Thermal processing

HEAT TREATMENT OF PM PARTS BY HOT ISOSTATIC PRESSING

COMPANY PROFILE
Praxair, Inc.

Technologies and Processes for the Advancement of Materials

MAY / JUNE 2018
thermalprocessing.com

Achieving Increased Profits and Response Times with Modular Vacuum, Atmosphere Furnaces

"Initially, what appealed to us about this Ipsen equipment was its general purposefulness ... We wanted a low-cost, off-the-shelf-type solution that would allow us the flexibility we required – which is what the ATLAS and TITAN® delivered. Now after having performed some pre-training, I would say what stands out the most for both are the ease of use and control of the equipment."

– Continuous Improvement Manager

Customer Story

Reduced lead times and increased flexibility by bringing the majority of heat treatment in-house

Increased process and part versatility with the installation of both atmosphere and vacuum heat-treating systems

Challenge:
The customer was seeing an increase in production demands and volume of parts. While they were relocating their existing facility to a new location, they also needed to find an equipment solution that would help them keep up with the recent influx.

Action:
Expanded their production capabilities by installing a complete ATLAS atmosphere heat-treating system and a TITAN® vacuum furnace at their state-of-the-art manufacturing facility.

Discover this customer's winning outcome:
go.IpsenUSA.com/Customer-Stories

IpsenUSA.com

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When your vacuum furnace hot zone is unexpectedly down or nearing the end of its service life, count on Solar Manufacturing's replacement hot zones to get you back in business. Rely on our world-class engineering, outstanding customer service and reliable aftermarket support. Whether you need a straight-up replacement or an improvement of an existing design, your new hot zone will fit perfectly and keep you going.

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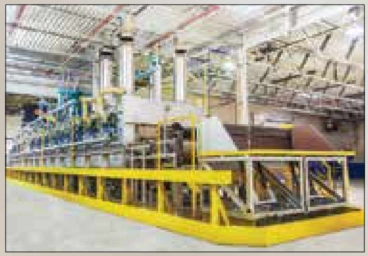
FEATURES

MAY / JUNE 2018






DEPARTMENTS

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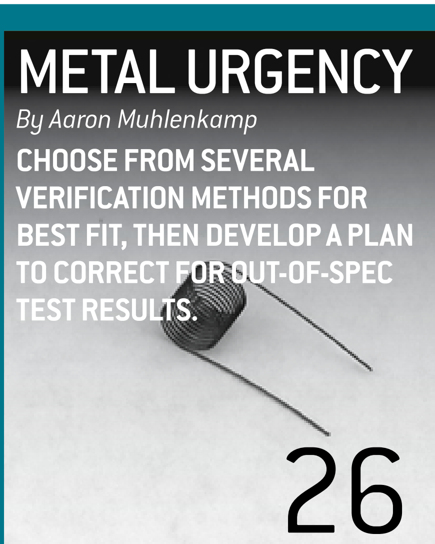

RESOURCES

Cover photo: Böhler Edelstahl GmbH & Co.KG

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LETTER FROM THE EDITOR

Mother Nature needs decent process control

It's a shame, with all this crazy weather that's kept the entire country freaked out, that Mother Nature can't control her temperature settings with the accuracy of the heat-treating industry.

Controlling important factors such as temperature and atmosphere are vital to the success of furnaces and ovens. That's why companies invest in process control tools to ensure the products that go through their furnaces get the treatment they require.

In this issue of *Thermal Processing,* we tackle process control as well as powder metallurgy.

In the process control arena, Conrad Kacsik takes us through a company's change over from its antiquated, decades-old control system to a state-of-the art system run with the latest software. The catch was that the new system had to work with its older hardware. Conrad Kacsik accepted the challenge, and not only was it able to install an upgrade, but it installed a cost-effective one.

In the area of powdered metallurgy, I'm excited to offer not one, but two articles from the Metal Powder Industries Federation.

Dr. Anders Eklund and Magnus Ahlfors share their knowledge on the advantages of using pre-stressed wire-wound hot isostatic presses for consolidating metal powder.

And a technical paper from Kyle Bear, Glenn Rishel, Brian Smith, and Stephen Feldbauer discusses how controlling filler metal at the braze joint of a sinter brazed product can have significant impact on the quality and yield of complex shapes.

I am also pleased to share Praxair, Inc.'s storied history in our company profile feature. Praxair has been offering industrial gases to all kinds of industries, including heat-treating, for decades. Check out how this leading industrial gas company helps its customers find the best ways to increase their efficiency.

And, as usual, we have our regular features from our talented and knowledgeable columnists. I learn something new every issue from them. I hope you do, too.

Enjoy this issue of *Thermal Processing* and take heart that Mother Nature's process control should be warming up the Earth any day now. But give her a break; her system is a few million years old after all.

Thanks for reading!

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OPERATIONS

Premier/BeaverMatic manufactures another IQF furnace line

The customer's expansion in Dubai includes purchase of a Premier/BeaverMatic Internal Quench Furnace with a complete system capable of processing 30" wide by 48" long by 26" high workloads, which weigh up to 1,500 pounds. (Courtesy: Premier/BeaverMatic Inc.)

A major manufacturer and supplier for oilfield logistics services has expanded to a new facility located in Dubai, United Arab Emirates. This company is expanding its capabilities for the manufacture, service, and repair of a variety of oilfield-related equipment such as manufacture of drilling tools, machine shop repair services, lifting equipment inspection services, fluid sealing gasket products, slotted liners, specialized welding, hard metal applications, and more. Its latest investment was with Premier/BeaverMatic heat-treating equipment, to meet the delivery for the many high-quality parts and components listed above. With this new expansion, they will become a unique 'client-focused upstream services provider,' and the manufacturer/supplier for many quality products for the oil, gas, energy, and process industries.

The primary challenge was to meet the need of growth with expansion through their heat-treating department. To match existing heat-treating equipment, and after many years of proven performance of existing BeaverMatic products, the solution was the purchase of another complete line of Premier/BeaverMatic atmospheric heat-treating equipment. The expansion includes a Premier/BeaverMatic Internal Quench Furnace including high-efficiency SER heating system, quench oil cooling and centrifugal separation systems, Premier/Beaver Ram transfer system, and front load table; Premier/BeaverMatic temper furnace; Premier/BeaverMatic drying oven; Premier/BeaverMatic spray and dunk washer, Premier/BeaverMatic endothermic gas generator; data collection system; and a manual load transfer cart. The complete system is capable of processing 30" wide by 48" long by 26" high workloads, which weigh up to 1,500 pounds.

By acquiring this Premier/BeaverMatic heat-treating system, this major oil field supplier will be able to service its customers around the world with quick, responsive production requirements. Creative and fluid engineering and ideas provide cost-effective, solid solutions.

BeaverMatic is a manufacturer of standard, custom batch, and continuous heat-treating equipment used domestically and worldwide in the commercial heat-treating, oil field, aerospace, automotive, fastener, gear, tool and die, and wind-power industries.

This supply center also has a strong manufacturing orientation with its focus on the upstream industry, but also manufactures pressure vessels, heat exchangers, and skid-mounted gas compression packages for both oil and gas and process industries.

In addition to equipment for drilling-related activities, this company also manufactures complete assemblies including, but not limited to, liner hangers, liner packers, by-pass cement manifolds, and anchors. This supply center has 1,300 worldwide employees and net assets of more than 1.2 billion Arab Emirates Dirham.

MORE INFORMATION: www.premierfurnace.com

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

Grieve mourns the loss of Pat Calabrese

The entire Grieve Corporation family mourns the loss of its longtime president, P.J. "Pat" Calabrese, who died on February 17, 2018, in Lake Forest, Illinois, at the age of 90. Pat was the president of Grieve, a world leader in industrial ovens and furnaces, from 1958 until his retirement in 2008. He worked closely with the company's founder, Price Grieve. Pat's son Frank is currently the VP of sales and marketing, while Price's son Doug is the president and CEO of the company founded by Mr. Grieve in 1949.

P.J. "Pat" Calabrese

Pat was born in Chicago, graduated in 1949 from the University of Illinois with a BS in Mechanical Engineering, and was awarded that school's prestigious Distinguished Alumni Award in 2001. He also held a number of positions with various industrial, business, and Catholic charitable organizations.

Pat began his career at Grieve in 1958 as national sales manager, becoming president in 1968, and chairman in 2006 following the death of Mr. Grieve. During his tenure as president, the company grew steadily to become a global supplier of heat-processing equipment for virtually every industry in every industrialized country in the world.

RAAL orders Seco continuous CAB lines for battery coolers

RAAL S.C., a manufacturer of automotive parts, has ordered Seco/Warwick's continuous controlled atmosphere brazing line for battery coolers for their maximum life and optimum performance. This is the third such line from Seco/Warwick with which RAAL decided to equip its facility within the last three years of successful cooperation.

RAAL is a manufacturer of complete cooling systems and brazed heat exchangers made of aluminum alloys and stainless steel: radiators, oil coolers, air coolers, condensers, and evaporators, designed for agricultural, construction, industrial equipment, and automotive applications.

With the addition of Seco/Warwick's continuous controlled atmosphere brazing (CAB) line for production of aluminum heat exchangers, RAAL takes another step toward producing high quality battery coolers for carmakers, ensuring long lasting products in different operating conditions. The line is customized for large size battery coolers and is designed for high capacity production.

"For decades, Seco/Warwick has been recognized globally as a leader in aluminum brazing technology and a number of aluminum heat-treatment solutions for the automotive industry. Three years ago, we decided to cooperate with Seco/Warwick, and we are glad to say that their solutions met our expectations, so it was only natural to place another order for the CAB line. Thanks to this proven technology we are able to meet the growing demand for quality among automotive parts manufacturers and increase our production capacity," said Clement Ivanescu, strategies director at RAAL S.C.

"Seco/Warwick's commitment to quality products begins in engineering and continues through the complete installation and professional technical services. Our cooperation with RAAL is another example of Seco/Warwick's ability to deliver excellent service and technologies. Each of our systems provides unique benefits and is designed to deliver efficient, flexible throughput on a continuous basis," said Piotr Skarbiński, global VP CAB & aluminum segment at Seco/Warwick.

The need for high reliability has driven most automotive cooling batteries producers toward simple and inherently reliable technologies. Such technologies are offered by Seco/Warwick, a leading global manufacturer of heat-treatment furnaces and equipment.

"The functioning of an electric vehicle is influenced by its power battery, which, in order to work most efficiently, should operate in the range of 25-45 degrees Celsius. The battery temperature affects vehicle performance, reliability, safety, and lifecycle cost. Seco/Warwick understands EV industry needs and has proven brazing solutions for manufacturing battery coolers that meet demanding requirements. Because of this, more and more EV manufacturers are reaching for our technologies," said Skarbiński.

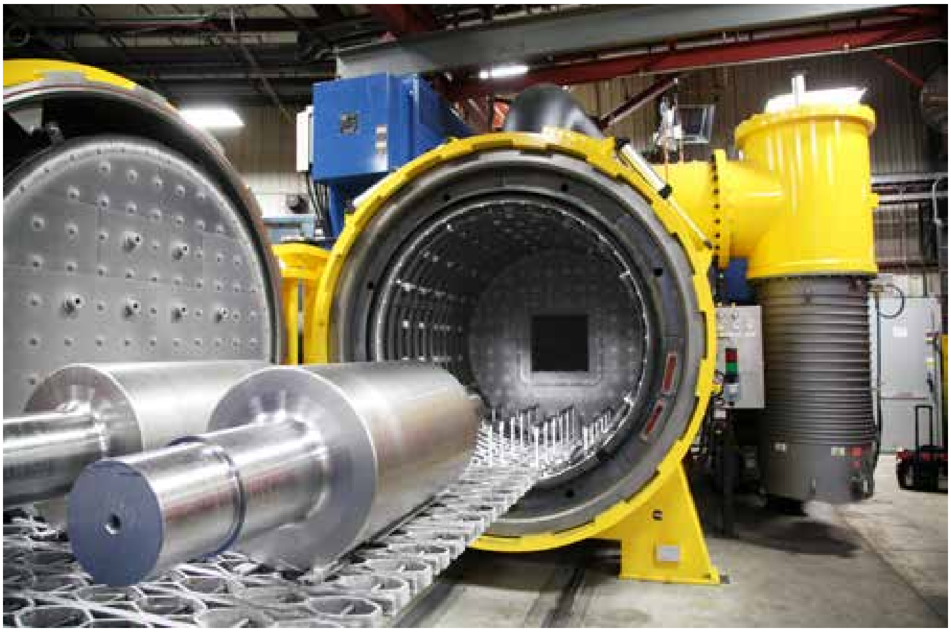
Knowledge of the market, trends, and expectations of automotive concerns, combined with constant improvement of technological solutions, allows Seco/Warwick's customers to use more and more modern materials in their products, thus giving them a competitive advantage. Seco/Warwick CAB aluminum furnaces and heat-treatment furnaces and systems are designed according to the individual needs of each customer. The solutions integrate and optimize production and logistic processes while also improving production flexibility.

MORE INFORMATION: www.raal.ro

Solar Atmospheres adds state-of-the-art 10-bar furnace

Solar Atmospheres, Inc., in Souderton, Pennsylvania, recently installed a state-of-the-art Solar Manufacturing, Inc. 74" diameter by 72" deep horizontal internal quench vacuum furnace at its Clearview Road facility. The investment totals more than $1.8 million, including additional utilities and installation. The furnace is designed to quench with argon at 10-bar while using a 600-horsepower motor running at 460 volts from a variable speed drive, and rear head moveable gas baffle doors. The goal of the massive quench system is to be able to quench larger batches of power generation castings by increasing the cooling rate and eliminating the supplemental use of helium and operating in 100 percent argon, which has proved successful in operation. The furnace incorporates Solar Manufacturing's latest SolarVac® 5000 control system, which allows for complete process automation.

"This furnace is a real game changer," said Mike Moyer, Solar's director of sales.



