 4H_2 + 4N_2$$

Small amounts of carbon dioxide and methane are also produced or left unreacted. Typical endothermic gas created from natural gas and air consists of approximately:

40% nitrogen — N_2
40% hydrogen — H_2
18.8% to 20.5% carbon monoxide — CO
0.25% - 0.50% carbon dioxide — CO_2
0.50% or less methane — CH_4

Nondispersive infrared analyzer (NDIR) systems are invaluable when trying to troubleshoot these issues. An analyzer will typically measure CO, CO_2 and CH_4. As mentioned earlier, if we know that 20 percent CO is being generated, we can cross-check the air/gas ratio and sticking flow meters, or determine that an adjustment of the air and/or gas ratio is required. The measurement for indication of sooted or nickel-depleted catalyst also can be achieved using an analyzer. If the indicated measurement of CH_4 is higher than 0.5 percent, a burnout of the catalyst is required, using the manufacturer's required procedures. If, after a burnout, the CH_4 level is still high or increases within a few days, the catalyst may need to be replaced altogether.

NDIR analyzers are also used to derive carbon in atmosphere furnaces. The combination of the temperature, CO, CO_2, and CH_4 provide enough data to calculate the carbon potential in the furnace. This technology allows for minor adjustments to the in-situ carbon probe controller calculation to minimize out-of-control carbon situations with the ultimate goal of producing quality parts without rework or — in the worst-case scenario — scrap.

NDIR THEORY OF OPERATION

The cells operate according to the Non-dispersive Infrared (NDIR) alternating light to generate frequency. The measurement principle is based on the band-pass filters for each specific absorption range of the gases being measured. Measurement of carbon monoxide, carbon dioxide, and methane gas is highly selective.

ATMOSPHERE GAS COMPOSITION

With all enriching gas and dilution air valves manually closed on the furnace just flowing endothermic gas, your gas composition should look similar to the endothermic gas being read directly from the endothermic generator.

The furnace atmosphere expected from a prepared atmosphere only can be seen in Table 1.

Furnace Atmosphere – Only Endothermic Gas		
Gas	**Range**	
CO	18-20.5%	Low readings Not enough endo flow. Air leak
CO_2	.20-.50%	High CO_2 readings Air leak in furnace (door, burner packing, radiant tube) Air leak in endo lines Water leak in furnace (fan housing)
CH_4	0 - .5%	High CH_4 Gas leak in furnace (manual valves for enriching gas should be closed for the test) Soot build-up in furnace Soot build-up in endo lines

TABLE 1

Furnace Atmosphere – At Carbon Setpoint		
Gas	**Range**	
CO	18-20.5%	Low readings Not enough endo flow. Air leak
CO_2	.20-.50%	High CO_2 readings Air leak in furnace (door, burner packing, radiant tube) Air leak in endo lines Water leak in furnace (fan housing)
CH_4	0 - 8%	Baseline will be dependent upon the carbon setpoint and temperature. If CH_4 increases more than normal, it is likely that the furnace carbon control is compensating for another problem such as an air leak. Other issue can be soot in the furnace, oxygen sensor or controller settings.

TABLE 2

When issues arise with the atmosphere, a good test and evaluation for potential issues can be identified by using straight prepared atmosphere and evaluating the composition of the gas as described.

If the endothermic generator gas or the nitrogen methanol system are not producing the proper gas, these values will be different (variations in straight nitrogen methanol gas will vary based on furnace temperature). Always start with your prepared atmosphere first and make sure your carrier gas is consistent for what you are expecting at the furnace.

To get a handle on the furnace atmosphere composition, one should have a baseline for the gases that produce good metallurgical results at specific atmosphere settings. Since each furnace will end up being slightly different, it is recommended that each furnace be evaluated. The furnace will have varied readings based on burnout schedule and carbon potential setpoint being used. The variations typically are caused by "seasoning" of the furnace. Any change in the ability to control the furnace around a desired setpoint can be caused from any of the issues described in Table 2.

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Minimizing distortion involves more than just optimizing cooling

By Lee Rothleutner

UNDERSTANDING DISTORTION MECHANISMS IS critically important in manufacturing due to their potential influence on alloy selection, material sourcing, process design, and process flow. Discussions centered on distortion frequently focus on controlling component cooling and the resultant stresses. This is understandable because it is typically seen as the primary cause of distortion for the majority of heat treatment processes and materials; however, many scenarios can result in the occurrence of distortion during heating. Distinguishing between heating and cooling distortion is often challenging but is critical to optimizing the complete heat treatment process and minimizing downstream costs.

IMPORTANCE OF DISTORTION CONTROL

Distortion is an important topic in manufacturing because it is directly linked to costs. Controlling both magnitude and part-to-part variation of distortion allows near net shape parts entering the heat treatment process to be optimized, permitting finishing stock to be minimized. Ultimately, this minimizes cycle times for finishing operations without appreciably influencing heat-treatment cycle times. Of course, this assumption of cost savings is a function of the process and component, which needs to be evaluated for each scenario.

UNDERSTANDING DISTORTION

Component distortion can be characterized as size change due to uniform microstructural changes, such as phase transformations, or shape change due to stresses from thermal gradients or gravity [1]. Quantifying the size and shape change of a component is typically the first step toward understanding its distortion. This is typically done by measuring a statistically significant quantity of parts with an appropriate level of precision, processing each part, accurately measuring each part post-processing, and finally comparing the pre- and post-processing measurements. Although this method yields a great deal of information that can be translated into process improvement strategies, it is iterative and therefore costly. Computer modeling software using accurate material behavior data from well-controlled laboratory experiments can reduce this iterative process significantly, allowing the initial part geometry to be near-optimal from the start. Dilatometry is one experimental method used to quantify material changes during virtually all regions of a heat treatment via accurate measurement of dimensional changes as a function of both time and temperature. Dimensional changes directly correspond to phase transformation behavior, thus providing a means for both quantitatively and qualitatively understanding a material's behavior.

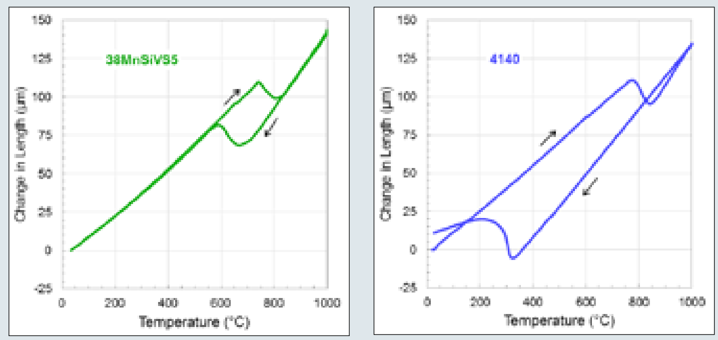

Figure 1: Change in length as a function of temperature for (a) hot-rolled 38MnSiVS5 steel and (b) hot-rolled 4140 steel. Both steels were heated to 1,000°C at 10°C/s, control-cooled to 500°C at 1°C/s, and then quenched to room temperature.

Figure 1 shows thermal expansion data for two steels heat-treated identically in a dilatometer. Although a significant amount of quantitative data can be extracted for these two graphs, they will be discussed and compared qualitatively in the interest of brevity. Figure 1a shows a medium-carbon vanadium (V) microalloyed steel, 38MnSiVS5, while Figure 1b shows a common medium-carbon chromium-molybdenum low alloy steel, 4140. Both steels were heated relatively quickly (10°C/s) to a high austenitizing temperature (1,000°C) then control-cooled at 1°C/s to 500°C before quenching to room temperature. Arrows shown in the graphs specify data recorded either during heating or cooling. In general, materials exhibit a near-linear increase in length during heating and decrease in length during cooling. Significant deviation from this near-linear behavior indicates a phase transformation has started. Subsequently, when a material returns to near-linear expansion during heating or contraction during cooling, the phase transformation is approaching completion. In Figures 1a and 1b, the steels behave similarly during heating and dissimilarly during cooling. During heating, they transform from a mixture of ferrite and cementite (Fe_3C) to austenite similarly due to their comparable carbon contents and starting microstructures. During cooling, the two steels behave dissimilarly due to differences in alloy content resulting in the 4140 steel being more hardenable and thus transforming at a lower temperature. The 38MnSiVS5 steel reverses the on-heating phase transformation at a relatively high temperature resulting in no net dimensional change from the start to the end of the heat treatment. The 4140 steel transforms at a much lower temperature resulting in martensite forming from austenite instead of a mixture of ferrite and cementite. The difference between the starting and ending microstructures of the heat-treated 4140 steel results in a size change measured as an increase in final length of the dilatometry sample. When this size change occurs uniformly in a component it can be easily accounted for in finishing stock changes;

however, non-uniform size changes due to thermal gradients result in shape changes, which are more difficult to address.

CAUSES OF ON-HEATING DISTORTION

The two primary factors influencing distortion during heating are material and geometry. Unfortunately, the root cause of on-heating distortion under many circumstances is a coupled effect of both factors, which can also influence on-cooling distortion, further increasing complexity. Ultimately, on-heating distortion is the result of phase transformation gradients within the component. Stresses induced during phase transformations can result in the local yield strength of the material to be exceeded and therefore an appreciable change in shape. Figure 2 shows the heating portion of dilatometry data from three materials showing significantly different on-heating behavior. The 38MnSiVS5 data is the same as Figure 1a, shown for comparison to Nickel 200 and Ti-6Al-4V. The two non-ferrous materials, Nickel 200 and Ti-6Al-4V, represent the best- and worst-case scenarios for distortion control during heating, respectively. The Nickel 200 alloy is a single phase material which exhibits no phase transformations while the Ti-6Al-4V alloy exhibits a significant size change during phase transformation during heating. Distortion control for Ti-6Al-4V can be very challenging because of the large temperature range over which the transformation occurs (two times that of 38MnSiVS5) as well as the magnitude of size change (five times that of 38MnSiVS5). Details for scenarios other than material selection which can result in on-heating distortion include:

Material homogeneity: Materials with slow solidification rates or high alloy content can result in significant variations in chemistry, which result in phase transformation gradients even during isothermal holds. Tools steels are a good example of this observation [1,3].

Component orientation: Gravity can cause thin sections to distort due to the weight of a component causing the yield strength at a given temperature to be exceeded or even in some extreme circumstances due to creep.

Thin cross-sections: Heat transfer is geometry dependent. Thin sections will expand faster and undergo phase transformations more quickly than the rest of the component during heating. Both cases will result in stresses that can distort the component.

ON-HEATING DISTORTION MITIGATION

Some approaches to minimizing distortion during heating include: slow heating rates, preheating, and intermediate isothermal holds. These process changes are listed in the order that they should be implemented in an effort to minimize distortion. Slow heating rates are the single most significant action that can be taken to reduce on-heating distortion because it reduces thermal gradients within the component and therefore reduces the distortion risk for all aforementioned scenarios. One way this can be achieved during furnace heat-treating is by always charging to a cold furnace. Preheating is typically sub-critical (before phase transformations during heating) and used in conjunction with slow heating rates for materials with significant alloy segregation or cross-sectional variation. Duration of the preheating hold is typically geometry dependent. Intermediate isothermal holds are used for many of the same reasons as a preheating hold, only this occurs slightly supra-critical (above phase transformations during heating) to get the full cross-section to a single phase before continuing heating to the final isothermal holding temperature.

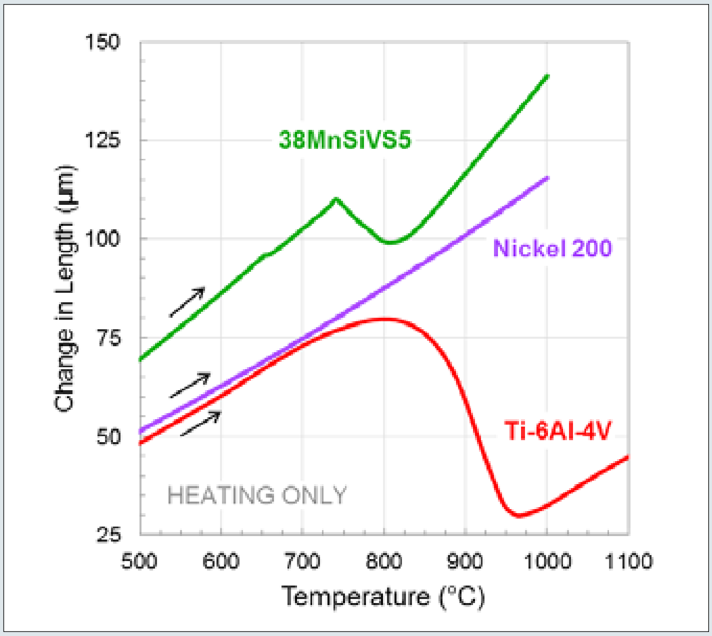

Figure 2: Change in length as a function of temperature upon heating for 38MnSiVS5 steel, commercially pure nickel (Nickel 200), and a common titanium alloy (Ti-6Al-4V). Titanium data from Motyka and Sieniawski [2].

CONCLUSION

Distortion can be minimized by controlling gradients. Although this can easily be seen as an oversimplification and not applicable in all cases, it provides insight into the majority of distortion mechanisms. Thermal and chemical composition gradients result in phase transformation gradients that induce stresses within a material, which can exceed the local yield strength at that temperature, resulting in a shape change. Distortion-sensitive materials or components may require a combination of slow heating rates, preheating, and intermediate holds to achieve desired results.

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52100: Simple, yet it embraces carbon's two-way benefit to steel

By Jack Titus

HARDENING, FULL ANNEALING, AND NORMALizing steel requires heating to a temperature that forces a lattice or crystal configuration change from body centered cubic (BCC) to face centered cubic (FCC) lattice called austenite or gamma iron. FCC lattice, in general terms, due to its larger atomic spacing, allows carbon via molecular diffusion to fill the lattice spaces. There is a limit to how much carbon the FCC lattice can hold, i.e. at 2,095°F, austenite will allow 2.03 percent carbon to diffuse into the lattice. As the temperature drops, the quantity of carbon the FCC lattice can hold also drops. For example, at 1,333°F, austenite will allow 0.80 percent carbon to fill the FCC spaces. As carbon saturates the austenite at a given temperature to the right of the Acm line on Figure 1, the iron-carbon equilibrium (Fe-C) diagram, it will precipitate as cementite or iron carbide (Fe_3C) a very hard and brittle intermetallic compound composed of 6.67 percent carbon and 93.3 percent iron.

Practically speaking, the Fe-C diagram (Figure 1) is an isothermal — or time, (time for carbon to reach an equilibrium phase in iron) temperature, transformation (TTT) diagram — for iron and carbon only with no alloying elements. To find the microstructure for a particular carbon concentration, draw a line vertically up from 1-percent carbon until it intersects the Acm line. Then draw a horizontal line left to find the temperature. That temperature is approximately 1,415°F — which means if steel with 1-percent carbon cools below 1,415°F, carbon will begin to precipitate as iron carbide, Fe_3C, reducing the percent carbon dissolved in the austenite matrix lowering the ultimate hardness the steel could achieve if quenched.

In the real world, the Fe-C diagram has more application to the theoretical relationship between carbon and iron since pure iron and carbon only is not a practical material, since manganese, silicon, and phosphorous are always alloyed with iron and carbon and affects the A1, A3 and Acm lines on the diagram. For true applied situations, the critical or continuous cooling transformation diagram (CCT) in Figure 2 is used to determine the products created by quenching. The TTT diagram in Figure 3 is used to predict the phases like lower bainite that will occur when the steel is isothermally held for a specific time and temperature such as austempering. Having said that, depending on the cooling rate below the austenite-forming temperature of 1,333°F (722°C), A1 line on the Fe-C diagram ferrous materials is often used as a guide to forecast the microstructures or phases based on the concentration of carbon atoms within the body centered cubic (BCC) lattice of iron. Carbon in solid solution within the austenite FCC lattice will determine the hardness level and alloying elements such as manganese,