Two Leadar Roll, Inc., 2,200-pound rolls, 4,400 pounds total, heated to 2150°F, quenched in 10-bar N2 and then tempered at 1,000°F. The core material is 4140 with outer case CPM9V, and the as-quenched hardness is greater than Rockwell C 60. (Courtesy: Solar Atmospheres)

MORE INFORMATION: www.solaratm.com

Paul Gies PE joins Diablo Furnaces as engineering manager

Diablo Furnaces has announced that Paul Gies PE has recently joined the company as engineering manager. Gies comes to Diablo with a long history in the engineering and construction fields, along with experience working for a heat-treating OEM manufacturer. With twenty years' experience, Gies is an accomplished engineer in technically calculating and mechanically designing heat-treating equipment. Gies is a licensed professional engineer from the State of Ohio of Professional Engineers and Surveyors and has a B.S. in construction engineering technology from the University of Toledo, Toledo, Ohio.

Paul Gies

As Diablo Furnaces' engineering manager, Gies will lead the direction of new furnace equipment and retrofits, while developing and refining its existing standard line of heat-treating equipment. With Gies' extensive experience, he will also assist with applications engineering and sales to better understand the customers' ever-changing needs.

MORE INFORMATION: **www.diablofurnaces.com**

Tenova is founding member of European Steel Technology Platform

Tenova, together with twelve other leading industrial and research stakeholders from the wider steel value chain across Europe, will cooperate to implement solutions for and in the EU steel industry under a newly independent entity, the European Steel Technology Platform (ESTEP) AISBL.

The legal establishment of ESTEP as an international non-profit organization under Belgian law was announced by Klaus Peters, Secretary General of the new organization, on March 26, 2018. Its mission is to engage stakeholders in collaborative actions and projects on technology and innovation, tackling EU-wide steel innovation challenges in order to create a sustainable European steel industry. These challenges include digitization, fostering a low-carbon future for industry, the circular economy, and resource and energy efficiency.

The thirteen founding members are EUROFER, ArcelorMittal Maizières Research, Dillinger, Outokumpu, Tenova, Rina Consulting – CSM, Swerea, Tata Steel Nederland Technology, Thyssenkrupp Steel Europe, voestalpine Stahl, VDEh – BFI, Jernkontoret, and Salzgitter.

ESTEP already has a track record of success over a number of years, during which it has operated under the umbrella of the European Steel Association (EUROFER).

"We decided to be a founding member of ESTEP because we believe that Tenova, as provider of innovative and sustainable solutions, can bring a valid contribution to the attainment of the new organization's strategic mission. Collaboration among multiple stakeholders creates synergies to further step up the efforts toward a sustainable EU steel industry," said Andrea Lovato, Tenova CEO.

Tenova's strong commitment to support ESTEP in enhancing innovation and sustainability across the industry was confirmed by the appointment of Roberto Pancaldi, Tenova Metals CEO, to the Board of Directors, together with Axel Eggert, EUROFER; Carl De Maré, ArcelorMittal; and Eva Sundin, Swerea).

"It's an honor to be granted a seat in the Board. I really appreciate the activities that ESTEP has been carrying on throughout the years and I am confident that Tenova's commitment and positive attitude at cooperating will be an asset to the organization," Pancaldi said.

MORE INFORMATION: www.tenova.com

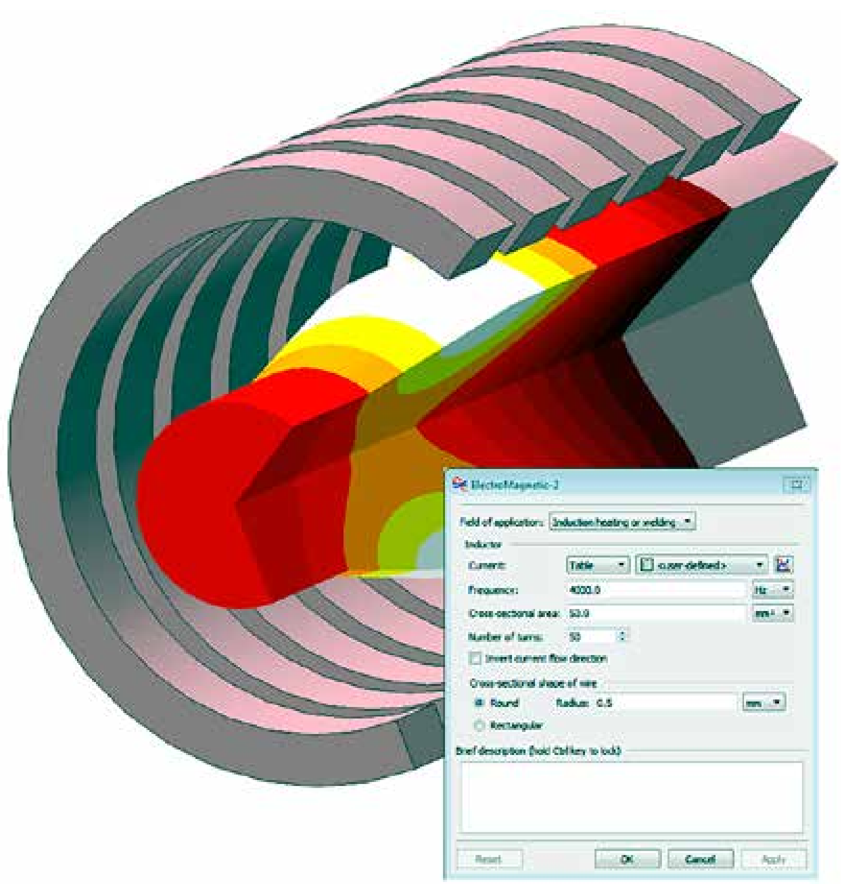
Simulate inductive heating and case hardening with Simufact

Simufact, an MSC software company, has announced the release of the next generation of its software solution, Simufact Forming 15, for the simulation of forming manufacturing processes. Users will now be able to simulate inductive heating processes as well as case hardening. One key new feature is the interface to the casting software Magmasoft® 5.4, which, in addition to the already existing ProCAST interface, pushes forward the idea of the process chain simulation. Results imported from the casting simulation via the Magma interface in Simufact Forming 15 for subsequent forming processes in the design cycle. With the added parallelizable Segment-to-Segment calculation method in the new solver, Simufact Forming 15 is now able to simulate large models with deformable bodies faster and more efficiently.

Inductive heating is used in many areas of industrial manufacturing, including heating of workpieces to forming temperature, induction hardening, and induction welding. Users can now optimize and design parts with inductive heating processes and subsequent hardening processes.

Simufact Forming helps design engineers gain a detailed insight into an inductive heating process. Users can identify errors, remove unwanted effects, and make optimizations. In designing the coil, for example, which is the core challenge of inductive heating. Simufact Forming 15 presents users with the complexity of physical context.

The required electromagnetic material properties needed for these types of workflow can be imported by the extended JMatPro interface.



Inductive heating of a die simulated in Simufact Forming 15. (Courtesy: Simufact)

Case hardening is one of the most widespread and important heat treatment processes. Dies, drive parts, or gear parts (gears) are often case hardened at the end of the manufacturing process to combine a wear-resistant surface with a tough behavior in the core. Simufact Forming Version 15 extends the functions of simulating heat-treatment processes in order to make practical use of the diffusion effects in case hardening. With the new version, it is now possible to calculate the adjusting carbon distribution that results during the carburizing below the surface of the component, and allows for the influence of this carbon profile on the transformation behavior during quenching.

The newly implemented contact positioner and significantly improved positioning options simplify the positioning of the workpiece and the tools. With the query results function (querying values), engineers can selectively record and determine result quantities. With the newly implemented user coordinate system, users can compare their simulated component with the target design or with 3D measurement data as a reference model. With the current version, Simufact introduces a re-implemented fast and automated fold detection feature that greatly simplifies the detection of folds, which is specifically useful for hot forging.

MORE INFORMATION:
www.simufact.com

New employment opportunities at Wisconsin Oven

Wisconsin Oven Corporation experienced a year of expansion in 2017 with the opening of a new facility in East Troy, Wisconsin, that doubled the manufacturing floor space. Due to this development and their record sales, Wisconsin Oven is hiring a variety positions in the skilled trades and engineering fields. Wisconsin Oven has been designing, engineering, and manufacturing industrial ovens and other heating equipment since 1973. Its custom and standard industrial ovens are used for a multitude of applications including heat treating, finishing, drying, or curing.

People often assume that Wisconsin Oven manufactures ovens for the food industry but that may be the only industry they do not serve. Henry Kubicki, the founder of Wisconsin Oven, often said, “You are never more than a few feet away from something that was manufactured by Wisconsin Oven.” Wisconsin Oven equipment is used to manufacture various everyday items such as bed springs, coffee cups, door knobs, car components, and airplane fuselages. The industries Wisconsin Oven serves include aerospace, automotive, pharmaceutical, military, and energy, to name a few.

Wisconsin Oven realizes that the success of the company depends on its championship team of employees, which is why it has developed a company culture that recognizes and rewards employees. They are looking for passionate people who are strong leaders and always give 110 percent. There are many opportunities for growth, advancement, and wage increases based on skill level.

Contact Wisconsin Oven to learn more about its competitive wages and benefits package that includes a generous time-off plan and 401K with a company match. Check out current job openings or submit an application at www.wisoven.com/careers.

MORE INFORMATION: www.wisoven.com

Hangzhou XZB Tech orders Tenova Bell-type annealing plant HPH®

Tenova LOI HPH® Bell-type annealing plant for wire rods (Courtesy: Tenova)

At the beginning of this year, Tenova LOI Thermprocess, Essen/Germany, and its Chinese subsidiary, Tenova LOI Thermprocess (Tianjin) Co. Ltd., received a joint order from a leading Chinese manufacturer of cold-formed components for the automotive industry.

The company Hangzhou XZB Tech Co. Ltd. ordered a Bell-type annealing plant high performance hydrogen (HPH®) for wire rod for its new works in Huzhou. This order includes the delivery of a furnace plant with three annealing bases, two heating hoods and one jet cooling hood. This HPH® Bell-type annealing plant uses hydrogen as protective gas; moreover, it features a useable diameter of 4,200 mm and a useable height of 5,300 mm for each base, which results in an average charge weight of approximately 48 tons wire rod per each annealing base. The new plant is designed for the annealing of both hot-rolled and drawn wire coils.

The production in this new annealing plant is scheduled to start in late autumn 2018.

The receipt of this order underlines the position of LOI Thermprocess, a company of the Tenova group, as a highly reputable manufacturer of Bell-type annealing plants for wire rods in China.

MORE INFORMATION: www.tenova.com

Bodycote opens new specialist technologies facility in U.S.

Bodycote, the world's largest provider of heat-treatment and specialist thermal processing services, is pleased to announce the opening of its newest facility for Specialty Stainless Steel Processes (S^3P) which increase mechanical and wear properties in stainless steel without adversely affecting corrosion resistance.

Demand for S^3P processes featuring Kolsterising® has grown exponentially across multiple markets including automotive, food processing, medical, and oil and gas among others in the United States. The new North Carolina facility will support the manufacturing supply chains in the southeast region. The site will be accredited for both ISO9001 and AS9100 to serve the customer base.

Bodycote opened a new facility for Specialty Stainless Steel Processes (S^3P). (Courtesy: Bodycote)

Kent Abrahamsen, senior vice president, Bodycote Specialty Stainless Steel Processes, said, "We are excited to respond to our customers' requests to expand Bodycote's geographic footprint and increase capacity to serve their growing demands. Our new, larger facility in Mooresville supports the increasing demands for Specialty Stainless Steel Processes (S^3P)."

Certain stainless-steel applications present unique technical challenges to metallurgists and engineers. Bodycote's S3P technologies are proven solutions dedicated to treating stainless steel, nickel-based and cobalt chromium alloys (including martensitic and precipitation hardened stainless steel materials) to improve resistance against surface wear such as galling, cavitation erosion, and abrasive wear. Bodycote's S^3P processes are special for a number of reasons, but in particular their anti-galling properties. Customers need a reliable and repeatable solution and Bodycote's Kolsterising® process delivers that.

Many surface treatments, when applied to stainless steel, will negatively affect the metal's inherent corrosion resistance. Uniquely, Bodycote's S^3P processes impart increased mechanical and wear properties without adversely affecting corrosion resistance, presenting engineering benefits.

MORE INFORMATION: www.bodycote.com

Lindberg/MPH ships electrically heated cyclone pit furnace

Lindberg/MPH announced the shipment of an electrically heated cyclone pit furnace to a steel heat-treater. This is a repeat customer for Lindberg/MPH and the pit furnace will replace an existing Lindberg furnace at the buyer's facility. The cyclone pit furnace will be used for a heat-treating process on aircraft components.

The maximum temperature rating for this electric pit furnace is 1250°F. The work chamber has a 38" diameter x 48" depth and is constructed with an alloy liner backed with 7 inches of block insulation. The customer requested tight temperature uniformity and this design met a +/-10°F temperature uniformity throughout the qualified work zone.

The top-load furnace features a thermo cartridge recirculating fan and solid wall baffle for uniform heat distribution. The furnace fan uses a centrifugal blower type alloy blade and a 5HP motor with belt and pulley drive system. The steel outer shell is constructed from heavy-gauge steel plate reinforced with structural steel members.

"Ease of use and maintenance is always a top priority when we engineer equipment. This new Lindberg/MPH design features a maintenance-friendly fan and motor assembly to provide reliable and easy maintenance when needed," said Kenneth Zielke, sales engineer.

Unique features of this Lindberg/MPH cyclone pit furnace include:

- Alloy liner protects work chamber from high velocity flow and prevents damage while loading/unloading
- Easily replaceable heater plug assembly
- Recirculating fan with variable frequency drive
- Temperature uniformity of +/-10°F
- Workload support for customer's baskets or fixtures
- Lid limit switch

A repeat customer has purchased an additional electrically heated cyclone pit furnace. (Courtesy: Lindberg/MPH)

MORE INFORMATION: www.lindbergmph.com

Ovako launches its digital heat-treatment guide

Ovako, a leading producer of engineering steel, has launched its Heat Treatment Guide, the first digital tool on the market to enable customers to calculate the mechanical properties of a selected steel after heat-treatment. This will save customers time and money by offering a digital alternative to physical testing.

"We are pleased to be able to offer the Ovako Heat Treatment Guide which will help users understand how chemical composition influences the hardness of a steel after quenching and tempering," said Göran Nyström, head of Marketing and Technology at Ovako. "This user-friendly tool further supports our commitment to share with customers the best of our technical expertise."

Ovako's Heat Treatment Guide can help a customer choose the right steel for the specific application. By choosing a steel grade composition in the Heat Treatment Guide, users will be able to predict how a steel of a specific composition will perform after heat-treatment. The user can alter the steel compositions to investigate the impact of different alloying elements and can compare different steel compositions by layering them in the resulting graphs.