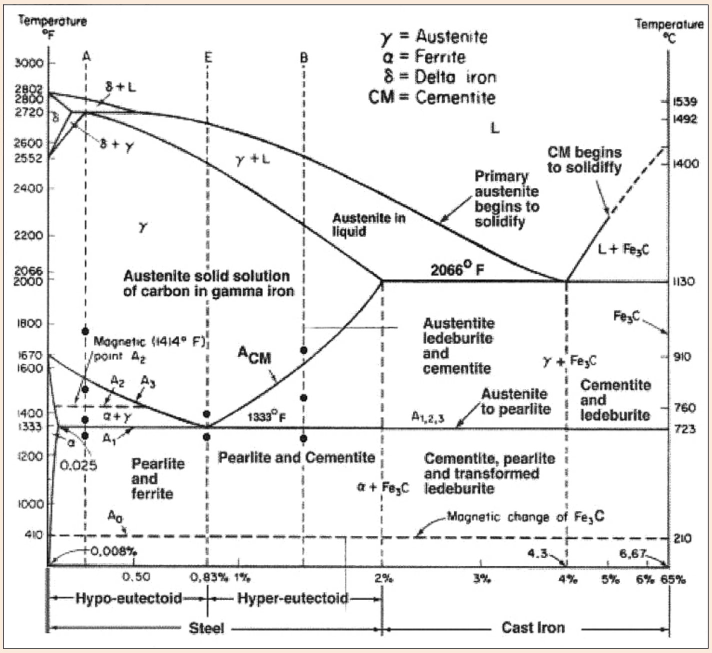

Figure 1: Iron – Carbon Equilibrium diagram

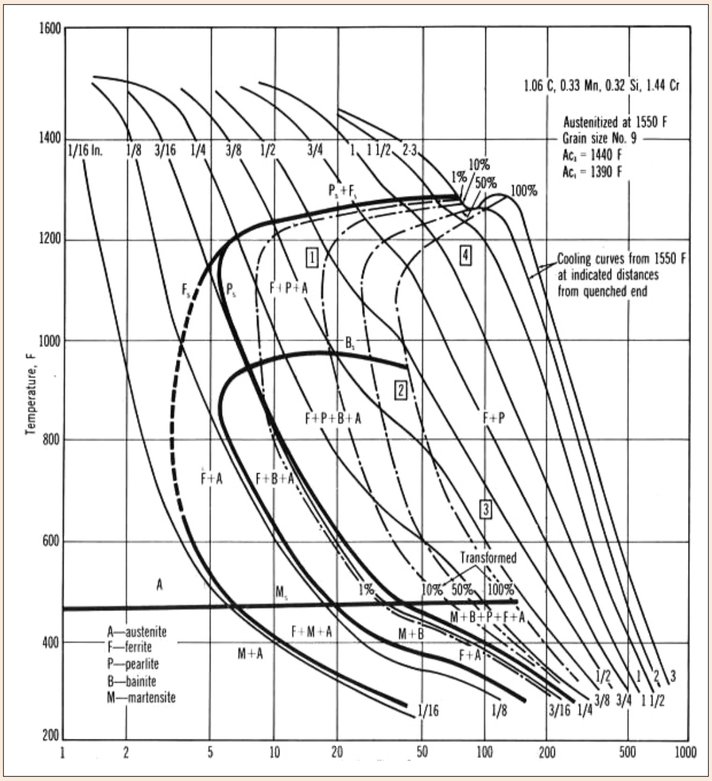

Figure 2: CCT diagram for 52100 steel

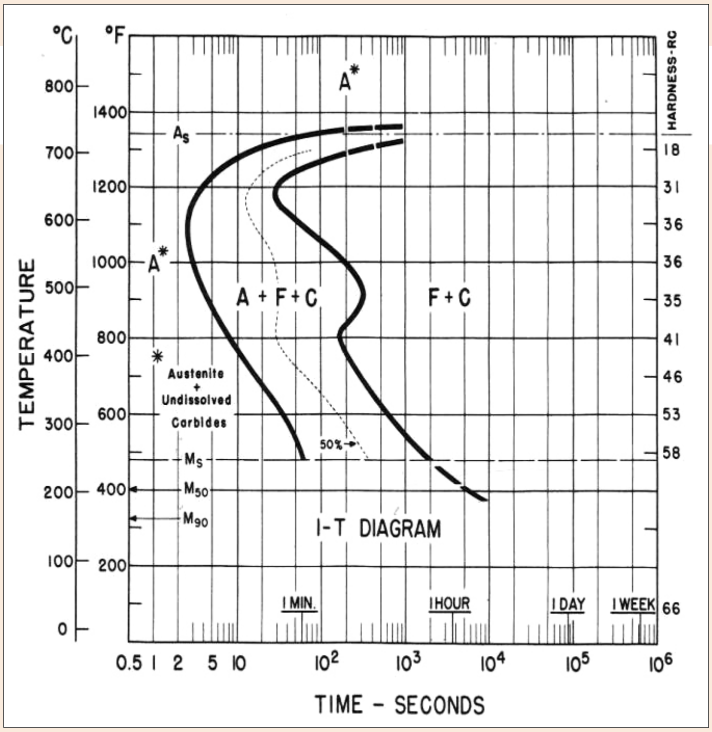

Figure 3: TTT diagram for 52100 steel

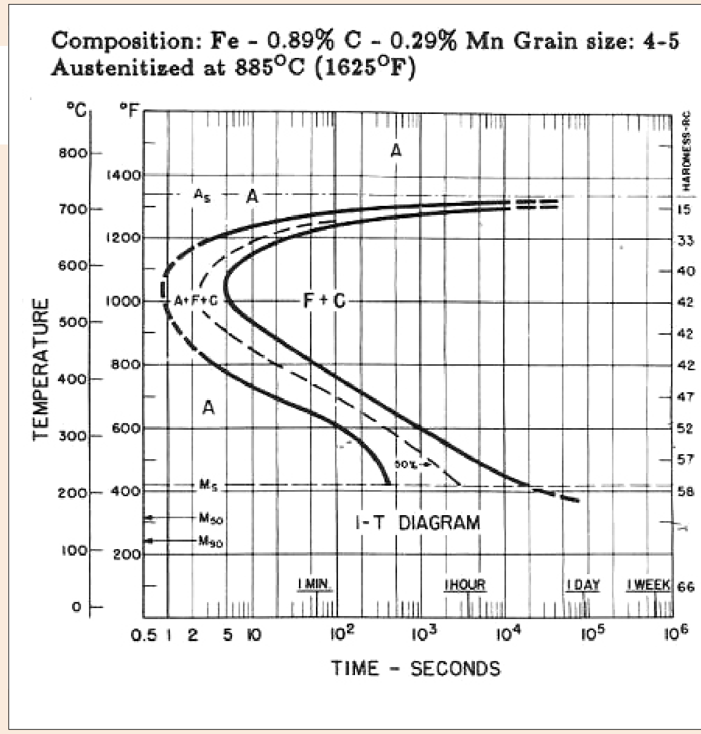

Figure 5: TTT diagram for 1095 steel

nickel, moly and others the depth of hardness when parts are quenched.

Carbon tied up as iron carbide Fe_3C in the austenite matrix and not integrated into the FCC lattice cannot contribute to the martensite hardness. In order to achieve the maximum hardness, parts must be heated to as high an austenitizing temperature as possible that will not increase the grain size and lower impact strength. In addition, too much carbon dissolved in austenite will lower the martensite start temperature resulting in excessive retained austenite when quenched. A case in point is 52100 steel where the carbon level is always shown as 0.95 to 1.02 percent, but that is the total carbon and does not separate the carbon tied up as iron carbide. Every tiny iron carbide Fe_3C particle seen in a photomicrograph of 52100 steel, Figure 4 actually contains 6.67 percent carbon.

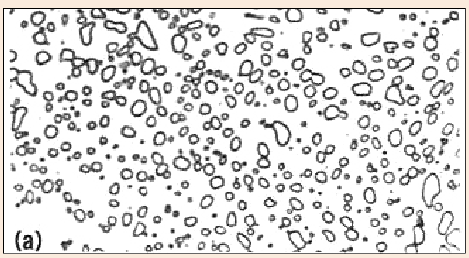

Figure 4: Spherodized 52100 steel. 1000 X. Particles have been enlarged approx. 10 times from the original. Image from Heat Treaters Guide, 2nd edit. pp. 431

I mention the matrix carbon to carbide carbon because the prior heat treat history has an impact on how the steel reacts during quenching or austempering. If the steel was isothermally held below the Acm line for an extended time, during a spheroidization process for example, more iron carbide would form, reducing the matrix carbon and thus reducing the maximum achievable hardness when quenched. Conversely, if the steel was austenitized at a higher temperature, say 1,800°F, more carbon would dissolve into austenite per the Acm line on the Fe_3C diagram, increasing the quantity of retained austenite by lowering the Ms and Mf temperatures. Carbon in steel can come from two sources: It can be manufactured with a specific carbon throughout the material allowing it to be through hardened, surface to core, or a medium or low carbon steel can be carburized with endo gas producing a case-hardened product. Either way, the phases discussed earlier can apply to the carburized case as well as the part's core.

52100 is a popular bearing steel because its hardness is achieved by martensite through quenching and, to some degree, by the excess iron carbide always present even after austenitizing. Iron carbide is a very hard, brittle material providing improved wear for bearing applications.

Many of the products made from 52100 will require cold forming and, due to the high carbon content, the material must be heat-treated to reduce the hardness — thus spherodizing is employed. Spherodizing involves first heating to above the Acm line to about 1,450°F (787°C), soak for five to seven hours, cool to 1,200°F (650°C) at 20°F (11°C) per hour until ambient. The ferrite matrix microstructure is very soft and provides a good prior structure for hardening.

52100 falls between a high carbon material and a low hardenability tool steel — tool steel in that much of its wear resistance comes from carbide as does tool steel like the M (molybdenum) and T (tungsten) high speed tool steels.

Because 52100 finds use as a bearing steel and has fairly low hardenability, it must be oil quenched when section sizes approach 1/4-inch diameter despite having 1.41 percent chromium and 0.020 percent nickel. Now, compare 1095 steel (actual carbon, 0.89 percent), Figure 5 that has no chromium or nickel: 1095's martensite start temperature (Ms) is 410°F (210°C) where 52100's is 465 °F (240°C). Generally, the higher the matrix carbon, the lower the Ms point but not in this case. Why? Likely it's because the matrix carbon of 52100 is lower than 1095 for one major reason: chromium. As stated above, carbon higher than 0.80 percent will form iron carbide, but 52100 has an additional carbide former in chromium. Nickel as an austenite stabilizer also lowers the Ms but not in the case of 52100.

All of the above characteristics make 52100 an unusual material suitable for high hardness martensitic applications and austempering where the higher carbon content and chromium produce a harder, lower bainite microstructure.

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Four essential maintenance steps for preserving temperature uniformity in your atmosphere furnace

By Ipsen USA

MAINTAINING TEMPERATURE UNIFORMITY IN A FURNACE MEANS THAT ALL parts of the furnace are exposed to the same temperatures, ensuring a superior product quality.

Temperature uniformity describes the variation in temperature throughout a furnace workspace and is stated in ±°F or ±°C at a set temperature [1]. In many atmosphere furnaces, the temperature is controlled by one thermocouple (or multiple redundant thermocouples in the same location), but this does not necessarily mean that the temperature throughout the entire furnace is the same as the reading given by the thermocouple. An obvious solution to this problem would be to design furnaces in such a way that thermocouples are distributed evenly throughout the furnace. However, design and pricing limitations mean this is rarely possible.

Temperature uniformity can be particularly problematic in large furnaces where large, or separate, areas of the furnace could be different temperatures than that measured by the thermocouple. Temperature fluctuations throughout a furnace can be caused by its different characteristics, including insulation thickness, position of furnace openings, air distribution, volume of airflow, control accuracy, and construction techniques. Strategic furnace design and precise construction from high-quality materials can help produce furnaces with tight uniformity.

The ATLAS integral quench batch atmosphere furnace.

For example, Ipsen's ATLAS atmosphere furnace uses Recon® III burners coupled with reliable fuel delivery and a burner management system to provide uniform heating. However, it is more than just how a furnace is built. Proper furnace maintenance is also critical to ensure the temperature in the furnace remains uniform throughout its life span.

This article outlines best practices for maintaining temperature uniformity in your atmosphere furnace [1-3].

FURNACE BURNOUTS

Burnouts, or cleanup cycles, remove carbon deposits (soot) that build up during operation by exposing carbon deposits to oxygen, which react to form carbon dioxide. Proper cleanup procedures are essential to maintain precise process control and temperature uniformity.

To conduct a cleanup cycle, the temperature of the furnace should first be reduced to 1,550-1,600 °F (845-870 °C). Then, air can be introduced into the furnace in a number of ways. The simplest method involves removing the protective atmosphere in the furnace and then introducing clean, dry, filtered air through a flowmeter for three to eight hours [4].

If furnace cleanup cycles are not conducted regularly (weekly to monthly depending on soot buildup), soot formation can damage the furnace components, such as reducing the life of heating elements and causing temperature fluctuations. Cleanup cycles that are not conducted carefully can be equally damaging. The formation of carbon dioxide is highly exothermic and can cause overheating or localized hot spots that can damage the furnace.

If the temperature in the furnace rises more than 100° F (38° C) during the cleanup process, the procedure should be terminated to protect the furnace components [4].

INSPECT FURNACE LININGS

Insulation and refractory materials used in the furnace lining prevent heat losses through the furnace walls. If this insulation is not well maintained and becomes damaged, more heat is lost through the furnace walls, and the temperature uniformity in the furnace is reduced.

Furnace liners can be inspected visually or using infrared thermography to identify any hot spots or areas where the insulation is breaking down. Skilled infrared thermographers can analyze the furnace lining from outside the furnace during operation, which saves downtime costs.

If a skilled thermographer is not present, visual inspection of the furnace lining can be carried out when the furnace is out of operation. However, as this technique is based on human vision, there is a higher chance of error.

Ipsen's Recon® burner system, which features single-ended, self-recuperative radiant tube (SERT) style burners.

If hot spots are found, they can be repaired or, if the area is too large for repair, the liner can be replaced to restore adequate insulation and improve temperature uniformity [5,6].

BURNER TUNING

The furnace's heating system plays a vital role in maintaining performance and temperature uniformity; the burners must be tuned together within a tight temperature range to maintain temperature uniformity throughout the furnace. An air-to-gas ratio of 10:1 should be maintained at each burner using individual controls that adjust the air and gas flows.

The air-to-gas ratio should be checked every six months using a combustion analyzer and maintained at 10:1. Doing so maintains temperature uniformity and ensures maximum efficiency. It is also important to check on a monthly basis that the air filter on the regenerative blower is clean and has no blockages, enabling it to maintain efficient airflow to the burners [3].

Placing a test fixture for performance of a Temperature Uniformity Survey (TUS).

TEMPERATURE UNIFORMITY SURVEYS

Temperature Uniformity Surveys (TUS) test the uniformity of a furnace using readings from six to nine thermocouples placed at different positions in an empty furnace. A representative process is conducted to mimic the conditions during actual production and data is collected from the thermocouples.

The temperature variation within the furnace's work zone is measured before and after thermal stabilization. A TUS can help identify reductions in uniformity and should be conducted before the first use and periodically (at least every six months) to ensure uniformity is maintained. A TUS should also be conducted after any major repair work or if the integrity of the equipment is questioned [7-10].