"The primary information provided by the Heat Treatment Guide is the hardness that can be achieved as a function of the cooling rate when the steel is quenched, presented as a CCT-diagram and a Jominy curve," said Joakim Fagerlund, developer of the Ovako Heat Treatment Guide. "Secondly, the tempering diagrams show how hardness and tensile strength vary as a function of the tempering temperature. A table also details the core hardness after quenching of bars in diameters ranging from 5 up to 500 mm using water, oil, or air as the quenching medium."

Ovako's Heat Treatment Guide is a development of the Ovako Steel Navigator, a digital platform created to help customers identify the best steel for their application, and can be used with most steel grades.

MORE INFORMATION: www.heattreatmentguide.com

Qalex reaches goals with new nitrex system

Qatar Aluminum Extrusion Company (Qalex) awarded a contract to Nitrex Metal for the supply and installation of an NX-1015 potential-controlled gas nitriding system configured for treating various sized flat and hollow dies used in the production of aluminum extruded profiles for the construction and transportation markets. Qalex sought to adopt new technological innovations in nitriding, when equipment and die quality requirements could not be met with the existing fluidized bed nitrider. Specifically, the company wanted to automate nitriding operations, cut gas consumption, eliminate post-nitriding cleaning operations, and take advantage of cutting-edge equipment that maximizes control of the process and guarantees repeatable results.

The NX-1015 furnace has a load capacity of 4400 pounds, and while this is slightly larger than current production needs, the additional capacity will accommodate future growth when Qalex adds a second extrusion press. The precise interaction between the furnace and advanced control system allows the atmosphere to be adjusted automatically, according to the recipe and parameters entered. Integral to the system operation, Nitreg® technology is customized and pre-tested for extrusion dies to ensure optimum results of the nitrided layer, as well as to obtain repeatable results and higher throughput per die. Thanks to closed-loop control, the Nitrex nitriding system and process are more efficient, producing best results while minimizing gas consumption and electricity. The installation and startup was completed in January 2018.

MORE INFORMATION: www.qalex.com.qa

Grieve's No. 1044 furnace measures 12" W x 18" D x 8" H. (Courtesy: Grieve)

Grieve's No. 1044 is 2000°F inert atmosphere bench furnace

No. 1044 is a 2,000°F (1,093°C), inert atmosphere bench furnace from Grieve used for heat-treating at the customer's facility. Workspace dimensions of this furnace measure 12" W x 18" D x 8" H. 6KW are installed in nickel chrome wire coils supported by ceramic plates.

This Grieve bench furnace features 5-inch-thick insulated walls comprised of 1 inch of 2,600°F ceramic fiber, one inch of 2,300°F ceramic fiber, and three inches of 1,900°F block insulation. Features include a vertical lift door with gas spring counter balance and inert atmosphere construction, including a continuously welded outer shell, high-temperature door gasket, sealed heater terminal boxes, inert atmosphere inlet, and inert atmosphere outlet.

Additional features include an inert atmosphere flow meter and normally closed solenoid valve on atmosphere inlet.

Controls on the No. 1044 include a digital programming temperature controller and manual reset excess temperature controller with separate contactors.

For more information: www.grievecorp.com

Can-Eng Furnaces selected for North American expansion

Can-Eng Furnaces International Limited was recently awarded a contract from an India-based conglomerate to design, manufacture, install, and commission an Aluminum Automotive Casting Heat-Treatment system for its new green field North American expansion in South Carolina. Can-Eng was chosen for this project largely due to the unique modular design concept which offers efficient product, process, and production flexibility for its partners' new line of Die Cast Light Weight Aluminum Automotive Components. This solution treatment, water quench and artificial aging system are arranged to provide both T5, T6, and homogenizing processes. The new system will service three distinct aluminum product groups with unique treatment cycles.

The Can-Eng modular systems have been a valuable offering to Can-Eng's partners since 2005. The ability to plan and scale equipment capital needs to production capacity needs is most beneficial to users.

Can-Eng Furnaces International is a global provider and leader of state-of-the-art thermal processing systems headquartered in Niagara Falls, Ontario, Canada.

MORE INFORMATION: www.can-eng.com

Bilstein places order for expansion of automatic batch annealing plant

In December 2017, Bilstein, based in Hagen-Hohenlimburg, Germany, placed its third follow-up order to Tenova LOI Thermprocess in Essen for the expansion of the fully automatic batch annealing plant. This furnace plant is the only batch annealing plant in the world with fully automatic stacking of coils and intermediate convectors, an automatic coupling of all media, and fully automatic operation of protective hoods, heating hoods, and cooling hoods. Except for one operator in the measuring station, no further operation personnel are required any more.

With the latest expansion of its batch annealing plant, Bilstein has strengthened its reputation as one of the most innovative companies in the industry and doubled the original quantity of annealing bases. The contract for stage I was placed in 2011 and consisted of twelve annealing bases with six heating hoods and six JET-cooling hoods. The plant started fully automatic operation in November 2012. After a successful test phase, the plant was expanded by four annealing bases in 2015 during in stage II. In December 2017, the contract for stage III, consisting of eight further annealing bases, was awarded. Production is scheduled to start in autumn 2018.

Hot- and cold-rolled steel strip coils with a coil weight of max. 30 t, an outer diameter of 1,000 mm to 2,000 mm and a coil width of 150 mm to max 1,350 mm are annealed in this plant.

To meet the requirements for fully automatic operation of the bell-type annealing plant, a series of adaptations were essential for the batch annealing technology itself. In automatic operation, the operating personnel does not have access to the plant. Various independent safety zones ensure that regular maintenance work does not interfere with automatic operation. The plant was designed in such a way that the previously required visual check is no longer necessary. Essential design modifications at almost all plant components including annealing bases, base locations, heating hoods, multimedia couplings, protective hoods, and instruments were successfully implemented. Furthermore, the heating hood features a particularly energy-efficient technology that leads to lowest combustion gas consumptions.

Due to the bypass cooling, Bilstein is able to extract large amounts of useable heat. Moreover, some of the waste heat is converted into electrical power, up to 400 kWh per annealing charge. Thermal energy of up to 5,300 kWh is achieved by the heat extraction.

Thus, the Bilstein bell-type annealing plant is not only the only fully automatic batch annealing plant in the world but also the highest-performance, most energy-efficient furnace plant of this type.

MORE INFORMATION: www.tenova.com

E Instruments introduces low NOx industrial emissions analyzer

The mission of E Instruments is to design, manufacture, and market a complete range of innovative instrumentation solutions encompassing portable emissions and combustion analyzers, and indoor air monitors especially designed for the industrial, HVAC, commercial, and institutional markets worldwide.

The new E4500 portable flue gas and emissions analyzer is designed for emissions monitoring, maintenance and tuning of boilers, burners, engines, furnaces, turbines, kilns, incinerators, and many other industrial combustion processes requiring accurate low NOx measurements.

Benefits of the analyzer include:

- Low NOx measurements with 0.1 ppm resolution and high accuracy under 100ppm NOx
- Available with Both NO & NO_2 sensors for total NOx
- Optional sample conditioning unit (SCU):
- Minimize NOx loss from condensation
- Ensure accurate NOx readings

Other key features include dilution pump for CO auto-range, measurements up to 10 percent, built-in printer (non-fading paper), automatic data saving feature, internal data memory (2,000 tests), software package with USB and Bluetooth, and temperature and pressure measurements.

E Instruments also offers the E9000 portable emissions analyzer, which is ideal for regulatory use. The analyzer with heated sample line is a complete portable system for EPA compliance level emissions monitoring and testing. The E9000 is ideal for regulatory and maintenance use in boiler, burner, engine, turbine, furnace, and other combustion applications.

Above: The new E9000 portable emissions analyzer with heated sample line helps with compliance, maintenance.

Right: The new E4500 portable flue gas and emissions analyzer is designed for industrial combustion processes requiring accurate low NOx measurements. (Courtesy: E-Instruments)

Features include:

- Up to (9) total gas sensors
- Electrochemical sensors – O_2, CO, NO, NO_2, SO_2, H_2S
- NDIR sensors – CO_2, CxHy (HC), High CO
- Heated probe head and sample line
- Internal thermoelectric chiller with automatic condensate removal
- Internal data storage memory (16,000 tests)
- Built-in printer with non-fading paper
- Android app to monitor and save data
- Software with automatic data logging
- Low NOx and true NOx capable
- Pre-calibrated gas sensors

MORE INFORMATION: www.e-inst.com

Ohio Valley Aluminum buys traveling log homogenizing system

Ohio Valley Aluminum Company's continuous improvement efforts at its facility in Shelbyville, Kentucky, continue with the purchase of an innovative Seco/Warwick solution to process aluminum billet and logs in a lean manufacturing environment. The traveling aluminum log homogenizing furnace and cooler combination enables seamless processing without moving product until the process is complete.

Ohio Valley Aluminum is an aluminum billet and log supplier to many major aluminum producers for applications in building and construction, transportation, and architecture. Seco/Warwick has been a supplier to the extrusion industry for more than 35 years with expertise in material handling and system integration.

"Our goal is to design the most efficient systems for our customers not only in terms of heat transfer technology, but also operator-friendly control systems and material handling designs to meet each location's unique requirements," said Jonathan Markley, Seco/Warwick managing director.

With employee safety the first priority, this updated aluminum processing technology enables operators to load multiple bases while the furnace processes the first load, then moves to the next. The cooler moves to the heated product, locks in place and cools the logs on the same base. This system reduces cycle time by eliminating the need to transfer product to stationery coolers. The automated control system is fully automatic with PLC controls, variable frequency drives, and operator interface to ensure optimum system efficiency and ease of control.

"We partnered with the Seco/Warwick design team to create a unique solution for our facility combining state-of-the-art heat processing technology with safe, efficient production planning to automate and streamline our material handling operation," said Steven Richardson, OVACO's president

The furnace uses Seco/Warwick's patented reversing airflow design with upstream/downstream temperature control using an axial flow fan wheel which reverses rotation on a timed basis, in turn reversing the direction of the horizontal airflow through the load. The air stream temperature is monitored and controlled on each side of the load. A thermal head is used during the early stages of the cycle for fast, efficient heating. This design increases both the heating rate and temperature uniformity of the load compared with one-way airflow, resulting in better efficiency, lower fuel cost, and improved metallurgical results.

MORE INFORMATION: www.secowarwick.com

Midwest Thermal-Vac expands capacity with TITAN® furnace

Nationally recognized commercial heat-treater and repeat Ipsen customer Midwest Thermal-Vac (MTV) recently purchased a TITAN® vacuum furnace with 12-bar gas quenching. This furnace features a diffusion pump for high-vacuum levels and an all-metal hot zone to ensure part cleanliness – an important feature for processing parts that need to comply with Nadcap and medical industry requirements such as MedAccred. The TITAN is MTV's second Ipsen furnace; the first is a horizontal furnace used primarily for processing tool and die work.

The TITAN furnace features an all-metal hot zone measuring 18" x 24" x 18" (455 mm x 610 mm x 455 mm), with a 1,000-pound (450 kg) load capacity. It is capable of operating at temperatures ranging from 900° F to 2,400° F (482° C to 1,316° C) with ± 10° F (±6° C) temperature uniformity. This shipment also includes PdMetrics® software platform for predictive maintenance and Ipsen's startup service performed by local field service engineers.

Midwest Thermal-Vac (MTV) recently purchased a second Ipsen furnace. (Courtesy: IpsenUSA)

Ipsen's TITAN vacuum furnace is a platform product that sets the industry standard for quality equipment at a cost-conscious value. These heat-treating systems are available in several sizes with horizontal or vertical configurations, nitrogen or argon quench, and graphite or all-metal hot zone construction. They are easy to operate and handle a variety of common heat-treating processes, making them an ideal choice for both new and repeat customers.

MORE INFORMATION: www.ipsenusa.com or www.mtvac.com

Manufacturing executive summit set for the thermal-process industry

Launched in the U.S. in 2016, The International ThermProcess Summit debuted as a successful and important event for executives in the thermal-process industry. Expanded to include industrial finishing and coatings for 2018 (IFCS), these joint summits offer a tremendous amount of valuable information to these two important manufacturing segments.

Scheduled for July 30 to August 1, 2018, at the InterContinental Hotel in the Buckhead area of Atlanta, the Summit will bring together an impressive and diverse group of business leaders to help executives stay on top of the latest trends and innovations affecting their manufacturing operations.

The Summit is co-sponsored by the Industrial Heating Equipment Association and the Chemical Coaters Association International.

"This combined event will provide a unique platform for industry intelligence and collaboration that drives manufacturing excellence," said Summit organizer Anne Goyer. "There is no other event like this in the USA for executives in these manufacturing segments."

Two general sessions will feature presentations that appeal to all manufacturing executives, while two breakout sessions will focus on topics specific to the industrial heating and industrial finishing & coating segments. Combined with an array of social and networking activities, this is a must-attend event for thermprocess and finishing/coatings executives.

Here is a sneak peek at some of the presentations that will be offered in the general sessions:

FACTORIES OF THE FUTURE / WHAT DOES THE FUTURE WORKFORCE LOOK LIKE?

Speaker: Dr. Irene Petrick, Market Innovation Director, Industrial Solutions Division/Internet of Things Group, Intel Corporation

An internationally recognized expert in strategic road mapping, Dr. Irene Petrick has worked with a wide variety of companies ranging from small businesses to Fortune 100 companies and the U.S. military. As Director of Business Strategy for Intel's Industrial and Energy Solutions Division in the Internet of Things Group, she provides leadership in the integration of business and technology strategy to develop solutions. Her presentation will focus on the future of manufacturing and the manufacturing workforce.

CYBERSECURITY: KEEPING YOUR BUSINESS SECURE

Speaker: Chad Hunt, Supervisory Special Agent with the FBI Atlanta Office

SSA Hunt leads a team of agents and analysts who conduct investigations in support of the FBI's Cyber Division mission to identify, pursue, and defeat cyber adversaries. As manufacturing becomes increasingly digitized, industrial internet hacking is of a rising concern to businesses. Learn how the FBI is addressing this important issue.

Executives from the thermal-process and industrial-finishing industries will gather in Atlanta to exchange ideas and learn about important business topics for manufacturing. (Courtesy: IHEA)

MANUFACTURING USA INITIATIVES: WHAT THEY ARE AND HOW YOU CAN BENEFIT

Speaker: Thomas Kurfess, Ph.D., P.E., HUSCO/Ramirez Distinguished Chair in Fluid Power and Motion Control and Professor in the Woodruff School of Mechanical Engineering at Georgia Tech

Manufacturing USA is an initiative focused on coor-

ITPS

International ThermProcess Summit

dinating public and private investment in emerging advanced manufacturing technologies that bring together industry, academia, and government partners to leverage existing resources, collaborate, and co-invest to advanced manufacturing innovation. Dr. Kurfess will provide an overview of these initiatives and how manufacturers can benefit from these efforts.

CONGRESSIONAL PRIORITIES & POLICIES

Speaker: Omar Nashashibi, Founder, The Franklin Partnership

This is your chance to hear directly from Washington, D.C., about the latest developments on regulations, taxes, trade, and other issues affecting your business every day. Omar Nashashibi lobbies the White House and U.S. Congress in Washington, D.C., on behalf of manufacturing trade associations and other clients seeking a voice before policymakers. He will provide insight into the latest developments on critical policy, what it means for your business, and how to plan for an unpredictable future.

DRIVING CONSISTENT PERFORMANCE EXCELLENCE

Speaker: Dr. Amber Selking, Founder, Selking Performance Group

From the manufacturing floor to the football field, delivering consistent performance excellence is critical to team success. Through her experiences working in manufacturing for SPX Corporation and as the mental performance consultant for the University of Notre Dame football team, Dr. Amber Selking will share insights from the field of human performance psychology that will help you deliver your best on a more consistent basis. The mind is an often untapped and unrealized source of energy, efficiency, and effectiveness. This presentation will lead you to discover the power of your mind and share strategies to help you deliver your absolute best, consistently.

TRENDS IN ADDITIVE MANUFACTURING

Speaker: Todd Grimm, Founder and President, T.A. Grimm & Associates, Inc.

An expert in additive manufacturing and rapid prototyping, Todd Grimm will present the latest technology trends and developments. Known for his energetic and passionate presentations, he effectively delivers highly technical aspects of this rising technology to both technical and non-technical audiences.

ECONOMIC TRENDS

Speaker: Chris Kuehl, Co-founder and Managing Director, Armada Corporate Intelligence

As Armada's economic analyst Chris Kuehl has worked with a wide variety of private clients and professional associations. His presentation will focus on economic trends and their impact on manufacturers. He serves as IHEA and CCAI's economist and delivers monthly updates on a variety of economic indices that impact manufacturing.

OEM MANUFACTURING PERSPECTIVE

Several representatives of major OEMs will share their insights on the state of manufacturing in their industries. Confirmed participating companies include:

AGCO: Through well-known brands including Challenger®, Fendt®, GSI®, Massey Ferguson®, and Valtra®, AGCO Corporation delivers agricultural solutions to farmers worldwide through a full line of tractors, combine harvesters, hay and forage equipment, seeding and tillage implements, grain storage and protein production systems, as well as replacement parts.

Ingersoll Rand: With market-leading brands such as Club Car, Ingersoll Rand industrial equipment, Thermo King transport temperature-control equipment, and TRANE air conditioning systems, this international manufacturer strives to enhance the quality and comfort of air in homes and buildings, transport and protect food and perishables, and increase industrial productivity and efficiency.

In addition to impressive general sessions, ITPS/IFCS will include breakout sessions specific to thermprocessing and industrial finishing. Featured topics in thermprocessing specific sessions include:

- Opportunities & Threats in the Thermprocessing Industry
- OEM Panel Discussion
- Risk Management
- Thermprocess Industry Trends

A tabletop exhibition inside the General Session ballroom will complement the outstanding Summit program. For details on the Summit, to register, reserve a sponsorship or tabletop, please visit www.itps-ifcs.com or contact us at 941-373-1830.

Why heat-treating furnaces look the way they do, Part 2

By Jack Titus

Natural gas is a clean-burning fossil fuel that, when ignited with air, produces heat, carbon dioxide (CO_2), and water in vapor form (H_2O). Mix one cubic foot of gas plus 10 cubic feet of air, a spark and the result will be one cubic foot of CO_2 plus two cubic feet of H_2O and eight cubic feet of nitrogen. Two cubic feet of water vapor equals 3.2 tablespoons of water.

Nitrogen obviously does not burn, but it still must be heated and contributes to the convection heat transfer of energy.

Anyone who has used a ventless natural gas room space heater can attest to the quantity of water that condenses on windows in cold climates. A 20,000 BTU heater requires 200 cubic feet of natural gas plus 2,000 cubic feet of room air. Per the formula above, the resulting combustion will produce 200 cubic feet of CO_2 plus 400 cubic feet of H_2O, or about two quarts per hour.

Gas-fired heat-treating furnaces use natural gas in two ways: They heat the process hot zone with a stoichiometric mixture (ideal combustion) of one part of natural gas to 10 parts of air to produce the endothermic atmosphere for carburizing.

Since no combustion reaction is perfect, it's possible that a small fraction or parts per million (ppm) of CO could be produced, therefore excess air is always used. Heat-treating furnaces, due to their operation in large industrial plants, release effluents into a hood mounted to the plant roof most of the time. It's not unusual to see some plants allowing the burner effluents to vent directly into the open area up to the plant ceiling where, typically, exhaust fans vent gases outside the plant. Where gases vent directly into the plant air, they mix with plant environment to form what we call an "indiscriminate atmosphere" — meaning that combustion products will be diluted in air.

Heat-treating furnaces can be gas heated with two methods: direct or indirect fired. Direct firing consists of burners placed in the refractory walls pointing just above and/or just below the parts being heated. Burners are never positioned to fire directly at parts since the temperature of the flame is near 2,000°F (1,093°C). Special flat-flame burners are the exception where the burner flame is designed to spread along the refractory wall, not straight out as a jet. Direct firing produces CO_2, H_2O, and nitrogen as mentioned above. Small amounts in the ppm range of oxides of nitrogen (NO_x) are also produced. Since both CO_2, and H_2O contain oxygen, they will, depending on temperature, be oxidizing to iron and steel. Where oxidation cannot be tolerated, indirect firing is the option.

Indirect fired furnaces attach burners to radiant tubes made from heat-resisting nickel, chromium, and iron alloys. This method is used where a special atmosphere is used to protect parts with nitrogen or carburize with endothermic gas. Endo gas consists of 20 percent CO, 40 percent hydrogen, and 40 percent nitrogen with trace amounts for CO_2, H_20, and methane (CH_4). We all know hydrogen, like natural gas, can be explosive if not handled properly. Heat-treating furnaces are designed to handle those gases appropriately. Take, for example, the batch furnace represented in my March/April Hot Seat column shown in Figure 1. In general, most people outside the heat-treating industry, and many even within the arena, believe that explosive gases and heat are not a good combination. Here's the truth:

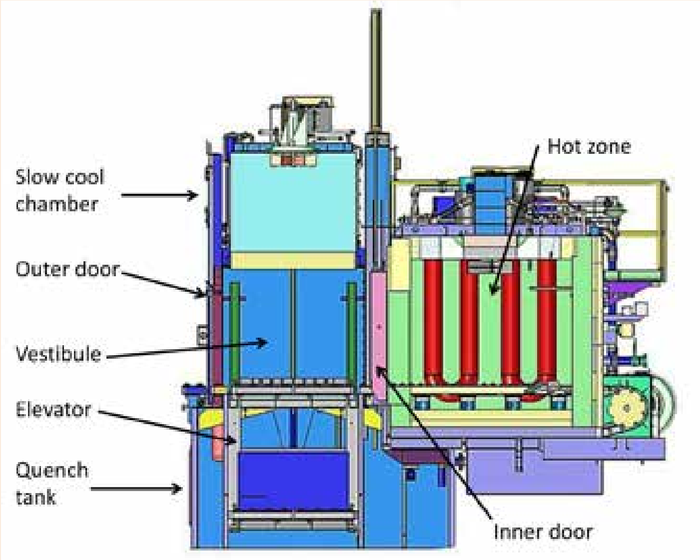


Figure 1 (Courtesy/AFC-Holcroft)

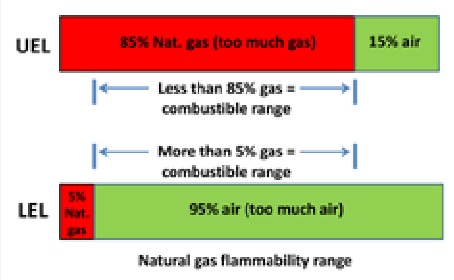


Figure 2

Whenever I encounter a furnace with a combustible atmosphere, I want it to be above 1,400°F (760°C). Why? 1,400°F is the auto ignition temperature above which natural gas and hydrogen will burn with air if they're within the combustible limit. The situation you want to avoid is combustible gases mixed with air below the ignition temperature; this is how explosions occur with premix combustible gases. For fuels such as natural gas and hydrogen to burn, the ratios of air-to-fuel must fall between the lower explosive limit (LEL) and the upper explosive limit (UEL). Anywhere outside of those limits, combustion can't occur. For natural gas, the LEL is 5 percent — meaning if the gas concentration in air is less than 5 percent, it's too lean to burn or explode. If the gas concentration is high, allowing only 15

Figure 3 (Courtesy/AFC-Holcroft)

percent of air, it's too rich to burn or explode. So, for an explosion to occur the mix must be between 5 to 15 percent air. Hydrogen's LEL and UEL are 4 percent and 75 percent respectively. The other combustible gas in endo is CO. Its LEL is 12.5 percent and UEL is 74 percent. The limits can be explained further in Figure 2.

Carburizing is the most employed heat-treating process because it has the greatest influence on ferrous alloy's strength properties. Carbon is added to the steel's surface by endothermic gas mentioned above. And as can be seen, it contains 40 percent hydrogen. So how can we as furnace designers and heat treaters safely use it? By controlling how and when it comes into contact with air.

Today, many heat treaters — commercial or in-house — have nitrogen stored as liquid and vaporized to gas. When endo gas is required, the furnace is first heated to above 1,400°F (760°C), then filled with five volume changes of nitrogen to displace the air. Five volume changes will reduce the oxygen to 0.67 percent of 21 percent or 1,415 ppm. Once five volume changes have occurred, endo gas is then added to purge the nitrogen. Nitrogen is a huge advantage in regions where electrical power is frequently lost because, when power drops, furnaces cool. And as stated, you don't want a furnace with endo gas cooling below 1,400°F. In such an event, emergency nitrogen immediately flows into the furnace(s), displacing the endo gas. If nitrogen is available, the stored capacity must accommodate the volume of furnaces in the facility.

Before the widespread availability of nitrogen heat treats that could experience lengthy power outages, the only option was to burn out the endo gas before the hot zone cooled below 1,400°F. If many furnaces are involved, this could be a pretty daunting chore. Burning out a batch furnace without nitrogen involves the following:

- Manually open the outer, or vestibule, door(s) which will ignite the flame screen under the door opening. The flame screen shown in Figure 3 is used to fill the vestibule with flue gas and remove oxygen.
- While the flame screen is burning, open the inner door, and the residual endo gas in the hot zone (the endo gas inlet valve would have closed with loss of power) will begin to be consumed. The flame will appear to recede toward the rear and top of the hot zone as air from the vestibule supports its combustion.
- The flame screen can be shut off, and the remaining endo gas will continue to burn out in a few seconds.
- Obviously, any parts still in the hot zone will be oxidized and of no use.

When adding endo gas to a hot furnace after an air burnout with nitrogen, proceed as follows:

- Always start by opening the vestibule or outer door, and turn the flame screen off.
- Introduce nitrogen for five volume changes.
- Turn off nitrogen and add endo gas.
- Place a natural gas torch or lance at the opening in the inner door, center or at the bottom.
- When endo gas begins to burn at the opening, remove the torch.
- Turn on the flame screen and allow the flame to burn into the vestibule for about five minutes to consume oxygen and fill the vestibule with flue gas, CO_2, and water vapor.
- Depending on the volume of the vestibule, endo gas will begin to burn at the vestibule effluent in a few minutes, indicating that the entire furnace has been purged and is ready to use.
- When nitrogen is not available and with a furnace above 1,400°F filled with air, endo gas can be added per the following:
- Open the vestibule or outer door, and turn off the flame screen.
- Place a natural gas torch or lance at the opening in the inner door, center, or at the bottom.
- Turn on endo gas.
- As the endo gas enters the air-filled hot zone, a flame will appear at the point of gas entry.
- As the endo gas consumes oxygen in the hot zone, the oxygen percentage will continue to drop until the LEL for natural gas, CO, and hydrogen has been reached and the flame will disappear, but endo will continue to replace the remaining air.
- When the endo gas begins to burn out of the inner door vent, the natural gas torch can be removed and the flame screen turned on.
- The flame screen is allowed to fill the vestibule for a few minutes and the vestibule or outer door can be closed.
- A minute or so later, when the vestibule has been filled with endo gas, the vestibule effluent will begin to exhibit the flame.
- At this point, the entire system has been purged with endo gas, and the furnace can be used.

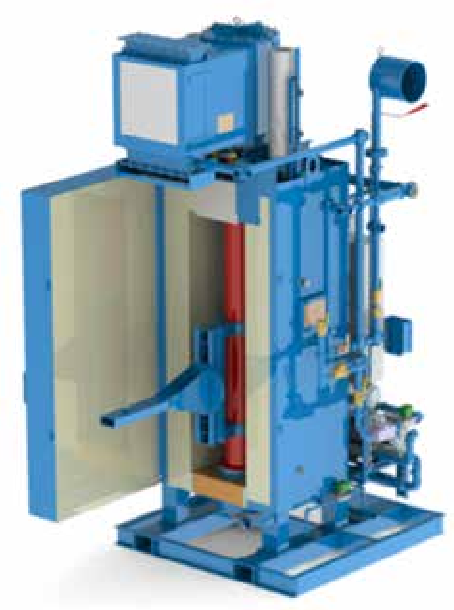


Figure 4 (Courtesy/AFC-Holcroft)

Endothermic generators like AFC-Holcroft's EZ® endo generator, Figure 4, produce gas for carburizing by passing natural gas and air over a nickel catalyst at 1,950°F (1,065°C). More on how heat-treating furnaces use endo gas for carburizing in part 3.