CONCLUSIONS

Temperature uniformity in atmosphere furnaces is vital to ensuring product quality. Well-designed and manufactured furnaces, such as the ATLAS atmosphere furnace, provide excellent temperature uniformity. However, regular and careful furnace maintenance is critical for preserving that temperature uniformity and superior performance throughout its life span.

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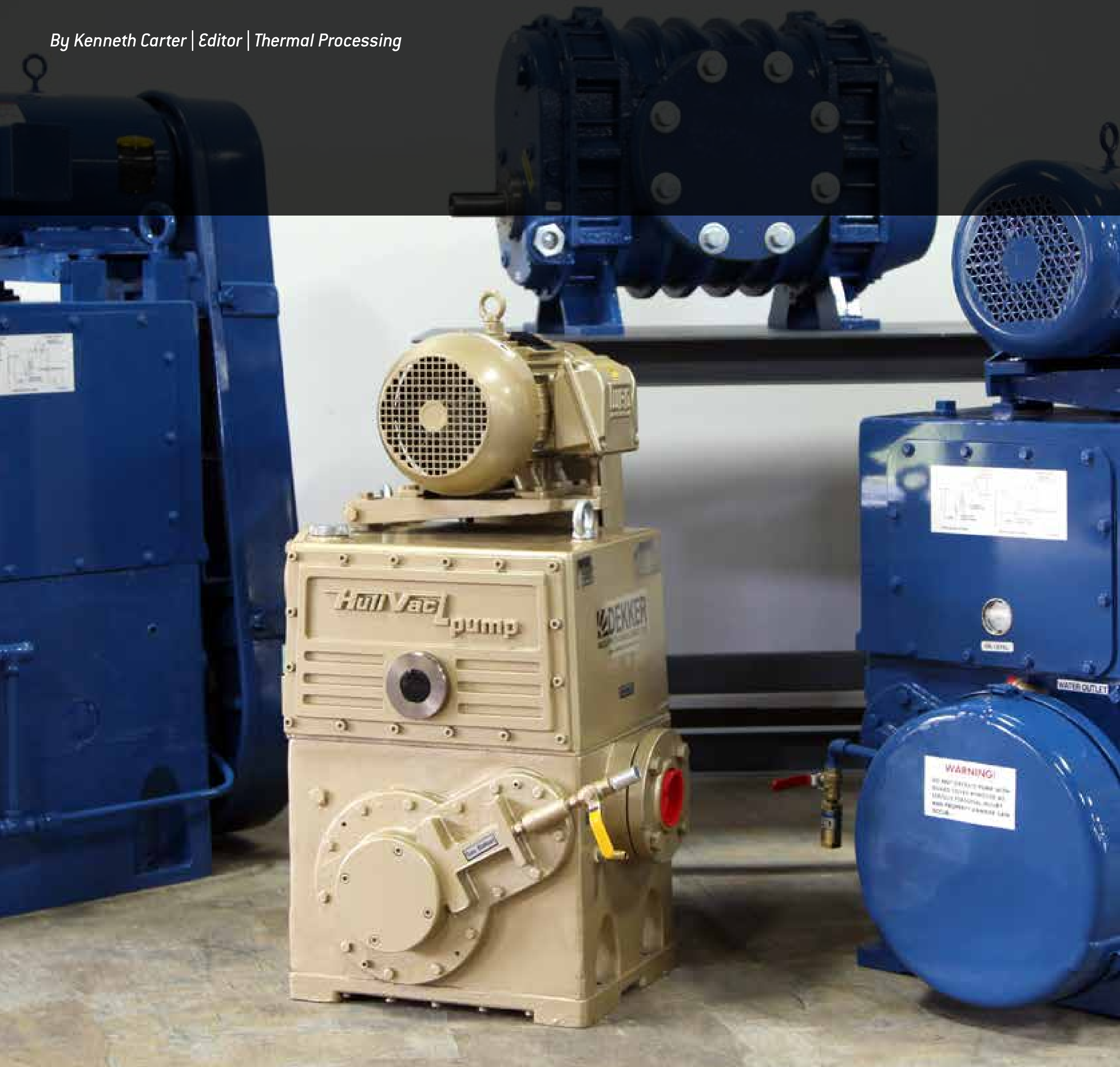
ABOUT THE AUTHOR: Ipsen USA designs and manufactures integrated heat-treatment solutions for a wide variety of industries, including aerospace, automotive, energy, and medical. With an extensive network of global locations in America, Europe, and Asia, it continues to provide expert-driven solutions that strengthen heat treatment throughout the world. Learn more at www.IpsenUSA.com.

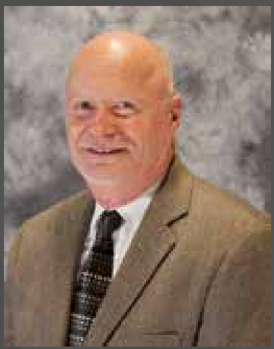
Vacuum Pump Services Corporation

By Kenneth Carter | Editor | Thermal Processing



VPS does pump rebuilds, repairs, and reconditioning. It offers helium mass spectrometer leak checking services, system troubleshooting, and onsite consultations as well as new equipment and spare parts for sale. (Courtesy: VPS)

Vacuum Pump Services offers quality vacuum pump repair, rebuilds, and reconditioning with customer satisfaction its main goal.



"We pride ourselves in customer service. If a customer calls me today, he has an answer today — not tomorrow, not next week."
— VPS President Bob Sandora

VACUUM PUMP SERVICES CORPORATION MAY BE NEW, BUT only in name. The talent and expertise behind its doors span decades.

"We have many years of experience," said VPS President Bob Sandora. "A combined 100-plus years of experience. Because we've been in the vacuum business for so long, we know what these pumps are capable of doing and what abuse they can and cannot take."

He said VPS affiliate company Solar Atmospheres has more than a hundred pumps in operation every day.

"Initially we started out just repairing our own pumps," Sandora said. "As time went on, we saw an opportunity to make our expertise available to other users of vacuum pumps."

EXTENSIVE SERVICES

VPS does pump rebuilds, repairs, and reconditioning. It offers helium mass spectrometer leak checking services, system troubleshooting, and onsite consultations as well as new equipment and spare parts for sale.

All that expertise doesn't mean as much without a positive customer experience, and Sandora names customer service as one of his highest priorities.

"We pride ourselves in customer service," he said. "If a customer calls me today, he has an answer today — not tomorrow, not next week. I want to get back to them the same day that they contact us."

ABOVE AND BEYOND

Customer service sometimes goes above and beyond even extraordinary promptness, according to Sandora. It extends to "going the extra mile" in other ways for a customer when called for.

VPS is currently working on two 300 CFM vacuum pumps, two 150 CFM vacuum pumps, and a 35-inch diffusion pump. In addition to those projects, there are seven rotary vane pumps on schedule to be rebuilt.

"We get them in, break them down, clean them up, and get them out the door," Sandora said.

PREPPING A JOB

When a job comes in, a simple process gets the job started and finished, according to Sandora.

"You call us with a pump that needs repair," he said. "We issue you an RMA number. The pump comes to us, and we do a complete evaluation at no charge. We then send that evaluation back to the customer with an estimate for the repair. If they are OK with the price, they issue a PO. We do what needs to be done to get that pump back online, and get it back to the customer as quickly as possible."

"Vacuum Pump Services is part of the Solar Atmospheres family of companies," Sandora said. "We've been in the heat-treating business for 30-plus years. Since the expertise already existed with in-house pump repairs, it seemed like a natural progression to extend those services beyond the company, so we started reaching out to our competitors and other end users, and continued on from there."

For affiliate company Solar Atmospheres, VPS rebuilds and repairs heavy duty Stokes-type vacuum roughing pumps and Roots-type vacuum blowers, performing those services at a reasonable cost as quickly as possible, according to Sandora.

PUMP REPAIR AND THE FUTURE

Sandora said he thinks the future of pump repair is strong despite a changing landscape in the industry.

"Dry pumps are on the scene," he said. "The dry pump definitely has its place in the industry, but commercial heat treaters such as we are don't make widgets. Every process we do is different — so the rotary piston pumps and the rotary vane pumps are not going away. They've been around for 50-plus years, and I expect that they'll be around for another 50. That's what we specialize in."

FOR MORE INFORMATION: vacpumpservices.com

Cryogenic process and application to ferrous alloy

Cryogenics or sub-zero treatment is the third parameter required to achieve maximum hardness in ferrous alloys.

By Jack Titus

Heat-treating metals is the controlled application of thermal energy ranging from 2,800° F (1,538° C) to -321°F (-196°C).

The Hot Seat column "Carbon, essential element or too much of a good thing" in this issue of *Thermal Processing* discusses the affect carbon has on iron and iron alloys when hardening, annealing, or normalizing it. And the two primary guides we use to predict the outcome of the hardening process are TTT and CCT diagrams.

Hardening steel to achieve the maximum martensite transformation from austenite requires a cooling speed fast enough to miss the pearlite nose of the CCT diagram, the first parameter and pass through the martensite (Ms) temperature; the second and the third is reaching the martensite finish point (Mf). The Ms and Mf points are determined by the quantity of carbon in solid solution in austenite and the alloying elements also in solution.

Elements such as moly, silicon, nickel, manganese, and chromium depresses the Ms and moves the CCT diagram to the right, allowing for a slower cooling speed and still miss the pearlite nose. These elements, in allowing for a slower cooling rate, provide the mechanism for hardening larger cross sections. Carbon, however, is the major contributor for lowering the Ms point. When the carbon content of the material is low, the Ms temperature increases. In carburizing grade steels, the base carbon is relatively low, so the core of a component such as gear teeth will not achieve the same hardness as the carburized case in order to provide some toughness and ductility to absorb the strain without cracking the gear tooth. If the case depth is too deep relative to the tooth cross section, the gear teeth can fracture under loading.