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Proper temperature is crucial to part quality, but don't overlook its effect on atmosphere control

By Jim Oakes

Time, temperature, and atmosphere are all common parameters necessary to deliver the right metallurgy of a raw material or finished part. Each parameter has its own level of complexity and if not properly controlled can lead to a part that doesn't meet the designed performance parameters. Previous Quality Counts articles have discussed each of these individually, and now we can bring these together to provide a holistic view.

Temperature, which is controlled using simple or sophisticated algorithms, addresses an action to achieve a desired setpoint based on the controller and thermocouple or temperature-sensing device. Temperature desired is defined/restricted based on the part or customer requirement and the ability to transform the part delivering the desired metallurgical results. Certain heat-treatment processes may have tight tolerances with restrictions on maximum temperatures, heat-up and cool-down rates, and targets for minimizing process time but not affecting metallurgy or quality.

Temperature monitoring is not limited to just a control thermocouple. It can be defined at specific locations in the furnace, such as the hottest and coldest spots defined by the last temperature uniformity survey. Temperature can be monitored to simulated part temperature, also referred to as a load thermocouple. Temperature transforms the material into the necessary state to alter the part — so precise control is critical. To ensure proper temperature readings and furnace performance, checks and balances are in place to ensure accurate reading of the control circuit using a system accuracy test. Overall temperature uniformity is thus ensured for the work zone of the furnace.

Temperature control can certainly affect atmosphere control, and of course, metallurgy. Using carburizing as an example: If a load is not in thermal equilibrium, the activity of the atmosphere at the surface of the part and the diffusion of the carbon to a specific depth can be affected. The combined effects of time, temperature, and carbon concentration determine how carbon is delivered at depth to a part. Assuming one of the three variables mentioned is not at the target value, carbon does not diffuse to the targeted depth for the desired effective case depth. For example, a cooler center of the load means less diffusion, and a potentially softer part.

Another aspect of temperature that is sometimes overlooked is its effect on atmosphere control. It is common practice to use in-situ carbon probes to ensure proper control in achieving desired changes to the surface of the part. Most heat treaters employ a practice of verifying the atmosphere using a method other than carbon probe measurement to ensure that the carbon probe itself is allowing for an accurate calculation of the neutral or carbon-rich atmosphere. This is important because the carbon probe bases the calculation of carbon on the partial pressure of oxygen in the furnace and uses the assumed prepared atmosphere on which to base this calculation. Alternative methods of verifying carbon percentage are NDIR gas analysis (using CO, CO_2, and CH_4), carbon wire resistance, shim

Variances in temperature and atmosphere setpoints are common practice for heat-treating equipment. In many cases, there is a sweet spot for control and then trouble points.

stock carbon content, and dew point analysis.

Again using carburizing as an example, consider the calculated carbon potential. The calculation of carbon in the atmosphere using an oxygen probe is based on the output millivolts — created based on the partial pressure of oxygen in the reference air versus partial pressure of oxygen in the furnace, the temperature of the furnace, and a calculation factor referred to as COF (CO Factor), PF (Process Factor), or Gas Factor. Using this information, it is clear that the atmosphere carbon potential calculation is dependent on temperature. Even with a steady state atmosphere, there are variations on the calculation of carbon based on swings in temperature. A percent carbon loop with tight tolerances can be put at risk of compliance if the control of temperature is not consistent. Properly-tuned temperature loops using PID parameters should be able to draw straight line control for the temperature. Poorly tuned temperature loops or temperature loops susceptible to electric noise can not only show issues on temperature control, but in the atmosphere control loop as well.

In the previous paragraph we talked about the calculation of carbon and the dependence of the proper prepared atmosphere. The prepared atmosphere — whether nitrogen, methanol, or endothermic — should be properly controlled and consistent so the calculation of carbon can be made accurately. At a minimum, checking your atmosphere with an alternative method proves to be beneficial in ensuring quality heat treating and reducing opportunities for scrap and rework.

Variances in temperature and atmosphere setpoints are common practice for heat-treating equipment. In many cases, there is a sweet spot for control and then trouble points. This can be with both temperature and atmosphere across the operating temperature and atmosphere range of the furnace. In situations such as this where you are attempting to maximize furnace recovery (in terms of temperature or atmosphere) you may want a different PID setting for the control — so there is an aggressive response to the big change, but still coming into setpoint slowly, so that overshoot and oscillation is minimized. Using a single PID may not hit the target for tight tolerances as specific temperature or atmosphere setpoints. Look to take full advantage of PID loop controllers to see if different PID can be established and other settings used, such as limiting the control output to help limit the downside effects but still maximize productivity.

ABOUT THE AUTHOR Jim Oakes is vice president of business development for Super Systems Inc., where he oversees marketing and growth in multiple business channels and helps develop product innovation strategies in conjunction with customer feedback. He has extensive experience working in the heat treating and software/IT industries. For more information, email joakes@supersystems.com or go to www.supersystems.com.

Choose from several verification methods for best fit, then develop a plan to correct for out-of-spec test results

By Aaron Muhlenkamp

The invention of the oxygen probe in the 1980s solved one of heat treatment's fundamental problems: inexpensive, precise, and responsive carbon control. However, every technological improvement has its own collection of issues, and oxygen probes are no different. They require additional verification of their reliability and accuracy to ensure the heat treater can take advantage of their precision.

In the simplest terms, an oxygen probe consists of two sensors: a thermocouple, usually Type R or S (or, more recently, K) — and a closed-end zirconia tube. The exterior surface of the tube is exposed to the furnace atmosphere; the interior is exposed to normal air. The transport of oxygen from the air side to the furnace side creates a voltage potential. The temperature and oxygen voltage potential are transmitted to a controller, which converts the signals to a "carbon potential" — the measure of the ability of a furnace environment containing active carbon to alter or maintain, under prescribed conditions, the carbon content of the steel [1].

Conversion of the signals from an oxygen probe to a carbon potential relies on two assumptions. First, the air side of the probe is always assumed to be P_{02} = 21%. Second, the CO content of the furnace atmosphere is assumed to be 20 percent. Both assumptions are reasonable in a properly functioning probe in an endothermic atmosphere. In nitrogen methanol systems, the latter assumption should be verified and corrected as needed.

But despite their convenience, oxygen probes have one disadvantage — they can drift over time. So, while they control the furnace second by second, they may not be consistent week to week. This long-term instability necessitates a system of verification or "backup" testing to ensure that the probe is reading correctly or, if it is not, to provide for a mechanism to adjust the probe's signal. There are a variety of methods available to accomplish this. The most common are discussed in the following overview.

VERIFICATION METHODS

SHIM STOCK

The oldest — and to many, the most definitive — test is the shim stock (or foil) test. In this test, a thin piece of low-carbon steel is inserted into the furnace atmosphere through a port for a period of time sufficient to allow the shim to through-carburize and reach equilibrium with the atmosphere. The shim is then removed, and the amount of carbon in the shim is determined through weight analysis or combustion analysis.

At first glance, shim testing appears to be simple and straightforward. However, the details of the test — such as port and insertion rod design, test duration, test sequence, sample cleanliness, operator technique, scale calibration (in the case of the weight method), or combustion analyzer calibration — can lead to a significant amount of variation.

Once the support infrastructure and appropriate procedures are in place, the shim test is the most direct measure of the furnace atmosphere's carbon potential because it returns a direct "%C" value of the carbon in the steel. The other verification techniques discussed below are not as direct.

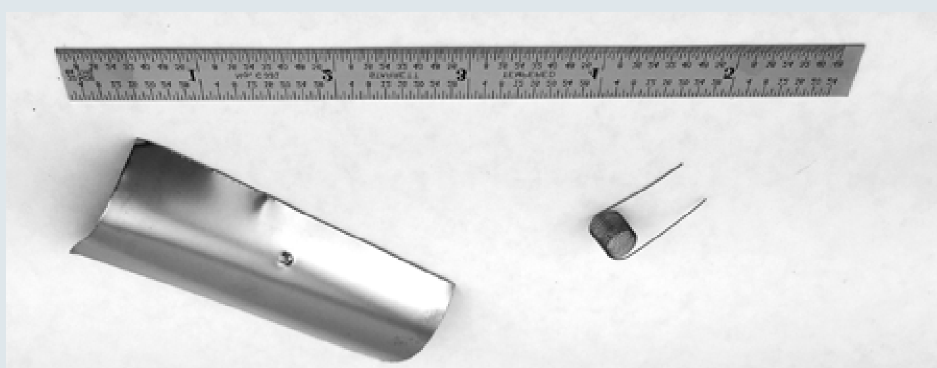

Figure 1: Examples of shim and resistance samples.

ELECTRICAL RESISTANCE

Akin to the shims method is the electrical resistance method. Thin springs are inserted into the furnace and allowed to through-carburize, similar to the way a shim would. The coils are then placed in a dedicated test device; their electrical properties are compared against nominal values, and a carbon potential is inferred. While fast and very convenient, resistance methods have the same drawbacks as the shim test.

DEW POINT

Dew point testing is perhaps the oldest of the indirect techniques and does just what the name implies — it measures the temperature at which dew (water condensate) forms. The dew point is the measurement of the water content of the furnace atmosphere, which through the chemistry of an endothermic atmosphere, can be used to calculate the carbon potential. Dew pointers are typically small, portable machines that can be taken from furnace to furnace, measuring each furnace as needed.

The Alnor fog chamber is considered the classic heat-treating dew point device. The Alnor works by manually pumping a sample of the furnace gas into the device, pressurizing it and then releasing the pressure (and thereby cooling the gas sample) to visually determine if a cloud forms in the device's chamber. Once the point at which cloud formation occurs is determined, the dew point can be calculated. However, dew point determination is an iterative and time-consuming process.

Although cumbersome to operate, Alnor dew pointers are very precise and work at extremely low dew points — beyond the capability of more modern devices. That said, the Alnor's accuracy relies on a radioactive isotope to ensure dew formation in the absence of nucleation particles. While not inherently dangerous, this does pose additional safety issues.

At the other technological extreme are the modern sensor-based dew pointers. With these devices, a sample is continuously pumped from the furnace across the sensor. The dew point is determined by the sensor material's electrical response to the water content of the sample. These devices have the advantage over the Alnor and similar techniques in that the output is essentially immediate and requires no interpretation.

Once the dew point is determined, the next step is converting it to a meaningful carbon potential. Many manufacturers provide a conversion chart with their dew pointers that converts dew point to carbon potential as a function of the furnace temperature.

Dew pointers themselves need calibration, which can be done in-house by purchasing samples of known humidity. As a practical matter, most users would rather avoid managing the calibration trail and prefer to send the devices back to the manufacturer or other qualified supplier for calibration. This, however, creates the need to have multiple devices in rotation so that there is always a dew pointer available for verification of the atmosphere.

Figure 2: Common dew point test machines: (left) Alnor 7000 [2]; (right) SSi DP 2000 [3].

INFRARED ANALYSIS

Similar in action to dew point testing is non-dispersive infrared (IR) gas analysis. IR gas analysis, sometimes referred to as "three-gas" analysis, continuously pulls a sample from the furnace and determines the CO, CO_2 and CH_4 content (the "three gases") of the furnace atmosphere. The CO/CO_2 ratio (or simply CO_2 in cases where CO is essentially constant) from the IR analyzer can be used to determine the carbon potential with the same calculations used in oxygen probe control. For more sophisticated results, the CH_4 component can be factored into the results to take into account its enriching effect. Gas analyzers intended for use in heat treatment often have built-in functionality for calculating and displaying carbon potential.

Since the infrared analysis is more complex, its calibration requirements are also more demanding. The IR units typically require that a zero (nitrogen) and span (calibration) gas sample be tested at least once a day.

IR units are available as portable units, similar to dew pointers, or as dedicated assets integrated into the furnace's carbon control scheme. They correct the carbon potential measurements in real time as the oxygen probe drifts. The dedicated arrangement is generally found in furnaces that use nitrogen methanol systems where the CO content of

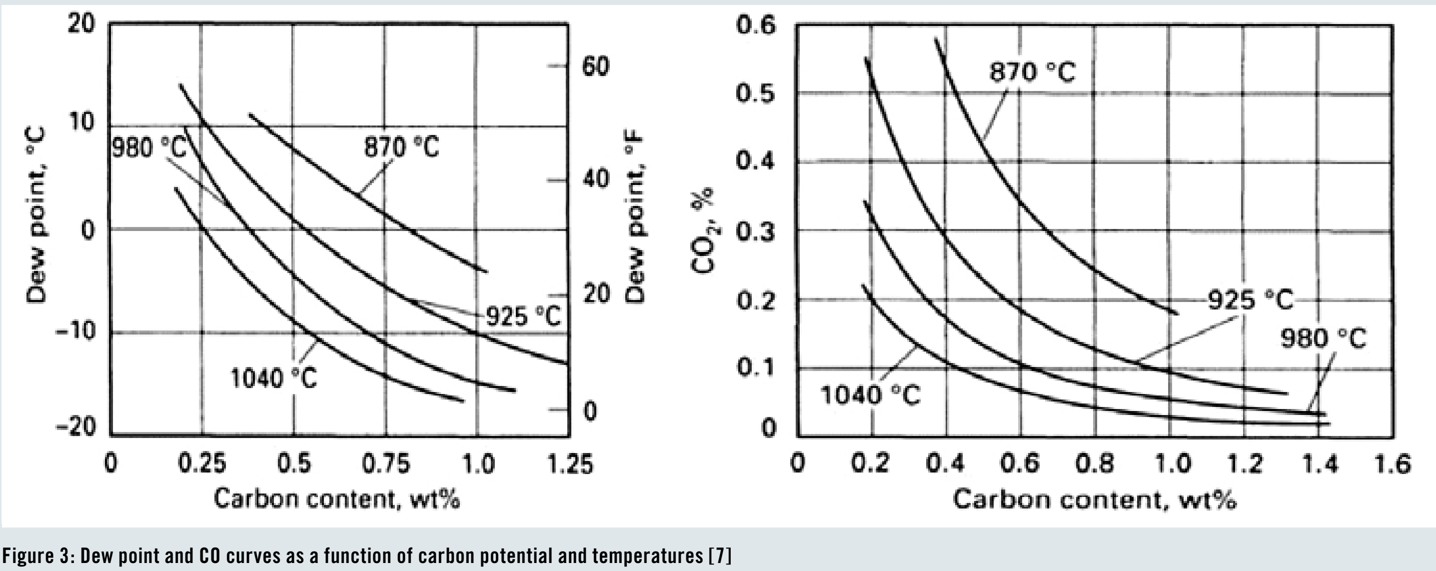

Figure 3: Dew point and CO curves as a function of carbon potential and temperatures [7]

Given that the goal of oxygen probe verification is the increased stability of the process, making constant adjustments to the carbon controller is not a recipe for success.

the atmosphere is variable over time. The integration of the IR analyzer into the control scheme compensates for the deviation from the nominal 20 percent CO value expected in a natural endothermic atmosphere.

Regardless of the method, when it comes to ex situ measurements, care must be taken with the disposal of the gas once it has been analyzed. Endothermic gas is explosive and can build up in control cabinets, vulnerable to an ignition source. Running the exhaust port of the machine back to the burning effluent is a best practice.

FREQUENCY OF VERIFICATION

Heat treating quality systems have evolved to the point where there are essentially two industry standards for managing heat treatment: CQI-9 and AMS2759. CQI-9 was originally conceived as way of standardizing the automotive approach to heat treatment and is becoming the de facto standard for all non-aerospace industries. AMS2759 is, of course, the aerospace standard for the heat treatment of steel.

The AMS2759 family of standards has no explicit requirements for verification of atmosphere control [4]. The carburizing standard (AMS 2759/7) has very specific testing requirements for verifying the surface carbon — which they refer to as "carbon potential" — of the specific material for each batch, but this arguably is a product test rather than a process control verification [5].

For those systems that don't continuously verify the probe, CQI-9 requires the minimum of a weekly verification of the probe [4]. However, this may not be sufficient for all processes and furnace types. Some heat treaters conduct shim stock tests with every batch — or multiple times a day, in the case of continuous furnaces.

While the frequency of verification is important, one often-overlooked aspect is that of the verification "points." In any calibration scheme, some thought should be given to the point at which the system is calibrated, since systems are not necessary linear and there is little value in calibrating a system to a region of values for which it is not used. In many instruments, the minimum, maximum, and midpoint of usage are the general recommendations for calibration.

As a practical matter, it may not be possible to verify the probe over such a range, but effort should be taken to select a combination of temperature and carbon potential that represents a large proportion of the probes' operating time. Another consideration is the point within the cycle of an asset at which the verification should take place. Conducting the verification at the very beginning of the cycle versus the very end may produce slightly different results, even if the temperature and carbon potential are the same — thereby increasing the potential error in the test.

VERIFICATION TOLERANCE

Again, CQI-9 is the more proscriptive of the two standards, requiring the oxygen probe to be within 0.05 percent of verification method tolerances [6]. For direct-read verification methods, this is straightforward. For dew pointers, a translation chart is required for accuracy, but typically means at an allowable variation of 1°-2°F (0.6°-1.1°C) from aim.

It can be argued that, given all the sources of error in both the oxygen probe and the verification technique, to achieve such tight limits on verifications is overly optimistic and a more open tolerance or other methodology should be explored. However, the standard is the standard, and it is difficult to argue that point with an auditor.

REACTION TO AND INTERPRETATION OF THE DATA

Once the values of the probe and the verification method are determined, the question becomes, "What next?" In many facilities, the answer may be unclear, as there is often no defined plan for the floor-level operators. As a best practice, there should be a clearly defined reaction plan that provides the operator with guidance on how to correct for out-of-specification test results.

Most carbon controllers have built-in adjustment parameters (often called "process" or "alloy" factors) that allow for correction of the oxygen probe reading based on a verification test. But given that the goal of oxygen probe verification is the increased stability of the process, making constant adjustments to the carbon controller is not a recipe for success. An alternate response is to implement a statistical process control approach in the verification process, along with a robust work instruction and documentation system.

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When your furnace is down for large repairs, use the opportunity to catch up on overdue or extensive maintenance

By Ipsen USA

You've taken important steps to keep your furnace running at peak performance. You perform routine inspections and preventative maintenance, yet over time, repairs and downtime still happen. While no one likes to experience downtime, there are ways to maximize the opportunity. The following suggestions are areas that should be examined while your furnace is down for large repairs:

INSPECT THE HEAT EXCHANGER

In many cases, maintenance to heat exchangers is overlooked or not done as often as recommended. A good time to inspect your furnace's heat exchanger is when a gas blower motor is removed for repairs or when the hot zone is being replaced.

The fins, which are between the coils, allow nitrogen or argon gas to flow freely across the heat exchanger and properly remove heat from the load and cool it. If you notice any excessive dust, dirt, or oil buildup, you can remove the heat exchanger and clean it with a pressure washer. If the fins are not properly cleaned, the furnace may begin experiencing slower pump-down times, reduced cooling rates, or hardness of parts being processed.

On some furnaces, accessing and inspecting the external heat exchanger is slightly easier than an internal exchanger. You can examine the external heat exchanger without having to remove the cooling motor. Here you would be looking for the same issues — dust, dirt, or oil buildup. You also clean the outside of the heat exchanger the same way — using a pressure washer.

CLEAN AND PAINT THE COLD WALL OF YOUR FURNACE

Another area of the furnace to focus on during downtime is the cold wall. Like with any part of your furnace, this can become dirty, and the paint can begin to chip away over time.

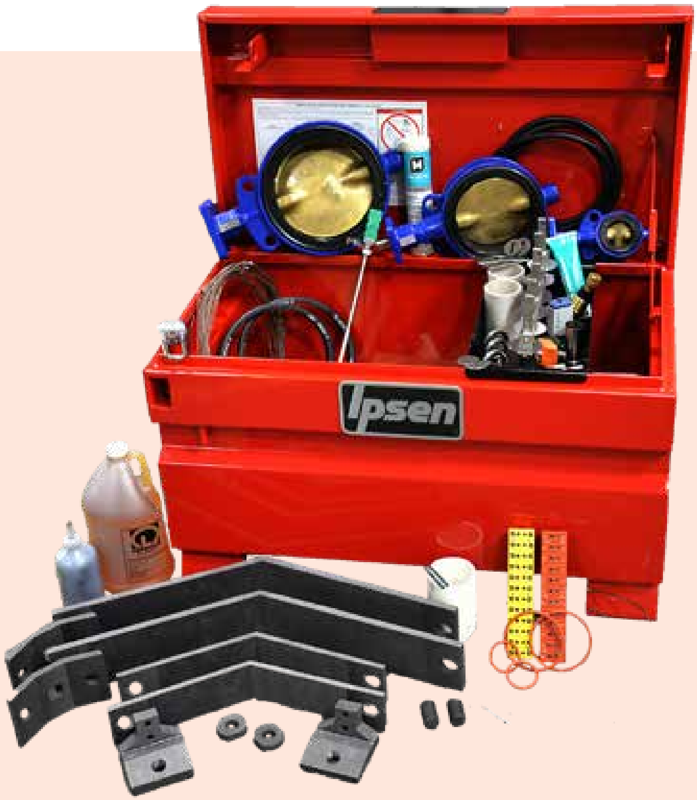
To clean the cold wall, in general you can use any cleaning products. After you are done, make sure to use alcohol or acetone to clean up any remaining contaminants left by the cleaning solution. It also is important to use caution with alcohol or acetone, as the vapors could ignite and burn you. In cases where a cold wall is severely contaminated, dry-ice blasting is an effective method for cleaning.

The best time to repaint the cold wall is when you are replacing the hot zone. However, you should only repaint if the existing paint is completely gone. When painting, use a single coat of silicone-based protective sealant. Painting excess layers can cause problems, since the base paint will not cure properly. Excess layers of paint can also cause virtual leaks or bubbles to occur. Paint flakes also could develop, which could potentially contaminate or burn during the quench.

A good time to inspect a furnace's internal heat exchanger is when a gas blower motor is removed for repairs or when the hot zone is being replaced. (Courtesy: Ipsen USA)

CHANGE THE O-RINGS ON YOUR FURNACE

A final place to consider inspecting is the o-rings on your furnace. Eventually, every o-ring needs to be replaced. Some need to be replaced more frequently than others due to higher exposure to



A well-stocked spare parts kit is essential to routine maintenance. (Courtesy: Ipsen USA)

wear and tear or their proximity to higher temperatures.

O-rings that are in difficult-to-reach places are often overlooked during preventative maintenance, like those of the diffusion pump or main valve. Another o-ring example is the seal cartridge assembly on an Ipsen TITAN® vacuum furnace. This type of seal keeps the gas blower shaft from going into the furnace. This should be sent in to be rebuilt if the motor is removed any time past two years on the seal cartridge assembly lifespan.

When your furnace is down for large repairs, it may take some time before it's back up and running properly. Use this time to address forgotten, overdue, or extensive maintenance and cleaning to prevent future issues. This is also a good time to think about ordering extra replacement parts — especially high-use parts that tend to be replaced frequently. By being proactive with your furnace's downtime, you can save future loss of time and money, as well as prevent potential safety concerns.

ABOUT THE COMPANY 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, Ipsen continues to provide expert-driven solutions that strengthen heat treatment throughout the world. Learn more at www.IpsenUSA.com.

Praxair, Inc.

“Praxair drivers have a procedure they follow to take a look at a system to see if there are any issues. If there are, they alert Praxair customer service. (Photos courtesy: Praxair)

Responding quickly to heat-treat issues

Through the use of industrial gases, Praxair, Inc. endeavors to help its customers find the best way to use its gases and increase efficiency in the heat-treat industry.

By Kenneth Carter
Editor | Thermal Processing

Atmospheric gases are often the unsung heroes of the heat-treating industry, but they are essential to successful operations.

Praxair, Inc. is a leading industrial gas company in North and South America and one of the largest worldwide.

Praxair offers a diverse portfolio of industrial gases and services for many industries, but has a strong focus on heat treating and combustion applications. These include heat treating atmospheres, purging and inerting, process gases, and oxy-fuel combustion applications. In addition to being a gas company, Praxair goes a step beyond by providing supply system on-site evaluations, supply system design, testing and installation, system start-up, and process support.

"Ultimately, we are an industrial gas company," said Steve Mueller, associated director of business development — Metals & Materials Processing. "We're safety conscious. Safety is a core competency of ours that guides the way we approach each application, focusing on the installation and use of our product."

FULL RANGE OF GASES

Praxair offers the atmospheric gases: oxygen, nitrogen, and argon. Praxair also provides rare gases including krypton, neon, and xenon and process gases such as hydrogen and carbon dioxide. These gases are provided in their highest purity in quantities required by the customer.

"The exciting part of our job is that our gases can be used for a variety of applications," said Pat Diggins, business development manager. "Nitrogen and argon are used for inerting applications. They both displace oxygen-rich air. Hydrogen, in heat-treating applications and in other field-use applications, is used as a reducing gas. Whereas argon and nitrogen are inert, hydrogen has a purpose of actually reacting either in the atmosphere to eliminate oxygen or to reduce oxides on the metal. These gases provide us with different tools and ways to help our customers obtain the quality that they're looking for."

YEARS OF EXPERIENCE

Praxair has been in the industrial gas business for more than 100 years. A team of experienced individuals, as well as a commitment to helping customers improve their process has led to increased success in the field. There are a lot of people involved in making sure each product delivery and each installation is completed safely and reliably.

Diggins said he is one of several business development managers who hail from a wide range of backgrounds, which, in turn, brings a lot of experience into the Praxair family.

"That helps us work with the customer and identify problems," he said. "Because we understand the process. I work with the metals industry, but I have peers who are in the food, chemical, and refining businesses."

As a business development manager, Diggins said his goal is to help customers find the best way to use the gases and technology that Praxair offers and assist with any process problems they may have with their operation.

"We spend time with customers just to find out what problems they're having," he said. "We've got a team of men and women standing behind us who have years of experience and high-level degrees that focus on doing research on what we find, allowing us to come back and resolve customer problems quickly and efficiently."

"The operator in the plant, the plant manager, or the maintenance manager in the shop, they are the process experts," Diggins said. "We're a really big resource to our customers; to be able to bring best practices to them and offer that 'out-of-the-box thinking' that they may not have tried."

INSTALLING SYSTEMS

In addition to the gases that Praxair provides, the company also installs the industrial gas supply systems. These systems range from cylinder and liquid containers for smaller or more specialized applications to bulk systems and pipeline for higher usage applications.

"We have trained customer service resources to make sure our equipment is properly sized and to provide the proper gas flows and pressures, etc," Mueller said. "But we also have a lot of experience with helping new customers maximize their capital investment."

As an example, Diggins explained how a company recently brought some state-of-the-art equipment from Europe.

"It was a reheat furnace, and the parts were going to go into a very large press," he said. "Not only did we help size the system and the piping, we also made sure they had the right pressures and flows and were there for the startup. We were able to help them debug some issues during the startup because we had seen them before at another installation."

SAFER DELIVERIES

But it doesn't end there, because Praxair's drivers do more than just deliveries, according to Mueller.

"As far as supply systems, our drivers have a procedure they follow to take a look at the system to see if there are any issues," he said. "And they would alert Praxair customer service if there was. Customer service, although it varies from state to state, does inspections, and we keep an eye on the equipment and make sure it's operating correctly and safely."

Part of that safety comes from training that Praxair provides, according to Diggins.

"Ultimately, we are an industrial gas company," said Praxair's Steve Mueller. "We're safety conscious. Safety is a core competency of ours that guides the way we approach each application."

"With hydrogen, oxygen, argon, and nitrogen, we'll conduct safety training and provide training materials where the customer can do continuous safety reviews after we leave," he said. "Safety is important with both cryogenic and inert gases. Low temperatures and air dispersement have the potential to create hazards. With hydrogen, you have flammability issues. So, we make sure their employees understand that these gases are tools. And like any tool, you've got to treat it with respect, so it'll be safe."

Praxair prides itself in delivering its products safely. Safety is a major focus for the company. Praxair drivers and technicians contribute to the safe handling of gas during usage and share the responsibility in making sure the customer is getting what they need, when they need it and strive to avoid gas disruptions in the customer's process.

CONTROLLING ATMOSPHERE

"It's all time and temperature dependent," Diggins said. "And time and temperature are fairly easy to measure. It's the atmosphere that is the difficult item to control, measure, and monitor. And so, we help our customers understand how they can measure the atmosphere and what instrumentation is necessary. We don't actually sell the instrumentation, but we can help guide them and make sure everything is working the way it should be."