When carburizing increases the case carbon, the Ms and Mf temperatures will be reduced compared to the lower carbon in the part's core. If oil quenching into 150° F (66° C), which is typical to reduce distortion, the part's core closest to the case will likely have reached its Mf point and transformed to martensite before the higher carbon case,

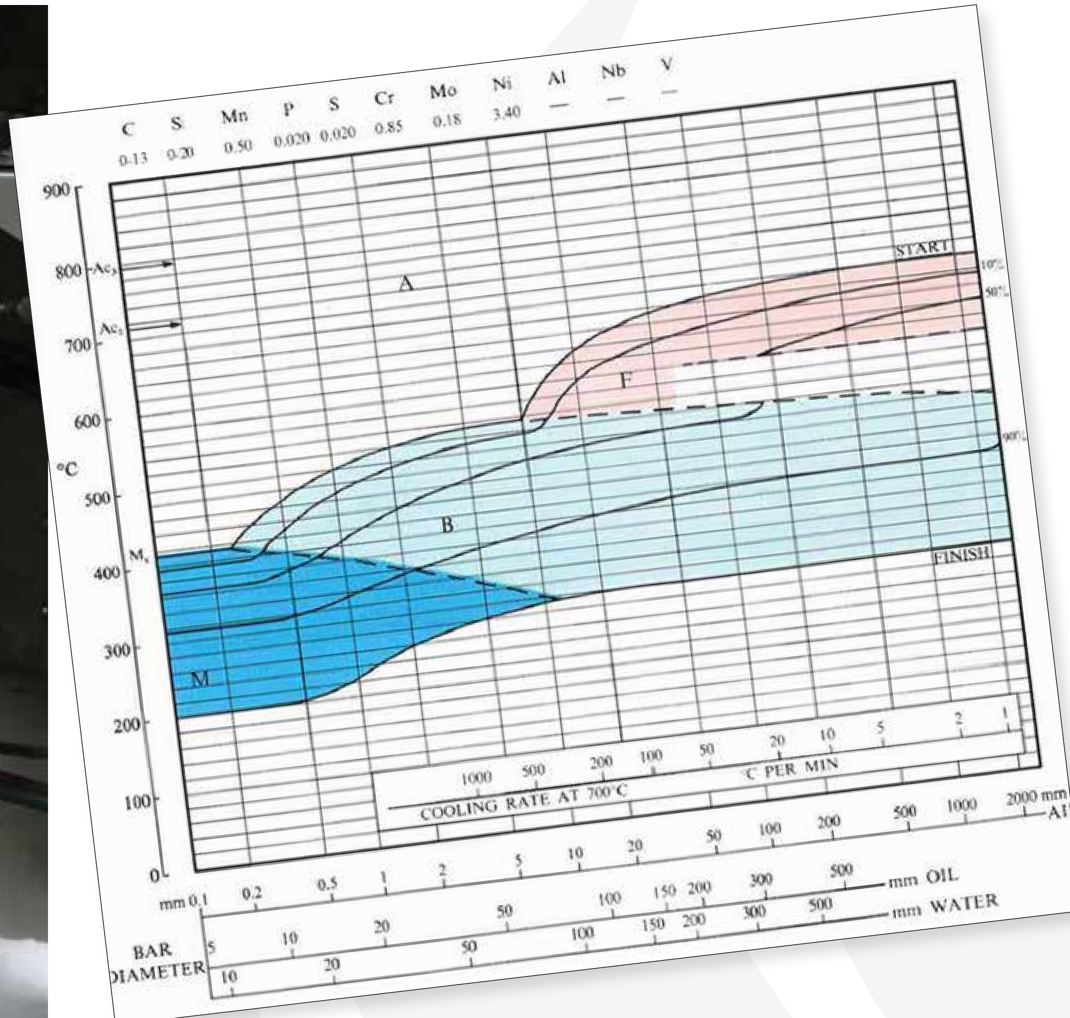


Figure 1

which has a lower Mf point. This condition is a major cause of distortion as martensite produces a larger volume lattice than ferrite or austenite, creating a tensile stress in the carburized case until it transforms to martensite. In the above example, RA will exist since the higher carbon case at 150° F (66° C) likely will not have reached the Mf point.

When the above situation occurs, three solutions are used to produce an acceptable microstructure:

- When carburized steel's alloy content is relatively low, tempering at 350° F (176° C) is used to temper the martensite but has no effect on RA after quenching and little if any effect on hardness. This process works because the Mf temperature is either just above or just below ambient and a small amount of RA does no harm and may be advantageous, more about that later.
- Most high-strength-alloy aerospace materials (Figure 1) by specification are required to transform as much RA as possible to avoid any post process microstructural changes that might occur during a component's operation. Due to the alloy content, the Mf point is generally below ambient.
- High speed tool steels such as the M, moly, and T, tungsten series plus die materials such as D2 for the same reason also require as little RA as possible due to the high wear these materials are expected to endure in operation.

Cryogenic processing or deep freezing is one of the methods used to cool steel below the Mf point and convert RA to martensite. Once cryogenic processing is completed, the fresh martensite must be tempered to reduce its brittle nature.

9310 (Figure 1) is a classic aerospace steel where the carburized case in addition to 3.00 to 3.50 percent nickel and 1.00 to 1.40 percent chromium plus other elements depresses the Mf near or below ambient; however, Figure 1 represents the core material, not the carburized case.

Generally, two sub-zero temperatures are used to convert RA to martensite: dry ice, with a temperature of -109° F (-78° C) and liquid nitrogen, -321° F (-196° C). Carburizing grade steels such as 8620 are typically held in a horizontal chest or chamber with dry ice for approximately one hour or until the material has cooled sufficiently; no soak duration is required as martensite transforms instantaneously. For higher alloys such as 9310, liquid nitrogen is normally used to be on the safe side.

Dry ice, where suitable, will be the preferred method simply because it's much less expensive than liquid nitrogen. All that's needed is an insulated horizontal enclosure with the bottom lined with dry ice where a tray can be lowered and the lid closed. Using liquid nitrogen, on the other hand, is much more complex consisting of an insulated enclosure horizontal or vertical; however, the liquid can be contained in a finned tube heat exchanger system much like an ordinary air conditioner minus the compressor. Some manufacturers for rapid cooling offer a liquid nitrogen spray directly onto the parts. In addition to the enclosure, a liquid nitrogen storage vessel and evaporator is required, and the necessary pressure relief and valves for flow and temperature control.

Liquid nitrogen sub-zero enclosures as indicated can be horizontal or vertical similar to the typical household freezer, but the vertical systems are preferred for ease of material han-

Figure 3

Figure 2

dling when integrated into a batch furnace heat-treat cell. But the similarity ends there because, due to excessive frost forming on the steel components when exposed to the humidity of room air, nitrogen gas is used as a purge prior to lowering the temperature in the enclosure. Also, to avoid rust if the parts are removed cold, the chamber is allowed to warm up to near ambient before removing the parts. Some manufactures offer a combination liquid nitrogen/temper unit where the parts can be heated after sub-zero treatment and temper the newly formed martensite.

Liquid nitrogen storage systems come in two forms: a large insulated tank outside the plant, (Figure 2), consisting of several thousands of pounds of liquid or smaller single 1,000-pound hand truck units that can be in the plant (Figure 3). In both cases, liquid and gas are produced. For small applications, a 45-gallon Dewar is available and produces 4,200 cubic feet of nitrogen gas. These systems produce gas from liquid by directing the liquid through a vaporizer that surrounds the tank's circumferential internal space. The large outside tanks use a separate stand-alone vaporizer system capable of producing several hundred cubic feet per hour.

Even after sub-zero treatment, alloys such as 9310 typically require two 350° F (176° C) tempers to ensure all of the brittle martensite has been treated.

Sub-zero treatments provide a critical function in the hardening process by ensuring that the maximum amount of retained austenite has been transformed to martensite. However, there are instances where a predetermined percentage of retained austenite can be beneficial. In selected pinion/ring gear applications, the contact point pressure can be mitigated by retained austenite under very high compressive forces. The mechanism of how compressive forces convert austenite to martensite without the characteristic brittleness is not completely understood, but the very thin soft austenite layer provides a "worked in" surface that improves the overall pinon-to-ring gear wear properties.

ABOUT THE AUTHOR: Jack Titus has been involved in heat treating and metallurgical industry for more than 50 years having held positions directly related to the following: R&D metallurgical laboratory management; failure analysis, via SEM and hot-stage metallographic analysis; ion (plasma) nitriding and carburizing process and equipment development; atmosphere carburizing; vacuum (LPC) carburizing; vacuum furnace development and design, and metallurgical and heat treating equipment and process troubleshooting.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Selecting Industrial Vacuum Pumps

An analytical guide to the down-select process.

By Christopher Estkowski

Do you know when your choice of a vacuum pump or pump system is correct before the purchase is made, money exchanged, and the system installed? Judging by the instances of systems that have failed to perform and live up to expectations, many users have not known. How do you verify that the pump type is the optimum selection and appropriate for the process? When purchasing vacuum systems used for industrial processes, there are risks. Many customers choose to mitigate these risks by using a turnkey system from an integrator or an original equipment manufacturer, the furnace manufacturer for instance, hoping its expertise will reduce the chance the installed equipment will underperform.

Generally, this is a smart decision, and it can remove the burden of becoming an expert and scale the risk back for customers. However, eventually the customer must have a significant level of competence with the theory, use, and operation of the equipment for maintenance, troubleshooting, and optimizing the process. The best place to start this learning curve and get up to speed on the technology in the vacuum industry is to create a specification for your system and use it as a discussion tool with your vendor. Process equipment is a large investment, and the time spent specifying parameters, operational, and equipment specific details will pay big dividends once the equipment is installed and the day-to-day production stress affects the new installation. This is particularly important when a vacuum system is used in the process. Understanding the customer's vacuum requirements is a critical aspect of a specification for any process, so a carefully specified system will benefit cycle time, reliability, and cost for the life of the equipment.

In many instances, the equipment used by an OEM is advertised as the "best" or "ideal" for an application in part because it is what the OEM sells, and the OEM has confidence in that equipment. There is a strong financial incentive for businesses to sell a certain brand particularly where they receive the best wholesale cost. With all the reputable equipment available, this can be a reasonable default for the customer and increases customer risk only marginally. However, it is prudent to apply the old adage "Trust but Verify" for large equipment purchases and critical installations. Developing a specification and negotiating through it with the OEM can bring the strengths and weaknesses of a proposed system to light and, at the very least, provide a framework for customer understanding of the engineering used to

integrate the proposed selection by verifying the process parameters and comparing them to the expected operational performance. This process can benefit customers in other ways, since a methodical analysis identifies omissions in the customer's list of requirements. A systematic selection process is just good engineering practice.

How can the complexities of a vacuum system or any complex machinery selection be quantified and systematically evaluated reducing the influence of preferential bias? There are both attributes and variables to evaluate, the interrelations of performance characteristics, pros and cons of machinery types, subjective information from experts, personal experience, cost, and a host of other factors that complicate the decision. All of these should be identified, rated, compared, and contrasted. Without a systematic evaluation method, the volume of information can be difficult to manage and might contain errors or omissions, particularly for anyone unfamiliar with vacuum technology. Using a universally applied methodical evaluation method helps organize inputs to the decision making in a process where many stakeholders are involved. In these cases, sometimes the loudest voice gets the most attention, which might result in less than an optimum selection.