All of these different abilities allow Praxair to better service its customers.

"We're one of the world leaders in industrial gas supply," Mueller said. "But we have the ability to go beyond that and provide services and some of the equipment necessary in heat-treatment. It gives us a broader range of how we can help our customers."

"One of the things we work really hard at is to identify opportunities and work with our account managers closely," Diggins said. "Between the account managers and us in business development, we assist customers at the very beginning of their process — what pipe size is needed, what size tank pad, and advice on where the pads should go, as well as what type of equipment will be used. We have

"The reason we're successful is because we help customers improve their operations."

Praxair has been in the industrial gas business for more than 100 years.

piping programs that will size the pipe and make sure they've got the correct pressures and flow rates. Those are some of the basics. And from there, depending on their expertise and how much they know about the equipment, we work with them on what it's going to take in order to have a successful startup."

GROWING WITH THE INDUSTRY

Praxair has extensive experience in developing applications to improve customer operations through the use of industrial gases. Technologies pioneered by Praxair have improved productivity and efficiency in many industries, but as the heat-treat industry continues to grow, Praxair wants to ensure that its place is second to none.

"Heat-treating, aerospace, automotive, and general heat-treating has all been growing," Mueller said. "It's definitely an area we want to be working in."

Some of that growth will come from control advancement, according to Mueller.

"A lot of traditional heat-treaters are looking at advancing their controls," he said. "They may be looking to upgrade to a more sophisticated type of equipment, so they can get better runs out of their furnaces, greater consistency, and less waste. To be a part of that process with the inerting gases, it's very important to be able to maximize efficiency."

Eliminating quality problems with better equipment will help the bottom line in the long run. Praxair stands by its mission to offer products, services, and technologies that are making the planet more productive by bringing efficiency and environmental benefits to the heat-treat industry.

"Everyone is trying to drive down costs; that's the name of the game at the end of the day," Diggins said. "We get to be the ones who help the customer. The reason we're successful is because we help customers improve their operations."

FOR MORE INFORMATION www.praxair.com/heattreating

Heat treatment of PM parts by hot isostatic pressing

Several advantages can be seen by using pre-stressed wire-wound hot isostatic presses for consolidating of metal powder.

By Dr. Anders Eklund and Magnus Ahlfors

Hot isostatic pressing (HIP) is a technology that has been around for 60-plus years. By using high temperature and high gas pressure, dry metal and ceramic powders can be consolidated, and a volume decrease can be achieved. Later developments include rapid cooling and rapid quenching to enable higher productivity and high-pressure heat treatment. This paper shows the advantages of having HIPing and heat treatment combined for powder metallurgy parts.

INTRODUCTION

HOT ISOSTATIC PRESSING (HIP)

Hot isostatic pressing has fundamentally two different designs when it comes to contain the high pressurized gas, typically argon. The two methods are called mono-lithic, sometimes referred to as mono-block, and pre-stressed wire-wound technology. An example can be seen in Figure 1.

The mono-lithic design will always experience tension stresses on the outside and inside of the pressure vessel making any material faults — and you will always have material faults — sensitive to fatal failures if the wall cracks. This failure mode is described as catastrophic. The consequence is a dramatic release of the gas pressure with serious damages to surrounding buildings. See Figure 2.

The pre-stressed wire-wound HIP will always experience compressive stresses both on the inside and outside of the pressure vessel and the yoke frames during all phases of the HIPing process. This is the safest design and is approved by ASME per ASME Boiler and Pressure vessel code, Section VIII, Division 3. This failure mode is described as "leak-before-burst." This means that if the pressure vessel will crack, the gas under high pressure will dissipate through the wire-wound package without any damages to the surrounding equipment and structures.

The combination of high temperature, 1,050 to 1,250 °C, and high gas pressure, 100 to 200 MPa, consolidates dry metal

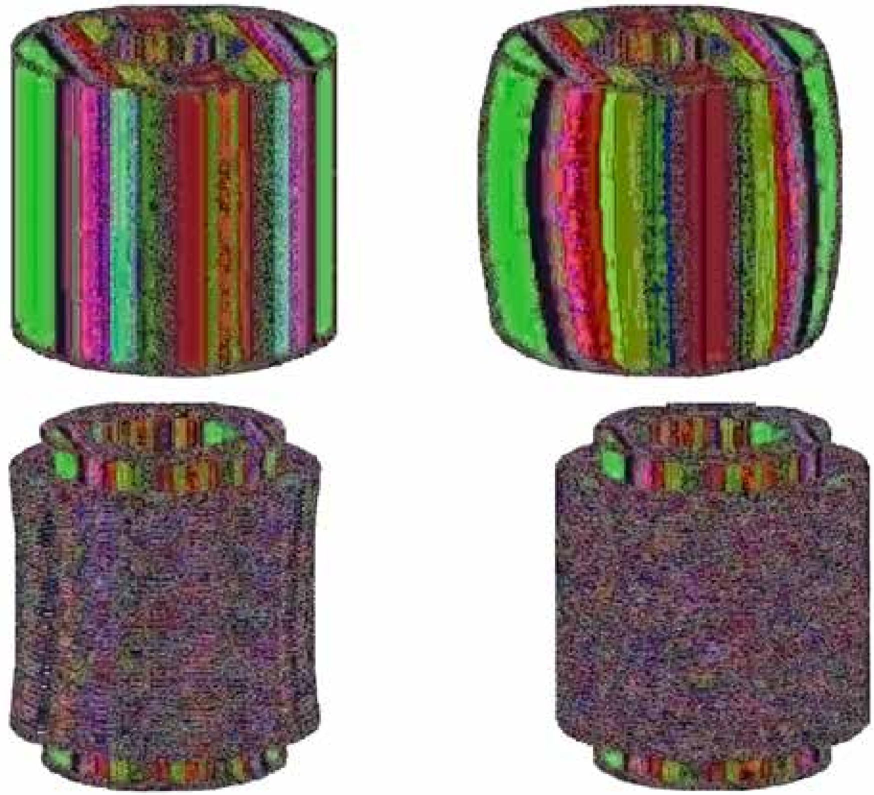


Figure 1: Mono-lithic vessel design (top) and pre-stressed wire-wound vessel design (below). Without pressure applied (left) and with pressure applied (right).

Figure 2: Through wall crack in a mono-lithic pressure vessel.

and ceramic powders by creep and diffusion, and heal internal voids, i.e. metal castings, to substantially improve the strength of any materials. The temperature depends on the material to be HIPed, e.g., aluminum has a lower melt temperature (650 °C) than steel (1,550 °C). An example of the effect of HIPing of voids in a material can be seen in Figure 3.

The HIP cycle itself is strongly dependent, as mentioned before, on the parameters temperature and pressure. But, also time is of the essence in most applications. Therefore, much efforts have been done the last decades to optimize and minimize the total cycle time. The introduction of Uniform Rapid Cooling (URC®) greatly decreased the cycle time and allows the HIP operators to optimize the cycle to be most suitable for them and their materials. An example of a HIP cycle with and without URC can be seen in Figure 4.

Recent developments in HIP technology have introduced Uniform Rapid Quenching (URQ®). A URQ® HIP furnace enables gas quenching with a cooling rate up to 3,000 K/min. This enables the user to perform high pressure heat treatment in the HIP and thereby avoid extra post-processing steps as annealing, tempering, or hardening. An example of a HIP-URQ® cycle can be seen in Figure 5.

The HIP system itself consists of the wire-wound yoke frames and a thin-walled cylinder, which can be considered as the backbone of the pressure vessel, since they take up the forces coming from the compressed gas. See Figure 6.

The furnace, which is the heart of the HIP machine, has an elaborate design to ensure good insulation, temperature accuracy, rapid cooling, and reliable and safe requirements. HIP furnaces can be supplied in steel,

Figure 3: Artificial pore before HIP (right) and after HIP (left).

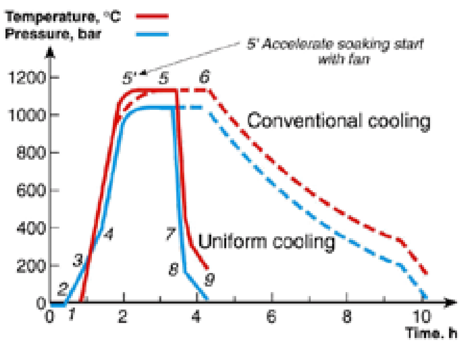


Figure 4: Typical HIP cycle times without and with rapid cooling.

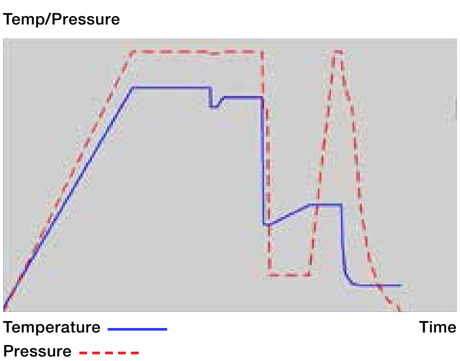


Figure 5: Example of a HIP-URQ® cycle.

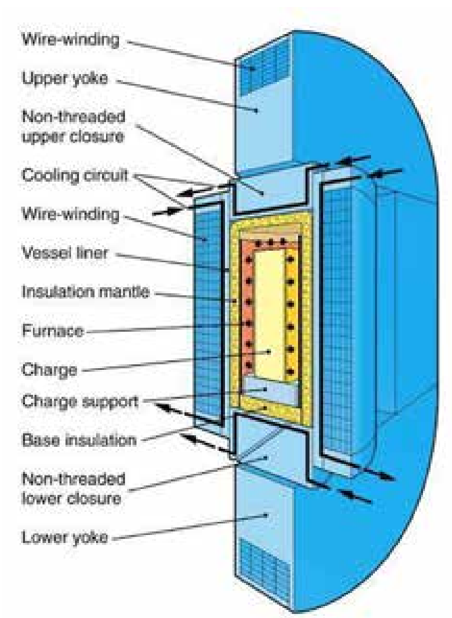


Figure 6: Pre-stressed Wire-wound HIP vessel.

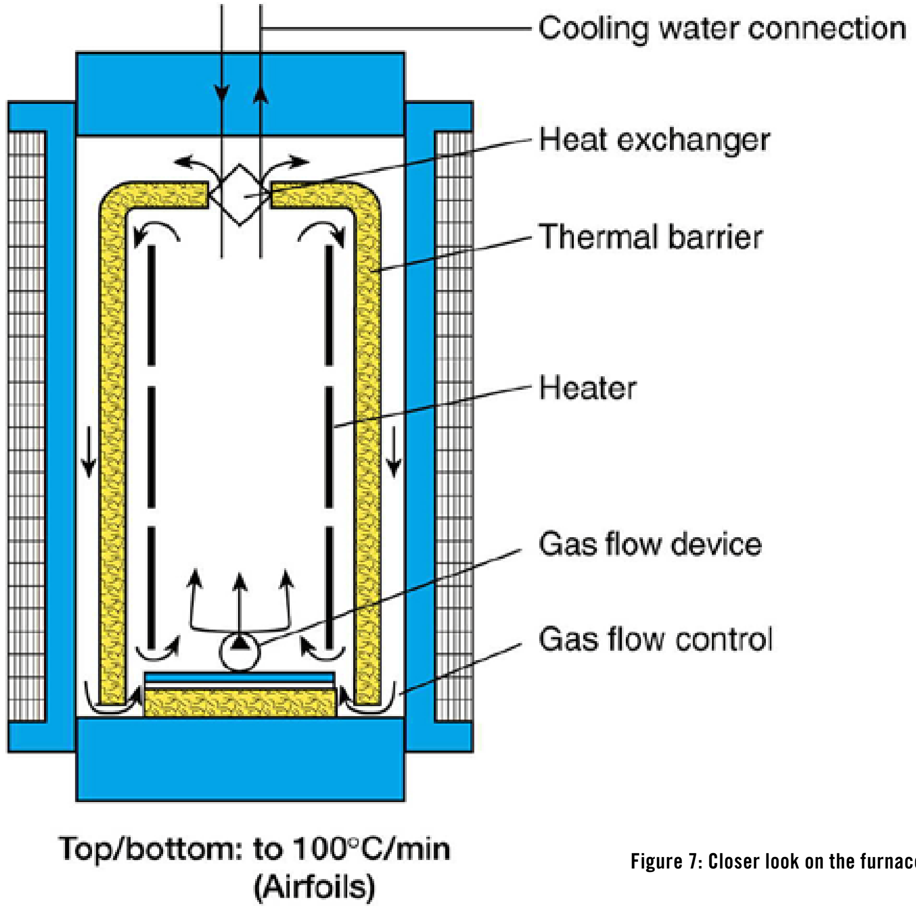


Figure 7: Closer look on the furnace.

molybdenum, or graphite, depending on the operating temperature. See Figure 7.

The charge, which can be canisters of powder, cast/forged parts or PM parts such as AM, MIM, and press+sinter parts, is placed on an insulated support structure. The gas flows freely around the charge for utmost temperature accuracy. The best temperature accuracy is achieved with a multi-zone convection furnace. See Figure 7.

CASE STUDY OF QUENCHING UNDER HIGH ISOSTATIC PRESSING

A study to see how the high external pressure during URQ quenching affects the thermodynamics of a steel have been made. Previous studies have shown that the thermodynamic kinetics in the Fe-C system was significantly decrease by very high external pressures up to 50,000 bar [1, 2, 3] and the purpose of this study was to investigate if the same effect can be seen for typical HIP pressures.

The material chosen for this study was steel 4340, EN 34CrNiMo6 or SS2541 which is a common quench and temper construction steel. The nominal chemical composition is in Table 1.

The set-up of samples for the HIP trials

Figure 8: Set-up of samples with thermocouples in the HIP furnace.

can be seen in Figure 8.

With this set-up, one can measure the temperature in the gas as well as in the material and compare cooling rates. The accuracy is very good for these high cooling rates, which can be seen in Figure 9.

RESULTS AND DISCUSSIONS

The HIP cycle for these trials was conducted at 850° C with enough hold time, 15 minutes, to ensure that the material uniformly reached austenization temperature. The temperature was then rapidly quenched to the heat treatment temperature, 650° C, and then held at working pressure and temperature for 25 minutes. See Figure 10.

Two different HIP cycles were performed

Elements (%)	C	Mn	Si	Cr	Ni	Mo	Cu	Fe
4340	0.37	0.74	0.26	1.45	1.50	0.19	0.16	Bal.