In an attempt to move away from subjective methods that often rely on personal bias, an analytical tool that can organize all the pieces and types of information is needed. It must allow characteristics to be prioritized and systematically rated while retaining the important and valid experiential elements from experts and real-world use but incorporate them in a manner that prevents equipment selection from relying on subjective preferences.

There is a tool developed in the mid-1960s in Japan now used in companies with Six Sigma programs that can be adapted to conduct this variable/attribute type of analysis and selection. Quality Function Deployment (QFD) is a structured method used to identify and quantify requirements, then translate them into critical parameters. It can assist in the prioritization of general items or detailed specifics; it is scalable so it can manage small or large amounts of information with relative ease. A key feature of the method is the ability to make analytical comparisons using ratings of criticality and correlation, to evaluate competing and complimentary characteristics, specifications, or attributes in order to systematically organize and prioritize information adding fidelity and resolution to the process.

With some creativity, the QFD House of Quality (HoQ) format lends itself well to a down-select analysis. Learning to populate the matrix with meaningful information and maximize the benefit has a learning curve, but once familiar with the structure and method of the House of Quality, it becomes an expedient tool. Like any analytical tool, the analysis is only as good as the information entered into the process. Detail improves the accuracy of the process but adds time to create and evaluate. It is a good idea to limit the customer requirements or "Whats" to only the important requirements considered essential and that improve performance when they are optimized. Characteristics that are industry standards, regulatory requirements, and other absolutes demanded from all the candidate equipment, will complicate the QFD unnecessarily, providing no value in the down-select process. Leave these out of the analysis, but not out of the specification. Concentrate on what the customer needs for the equipment and how the equipment performs to improve the resolution of the process. This voice of the customer section is the key to making equipment selections result in delivering the equipment that is required and maximizing satisfaction for the customer and ultimately the users of the equipment.

There are a few areas worth emphasizing that are well suited for the down-selecting process. The diagram in Figure 1 is a partial example of a QFD analysis for optimizing the

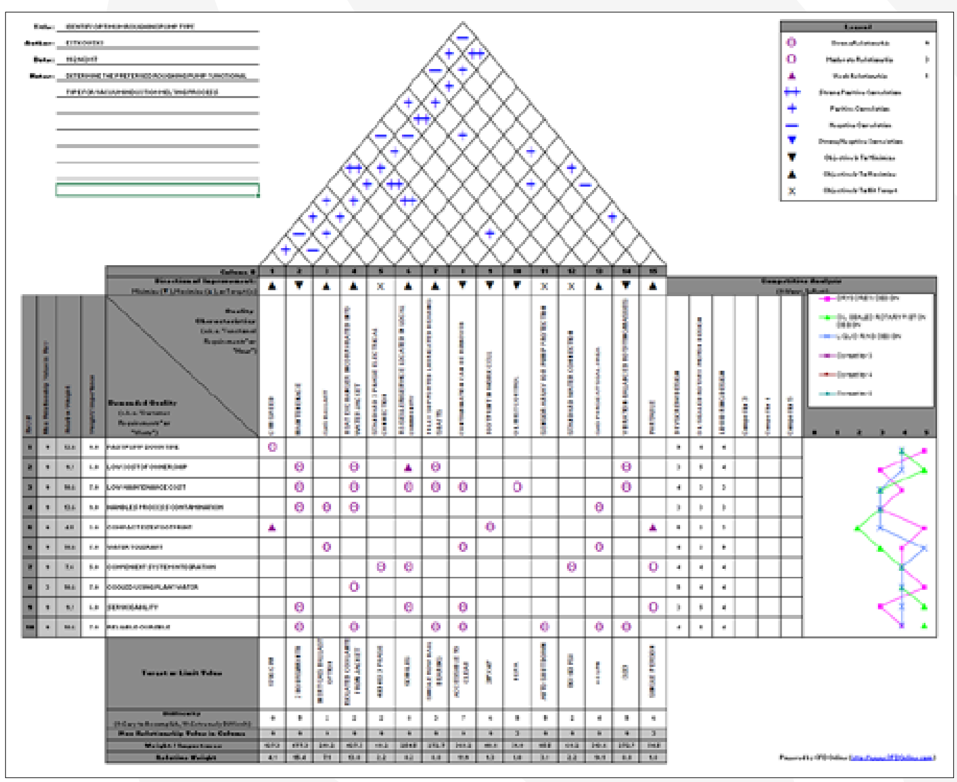

Figure 1: House of Quality (HoQ), Quality Function Deployment diagram.

selection of a roughing pump for a vacuum induction melting process and shown so all the sections can be seen collectively. Some of the details of the HoQ will be described in this article. Note there are references at the end of the article with tutorials that will describe the HoQ in more detail.

The most critical and first information placed into the analysis is what the customer requires. This is the demanded quality or the "What's." They need to be carefully selected and prioritized for the numeric values to indicate what is really important to the customer. This is an area where focus and eliminating extraneous detail is essential. List only the critical requirements to simplify the process. Spend as much time as needed to flesh out the voice of the customer in this section. When selecting equipment, the needs of your customer must be identified in these requirements. Note that all the elements listed drive down to the basics of efficiency, reliability, and convenience that result in low cost and on-time products.

The next section to work through is the quality characteristics, (functional requirements) or "How's." These are the technical requirements (How's) necessary to realize the customer requirements (What's) itemized on the left side of the HoQ. They generally are engineering drivers for the system. Figure 2 shows the detail of the What's and How's sections and the relationship table associated with the two along with a legend to define some terminology and the values for weighing importance. To demonstrate the relationship between the "What's" and "How's," look at row 1 and identify the customer requirement for fast pump down time. To achieve a fast pump down time the pump must have sufficient speed for moving the gas within the timeframe desired.

CFM speed is listed as a functional requirement and can be associated with item 1 as a strong relationship providing a method or "How" for that requirement. Also, important here, is identifying the direction of improvement in the bar above the functional requirements. These indicators identify whether maximizing, minimizing, or hitting a specific target is desired for each functional requirement. Using the same case above, maximizing the CFM speed will decrease pump down time so the maximize character is selected. The roof area of the HoQ, Figure 3, provides a table to identify correlations between the functional requirements. The functional requirements are compared and correlation values assigned to pairs of requirements in order to establish a hierarchy of how each requirement may influence another. The correlation ratings are described in the legend. No correlation

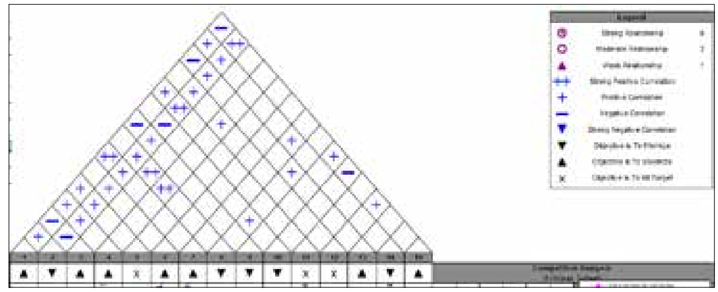

Figure 3: House of Quality (HoQ) Functional Requirements Correlation table

results in a blank cell. Identifying these relationships forces decisions to consider how technologies used to achieve the customer requirements compliment or limit their implementation.

On the left side of the HoQ, a rating system includes a weight tabulated that assigns an importance value for each customer requirement. This places a relative weight to each customer requirement, ranking it in degree of importance. The weight/importance is established by the customer or considerations based on the customer's requirements. When requirements are assigned the same value, they are equally important. Ratings must be consistently applied for meaningful results, especially when large numbers of requirements complicate the process. The importance ranking is fundamental for increasing the fidelity of the process and providing a sorting mechanism based on the information from the customer.

One particularly valuable feature of the HoQ method is the relationship table that indicates how each customer requirement relates to each functional requirement by assigning a value or rating that is incorporated into the overall calculation of weight/importance of the functional requirements. In Figure 4, a part of the relationship table in the example is shown with some of the What's and How's. When a relationship exists between the requirements, it is assigned a symbol that corresponds to a numerical value — typically 1, 3, or 9 — to indicate how strong a relationship exists. Because it affects the rating weight, time here is well spent and worth working through carefully. This analysis sifts through each customer requirement and identifies if there is a relationship with each functional requirement, and if there is, indicates how strong a relationship it is. The numeric values identified in the table are incorporated into the weight/importance value assessment in a column on the left side of the customer requirements.

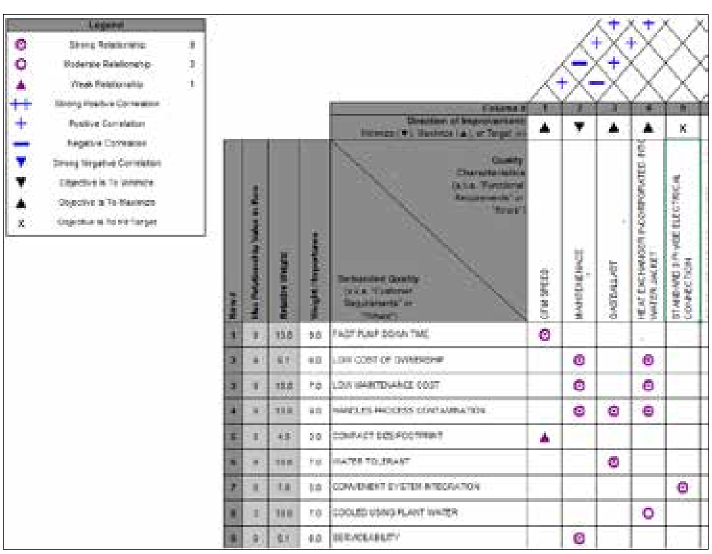

Figure 2: House of Quality (HoQ), What's section, How's section matrix with legend.

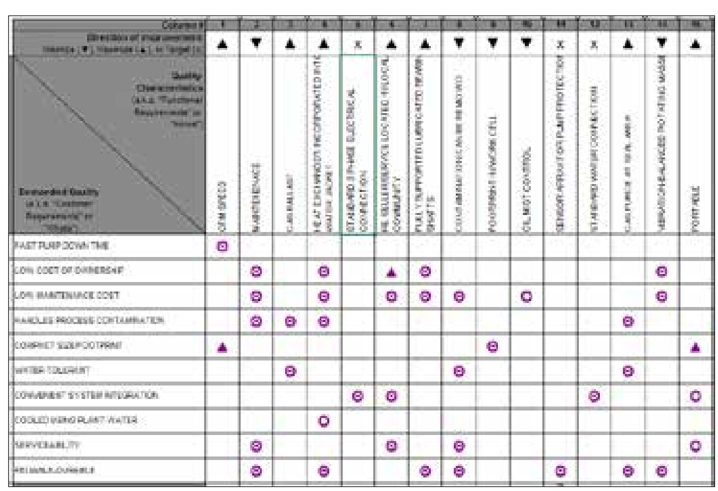

Figure 4: House of Quality (HoQ) Relationship table

There is a comparison table on the right side of the HoQ that is used to graphically display how various candidate pumps, in our example, compare against the customer requirements. This competitive analysis is based on a scale from 0 equaling the worst to 5 equaling the best when compared to the demanded quality requirements listed on the left side of the HoQ. When populated, the graph clusters the best performance to the right side of the view, each color representing a different candidate pump, shown in Figure 5. The graph visualizes what candidate would perform the best when contrasted against one another using the customer requirements as the performance sorting criteria.

While all the mathematical values are attribute based to some degree when there are opportunities to assign variable data, they can be captured. As an example, when there are numerical values that are targets, maximums or minimums defined for the functional requirements, they will fall into the target or limit value table at the bottom of the HoQ. When there is a numeric value and a specified direction of improvement, it assists in establishing a competitive ranking in this analysis. Figure 6 shows the target/limit value table.

Below the target/limit value table, there is a row to define the difficulty of accomplishing the target based on available knowledge of the performance compared to the criteria for performance. It is an excellent reference for evaluating if a pump meets a requirement or is at the edge of performance and just able to meet a requirement. For process equipment, operating at the maximum capacity is usually trouble for the system eventually. It is prudent to have some cushion in your pumping capacity so adverse factors such as moisture in the process gas or pump wear do not reduce pump capacity prematurely, rendering the system underpowered for the process.

When selecting new equipment, the selection process is limited by available information. Organizing the down-select process and information systematically helps tease out the less obvious details that might otherwise be overlooked. Using the QFD HoQ to organize the information keeps the analysis and selection process focused on the customer requirements that can be overshadowed by engineering details early on. Using the HoQ where the customer requirements relate directly to the functional requirements maintains a direct association between what needs to be done to how it is done. Controlling this close relationship prevents the equipment selection from straying away from the requirements and allows equipment characteristics to be compared to verify they meet requirements.

All of this analysis can be done before any purchase agreements are made. Carried further, it will result in a specification that is straightforward, easy to understand, and supported with a systematic and logical thought process. The example above is just a small snapshot of the potential of the HoQ. For more complex projects there is a five-step house of quality process that captures customer requirements and focuses them all the way through the production process to build the quality control parameters for purchasing and production. For more information consult the references sited at the end of the article.

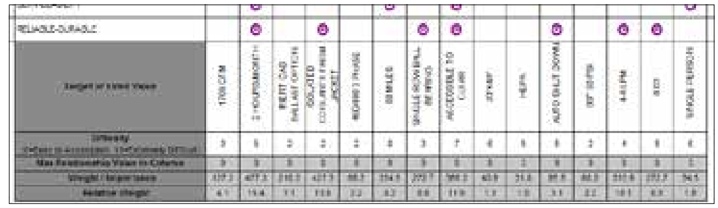

Figure 5: House of Quality (HoQ), Competitive Analysis.

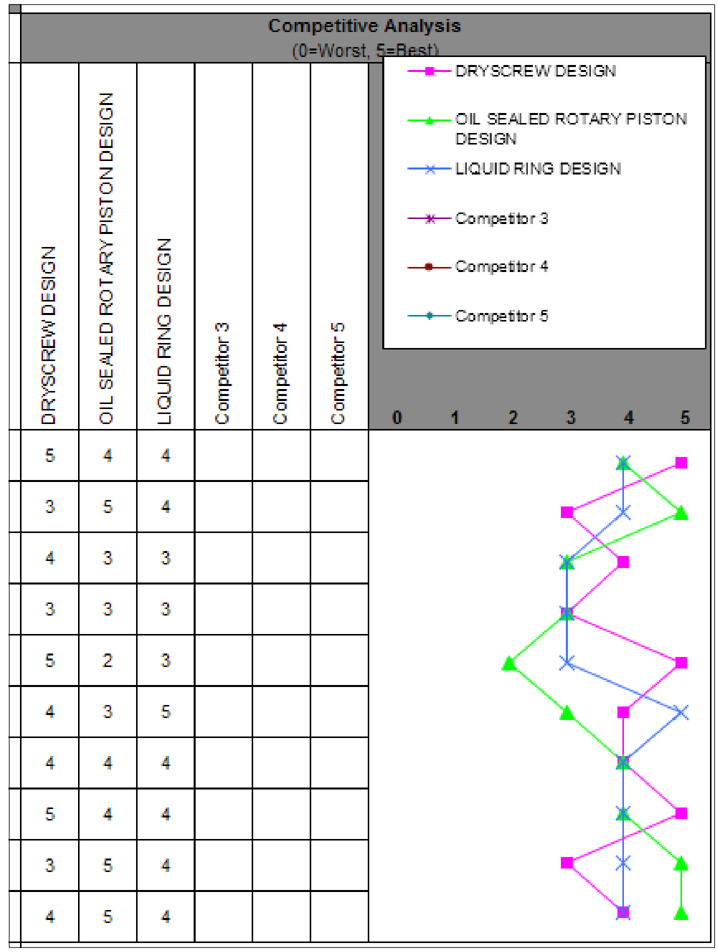

Figure 6: House of Quality (HoQ), Target or Limit Value.

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ABOUT THE AUTHOR: Christopher Estkowski has been working in engineering for 32 years. After few years leading in the Quality Engineering/Assurance disciplines, he moved into engineering management and is the founder and president of a successful product development firm. Seeking additional challenges, as VP of Engineering at Metallurgical High Vacuum Corporation, Estkowski is engaged in all aspects of industrial vacuum science. Metallurgical High Vacuum is a premium manufacturer and rebuilder of high vacuum equipment used in many industries serving customers across the United States.

Figure 1: Vacuum system consisting of an R 5 rotary vane vacuum pump and a Puma vacuum booster from Busch. (Courtesy: Busch Dienste GmbH)

Reliable Vacuum Supply for Plasma Nitriding

Plasma nitriding is becoming more and more important for heat treatment.

By Uli Merkle

The core area of expertise of HWL Löttechnik GmbH in Berlin is heat treatment of steel and other metals, mainly for the aerospace and automotive industries and for power plant technology. It offers nearly all types of heat treatment, including induction hardening, annealing, vacuum hardening, annealing and brazing, and all types of casehardening.

For the plasma nitriding, HWL Löttechnik was founded in 1981 in a courtyard in Berlin-Wedding, Germany, with just one employee. In 1983, Berlin's first-ever vacuum furnace began operation at HWL. Since then, it has dealt with the heat treatment of steel and other metals including titanium.

In 1996, the company moved to a new building in Berlin-Reinickendorf. In 2006, it moved into a second site. Today, HWL has 30 employees and is already planning further expansion to a third site. The equipment is in operation 365 days a year.

Kai Lembke has worked in the HWL family-run business since 2004 and has been a shareholder and member of the management board since 2011. He sees his company as a development partner for many of his customers, who often come to him with only an idea. These ideas become the basis for prototypes, small-scale production, and often result in large-scale production. In most cases, the process includes extremely complex tasks in which HWL works together with the customer to find a solution. HWL's activities as official Rolls Royce Aerospace research association partner are a sign of respect for the family business as a competent supplier.

IMPORTANCE OF PLASMA NITRIDING

Plasma nitriding is becoming more and more important for heat treatment at HWL. It has more than 30 years of experience with this process. Today, state-of-the-art system technology and control ensure the structure and composition of the compound and diffusion layers can be continually controlled and monitored. Pulsed direct current plasma is used to achieve uniform heat-treatment results. The advantage of this thermochemical process is that heat treatment can be performed at comparatively low temperatures between 520° and 580° Celsius (968° and 1,076° Fahrenheit).

Free charge carriers for electricity transmission must be available to make the plasma electrically conductive. At atmospheric pressure, economically unrealistic temperatures would be required to produce electrical conductivity of the plasma. HWL works with pressures of 2.5 millibar, which, in practice, enables heat treatment below 600° Celsius

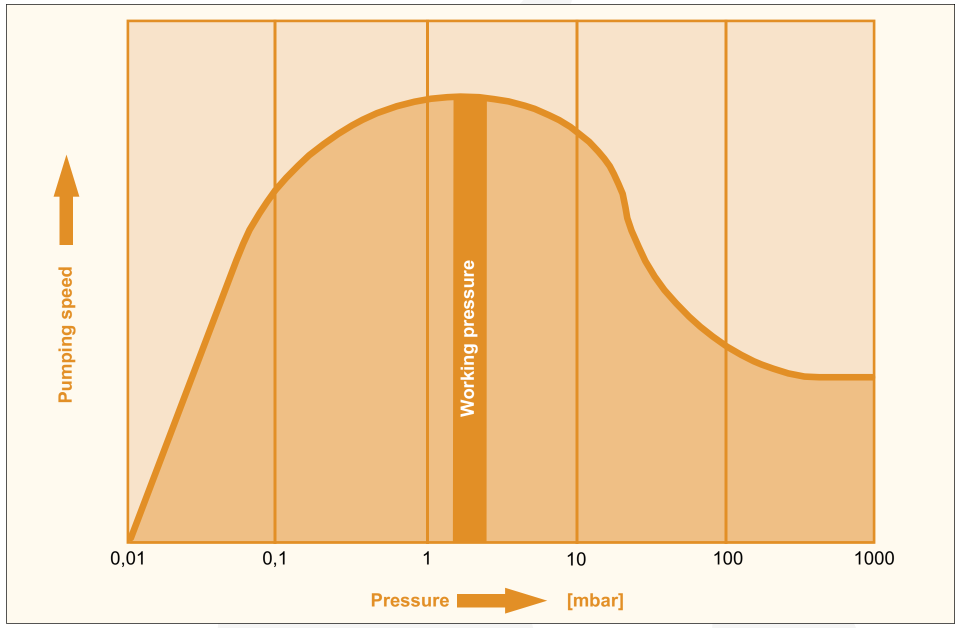

Figure 2: Vacuum system pumping speed. (Courtesy: Busch Dienste GmbH)

(1,112° Fahrenheit). The temperatures are low when compared to other heat-treatment methods, and this has an extremely positive effect on the warping behavior of the components. Another advantage to this method is that individual sections of components that should not be nitrided can be mechanically masked and thus selectively excluded from the nitriding process. This does not change the properties of the surface underneath the masked sections.

Before the actual plasma nitriding process, the components to be treated are precisely placed on the mounting device. HWL's many years of experience pay off here, as the parts must be optimally positioned in the furnace to achieve the desired surface properties. After the charging procedure and after the furnace is closed, it is evacuated to the required process pressure and heated using the wall heater. After this heating process, the components are exposed to glow discharge in a nitrogen atmosphere. A plasma is created in this glow discharge. The nitrogen dissociates in the process, ionizes, and is fired at the surface of the components. The exact handling temperature and nitriding duration depend on the material, size, and composition of the components, and the nitriding depths to be achieved. After the nitriding procedure, the furnace with the components is cooled down. The entire process lasts between 17 and 30 hours. The vacuum system is in operation during this period (Figure 1).

NEW NITRIDING FURNACE

After HWL already had positive experiences with other heat treatment systems with vacuum pumps from the company, Dr.-Ing. K. Busch GmbH, a new nitriding furnace was acquired in 2013, and it also had a Busch vacuum system. It consists of an oil-lubricated R 5 rotary vane vacuum pump as a backing pump and a Puma vacuum booster. This vacuum system achieves an ultimate pressure of <1 x 10^{-2} mbar while the actual operating pressure during the process is 2.5 millibars. This uses the optimal pumping speed of the vacuum system, which is highest in this operating range (Figure 2).

At the beginning of the process, the R 5 rotary vane vacuum pump evacuates the furnace from atmospheric pressure to a rough vacuum of 100 millibars. The Puma vacuum booster is only turned on now. As a booster, it considerably increases the pumping speed of the vacuum system to quickly achieve and reliably maintain the process pressure. By combining the vacuum system with a rotary vane vacuum pump and its controls, which are specifically coordinated for the process, it is possible to achieve maximum pumping speed with the lowest possible energy expenditure.

DESIRED PRODUCT PROPERTIES

Precise maintenance of the operating pressure and pumping speed ensures the ability to run and document replicable processes. This makes it possible to precisely achieve the desired product properties. Most of the time, high-alloy stainless steels are plasma nitrided at HWL, but construction steels or sintered metals are also heat-treated using this process. Since starting up the nitriding furnace in 2013, there has never been a vacuum system malfunction or failure even though it is in operation around the clock. Continuous operation is only interrupted by set-up or placement times.

For Lembke, absolute reliability of the vacuum technology has the highest priority. This is because failure of the vacuum system during the process can make the entire batch of top-quality and costly precision components unusable. During this time there has never been a vacuum supply malfunction.

Maintenance of the vacuum system is limited to a minimum. In addition to daily visual inspection of the oil level, the oil in the R 5 rotary vane vacuum pump and in the gear of the Puma vacuum booster is changed every two years. Lembke also knows that the Busch Service Center is nearby and can be on site immediately if anything ever happens.

For more information: buschvacuum.com

ABOUT THE AUTHOR: Uli Merkle has worked for more than 30 years in the sector of industrial vacuum technology. He is head of marketing services at Busch Dienste GmbH in Germany, a company of the international group of Busch Vacuum Pumps and Systems. He has released numerous publications about industrial applications with vacuum technology. He can be contacted at uli.merkle@busch.de

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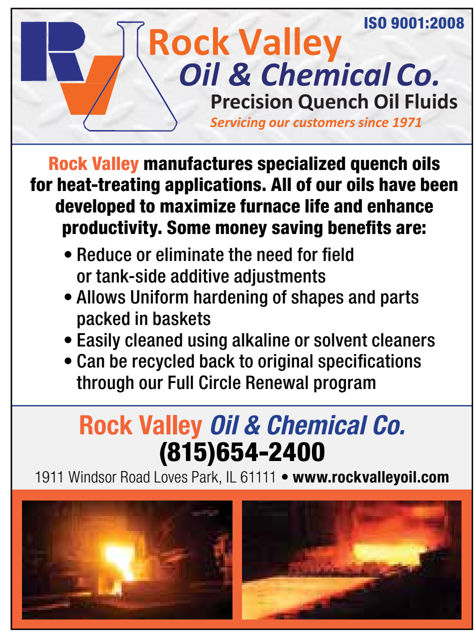

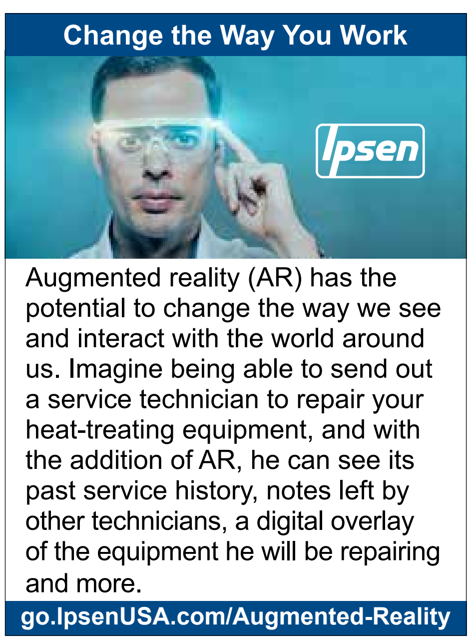

AD INDEX

RICK DIEKMAN
OWNER AND PRESIDENT OF CONTROLLED THERMAL PROCESSING, INC.

HOW DID CTP BEGIN?

CTP was started by an early NASCAR racer, named Jim Birks, after he accidentally cryogenically treated an engine. He built his own engines, and he bought an engine block from a junkyard that had been cycled through the northern Illinois winters many times. That gave it a cold cycle — it really wasn't a cryogenic cycle — and he tempered it when the barn it was in accidentally burned down around it. Jim noticed that engine lasted longer than any of his other engines. He talked to a metallurgist, and the metallurgist told him to read some research on true cryogenics. Jim did, and he started the company.

HOW DID YOU GET INVOLVED?

I was working in the field of wear resistance, and one of my fellow engineers came by my cubicle and said he had a buddy who had this cryogenic process. We had tried cryogenic processing and found it didn't work. But as a courtesy, I agreed to talk to him, but guaranteed nothing. He brought Jim Birks in, and Jim started to make a heck of a lot of sense. He told me why the cryo process I tried didn't work. I was supposedly working with the experts. Basically these supposed experts took the test die, and they dumped it in liquid nitrogen. It didn't give a very good increase in life, so I thought it didn't work. What I found out from Jim was that you have to reduce the temperature slowly. And with the case of most metals, you do have to temper afterwards. We gave him some dies to do, and we got about three times the life. You just don't dip it. It's like heat-treating; it has to be done right. I was so impressed with the results, I bought half the company.

WHAT ARE SOME OF THE SERVICES YOU OFFER?

Our main service is deep cryogenic treatment (DCT). We can go down to -450 degrees Fahrenheit. But, generally speaking, we go down to -300. The -450 has added advantages, but it's extremely expensive to do. We also work with our clients to help them better their products they're working on. We've found a lot of people don't have metallurgists on staff. And if you cryogenically treat a piece of junk, it remains a piece of junk. So if we go in there and say we're working with a die and the grinding is not being done in the best way, we advise them to straighten that out, and then we cryogenically treat it. That makes both them and us successful.

Grinding is the worst way of removing metal that you can imagine, because if you take too much off, you heat the surface area tremendously. Grinding heat will either temper the surface back, or austenitize the surface and give it a drastic quench with the grinding fluid. Some metals don't like being quenched with water. They crack. If you eliminate those cracks, you can get two to three times the life by grinding correctly. We help our customers with subjects like that. And then we apply cryogenics and get a good result.

HOW HAS CTP LED THE WAY USING CRYOGENICS IN THE HEAT-TREATING INDUSTRY?

We started a subcommittee in ASM. That subcommittee took Controlled Thermal's database of research papers to the Cryogenic Society of America. They created a database available to anyone on the web. The CSA has been increasing the articles in that database ever since. Every article is peer reviewed by a committee.

We're trying to make the process more scientific. We've done a lot of research with Illinois Institute of Technology, U.S. Army Aviation and Missile Command, various arsenals, Los Alamos National Laboratory, and various other colleges and universities. Our participation is to advise people doing the research and how DCT should be done. They do the research to prove whether DCT works. So far, it always has. We've also done a lot of articles on the process using our experience with our customers.

We do a lot of carbide cutting tools and getting three to four times the life on those. For gear makers, we do the hobs, and they love it, because hobs are expensive. We do a lot of broaches, copper-welding tips for spot welding. They last three times as long, and there's research on that.

HOW ARE YOU ADVANCING THAT TECHNOLOGY?

We are working with a lot of different companies on their parts to increase the wear resistance or the functionality of the part. We are engaging with a lot of universities. If they want to try this and see why it works, we will help them. We are currently working with a metropolitan transit authority on different parts of their train engines, and seeing if we can cut the maintenance costs. Maintenance in a train is one of the biggest costs for a railroad. A side benefit of reducing wear is we think we can help them keep their underground stations cleaner. Much of the dirt in underground stations is iron oxide coming from the wear of the brakes and wheels. So if you can cut that wear in half, then the station remains cleaner. So basically what we do is work with a company or governmental agency and try to get them to use the process or at least try it in ways it has not been used before.

WHERE DO YOU SEE THE FUTURE OF CRYOGENICS?

It's going to go in several directions. In the heat-treating process, it's going to be the finish of heat-treating. Right now, heat-treating is finished by tempering, but it will be finished in the future by cryo-treatment with a temper. And we know that because in India, that is becoming the norm.

Another big use will be on automotive brakes. The USPS is currently using it after they tested it and got five times the brake rotor life. Police units and freight fleets can cut costs substantially.

The other place it's going to go is treating aluminum, titanium, magnesium, and other metals. We've had great success with treating 3 series stainless for abrasion resistance. Aircraft companies will start to use it because of the substantial increase in fatigue life it creates. And it will be used more and more and more on tools, molds, dies, and cutting tools — carbide cutting tools and such.

FOR MORE INFORMATION: ctpcryogenics.com

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When you need precise temperature control and heating compatible with any furnace atmosphere,
Think Custom Electric.

When you are looking to maximize electric furnace performance, reduce downtime and save money,
Think Custom Electric.

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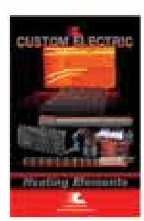
Custom Electric has 44-years experience and a demonstrated performance record. Most importantly, we want to be your heating element supplier and will work hard to make this happen. Whenever you think about heat treating gears in electric furnaces,
Think Custom Electric.



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