Table 1

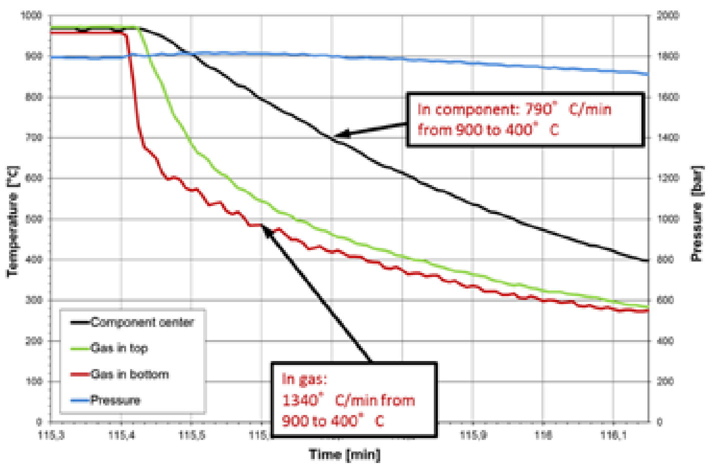


Figure 9: HIP cooling curve.

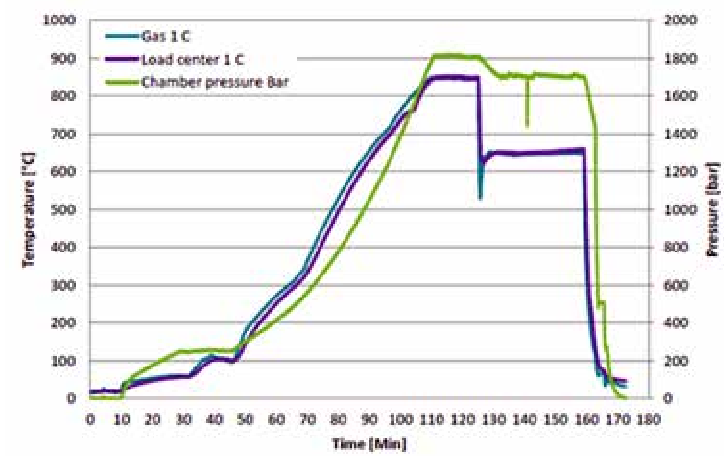


Figure 10: HIP log curve at 1,700 bar and heat treatment at 650° C for 25 minutes.

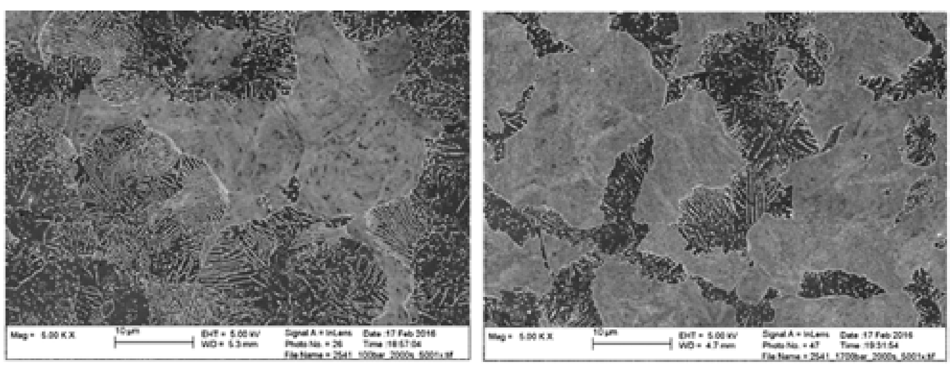


Figure 11: Microstructure for 25 minutes at 100 bar (left) and 25 minutes at 1,700 bar (right).

where the working pressure was 100 bar and 1,700 bar. The change of microstructure can be seen in Figure 11.

The pearlite content and hardness were measured for the different samples. For the 100 bar trial, the hardness was 344 HV, and the pearlite content was 70 percent. For the 1,700 bar trial, the hardness was 497 HV, and the pearlite content was 26 percent. These results show that the high external pressure during HIP quenching is enough to influence the phase transformation kinetics of a steel. This means that the pearlite nose is pushed toward longer times in the TTT diagram and that the material gets an increased hardenability when quenched in a HIP.

CONCLUSIONS

Several advantages can be seen by using pre-stressed wire-wound hot isostatic presses (HIP) for consolidating of metal powder. HIP is a proven technology since 60-plus years with world-wide safe operations. HIP systems are built per ASME Boiler and Pressure vessel code, Section VIII, Division 3, “Leak-before-burst”.

High pressure heat treatment is a possible way forward to minimize process time, save cost, and improve quality to maximize your parts properties.

ACKNOWLEDGEMENTS

This work was supported by VINNOVA, Swedish Government Development Board.

SEM-photos and material data was performed by Swerea KIMAB.

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Filler metal control in sinter brazing

The control of the filler metal at the braze joint of a sinter brazed product has significant impact on the quality and yield of complex shapes.

By Kyle H. Bear, Glenn Rishel, Brian Smith, and Stephen L. Feldbauer, Ph.D.

Sinter brazing has become a significant tool in the manufacture of complex powder metal components. The primary issue associated with this technology is holding the filler metal at the joint while sintering. The capillary forces of the porous base material and the braze joint, both compete for the filler metal. In cases where the filler metal is pulled into the compact and away from the joint, weak, or no bonding may result in a defective component. Only by understanding the variables that influence the control of the filler metal can a defined process be implemented to ensure optimal quality. The variables investigated in this study are: compact density, atmosphere chemistry, and the presence of flux in the filler metal.

INTRODUCTION

Sinter brazing has become a necessary means of manufacturing many complex powder metal shapes. Although the compaction technology has advanced substantially over the years, the ability to bond two components together while sintering has enabled the industry to broaden its capabilities and remain competitive in many markets.

The primary issue with the brazing of two powder metal components, in either the green or sintered states, is the competition between the capillary effect that draws the filler metal into the gap and the capillary effect produced by the porosity of the compact that results in the filler metal being pulled away from the gap and into the part. If this filler metal is pulled into the part, the bond may be compromised or not form at all.

In this work, we review the key fundamentals of brazing and apply them in such a way as to better control the flow and retention of the filler metal at the sinter braze joint. This is achieved by reviewing the key variables and their effect on the wetting of the filler metal. The sintering atmosphere, flux content of the filler metal, and the density of the components are all important to the control of the filler metal.

BRAZING FUNDAMENTALS

The fundamental driving forces for the formation of a good braze joint are the wetting of the base metal by the filler metal and the

capillary force that results and pulls the filler metal through the braze gap.

$$\text{Capillary Force} = \frac{2\gamma\cos\Theta}{r}$$

Where ϒ is the surface tension, Θ is the contact angle, and *r* is the radius of the capillary.

There are a few key steps that must be followed to produce a good braze joint:

Surface Preparation

- When the filler metal melts, the wetting of the filler metal is strongly affected by the cleanliness of the surface.

Figure 1 shows the effect of a carbon ring on the flow of filler metal (AB-72) on a carbon steel plate. If the surface is not free of dirt, oxides, and oils, the filler metal will not wet the base metal and will not be pulled into the braze joint.

Braze Joint Design

- Proper braze joint design is critical to achieving the desired strength in the component. The total length of the braze joint should be three times the thickness of the thinnest cross section being joined. This will ensure that a good braze will result in a joint that is stronger than the base metal. (Figure 2)

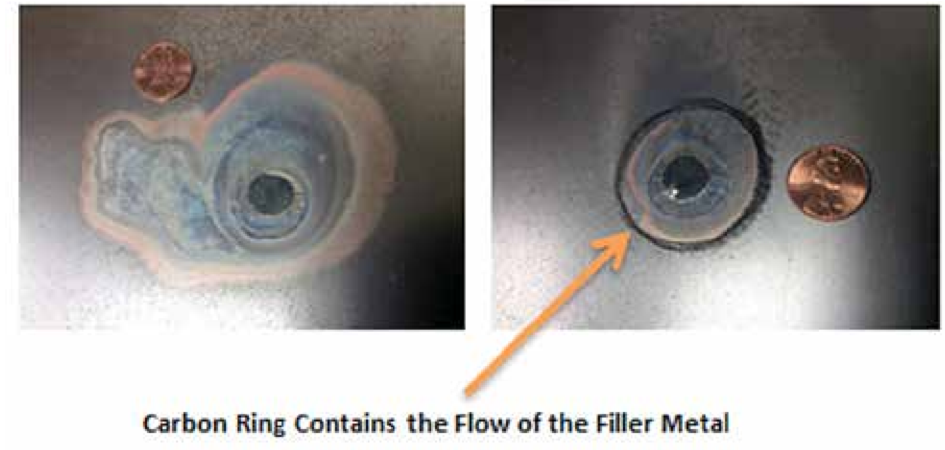

Figure 1: Effect of surface contamination on wetting.

- The gap, through which the filler metal is pulled via the capillary force and is a strong function of the gap *r*, must be 0.05 mm (0.002") to 0.20 mm (0.008") wide at the brazing temperature. This means that the thermal expansion of the components must be considered when designing the joint.

Furnace Atmosphere

- All metals contain oxides on their surface. If these are not removed, the filler metal cannot alloy with the base metal. Hence, the oxides must be removed from the surfaces of the base metal and filler metal prior to the filler metal melting. This can be accomplished by using a flux (typically an acid or other material that will remove/react with the oxide layer to produce a clean metal surface.) or a reducing furnace atmosphere. Unlike a flux, the reducing furnace atmosphere will not leave a residue that must be removed post brazing. Some typical dew points of reducing atmospheres are -51°C (-60°F) for stainless steels and -35°C (-30°F) for carbon steels.

Time and Temperature

- The time for a filler metal to flow into a clean, properly designed braze joint and form a good braze is three to five minutes at the brazing temperature that is above the liquidous temperature of the filler metal.

SINTER BRAZING

Sinter brazing is a manufacturing technique used to produce complex shapes from powder metal that cannot be produced directly from the compaction press. Multiple shapes are produced using current pressing technology. These shapes are then assembled in the green state, or some may be presintered, and a filler metal is placed in or near the adjoining surfaces of the shapes to allow for brazing to occur simultaneously with the powder metal sintering process.

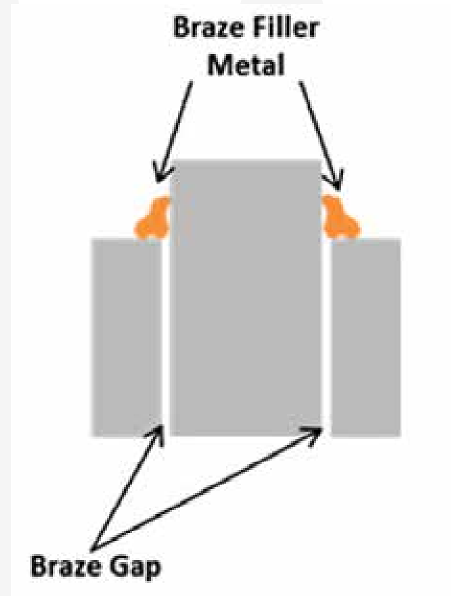

Figure 2: Proper braze joint design.

Common to sintering and brazing, the metal particles and surfaces must be free of dirt and oils. The hydrogen in the furnace atmosphere then reduces the oxides on the surface of the metals to produce clean particles and surfaces for sintering and brazing. As the components continue to travel through the sintering furnace and heat up to the sintering temperature, the filler metal melts and begins to wet the surface of the component surfaces; however, this is where the most common issue related to sinter brazing arises. Not only is the filler metal able to wet the surfaces that are to be brazed together, but the pores within the compacted components also compete for the filler metal. The surface tension between the filler metal and the base metal, along with the capillary effect produced by the small pores of the compact, pull the filler metal away from the braze joint and compromise the bond. This compromise may be a reduced amount of joint filling to no bonding at all.

If the wetting characteristics of the filler metal can be controlled, the retention of the filler metal at the brazing joint can be maintained and an improvement in the bonding and overall strength of the assembly may be maximized. For many years, manufacturers have added sulfur to the compact mix and manganese to the filler metal to retard the wicking of the filler metal into the pores of the compact. Unfortunately, sulphur is not always a desired additive. For this reason, current techniques use the addition of carbon-monoxide-containing atmospheres as a sintering atmosphere or as an addition to the sintering atmosphere. The impact of and mechanisms associated with the carbon monoxide addition were not clear; however, many swear by this approach. In this work, along with the influence of flux and density, the impact of and the mechanism associated with the addition of the carbon monoxide as it relates to controlling the wetting of the filler metal and its retention at the braze joint is investigated.

EXPERIMENTAL PROCEDURE

Discs of F-0000 were compacted to densities of 6.0 g/cc, 6.2 g/cc, 6.8 g/cc, and 7.0 g/cc. The discs had a dimension of approximately 7.62 cm (3 inches) in diameter by 2.54 cm (1 inch) thick.

Two filler metal chemistries were pressed into 1.5-gram pellets. One of the chemistries was a standard AB-72 material. The other filler metal chemistry did not contain a fluxing agent.

The pellets were then placed on top of the discs and sintered in two different furnace atmospheres, one atmosphere contained hydrogen, nitrogen, and carbon monoxide, and the other contained only the hydrogen and nitrogen.

The discs were then sectioned, polished, and etched with 2 percent Nital etchant to reveal the infiltration of the filler metal into the compact. Image J software was used to measure the infiltration area.

RESULTS

As can be seen in Figure 3, increasing compact green density results in a decrease in the amount of filler metal that flows into the powder metal compact. This is to be expected since there is a 16.7 percent difference in the relative pore fraction when comparing a 7.2 g/cc compact and a 6.0 g/cc compact.

Flux is often added to the filler metal to help to clean the surface of the base metal and enhance wetting; however, in this application, the flux not only cleans the braze joint surface but also the particle surfaces inside of the pores of the compact. The result is an enhance wetting of the pore surfaces and more filler metal being pulled from the braze joint (Figure 4).

As the powder metal compact exits the preheat section of the furnace and enters the high heat section of the furnace, the compact temperature is in the range of 900°C (1,650°F) and 1,035°C (1,900°F), carbon monoxide results in the carburization of iron and steel at these temperature [1]. Since the amount of time that the product is in this condition is small, the carburization will be a small layer on the

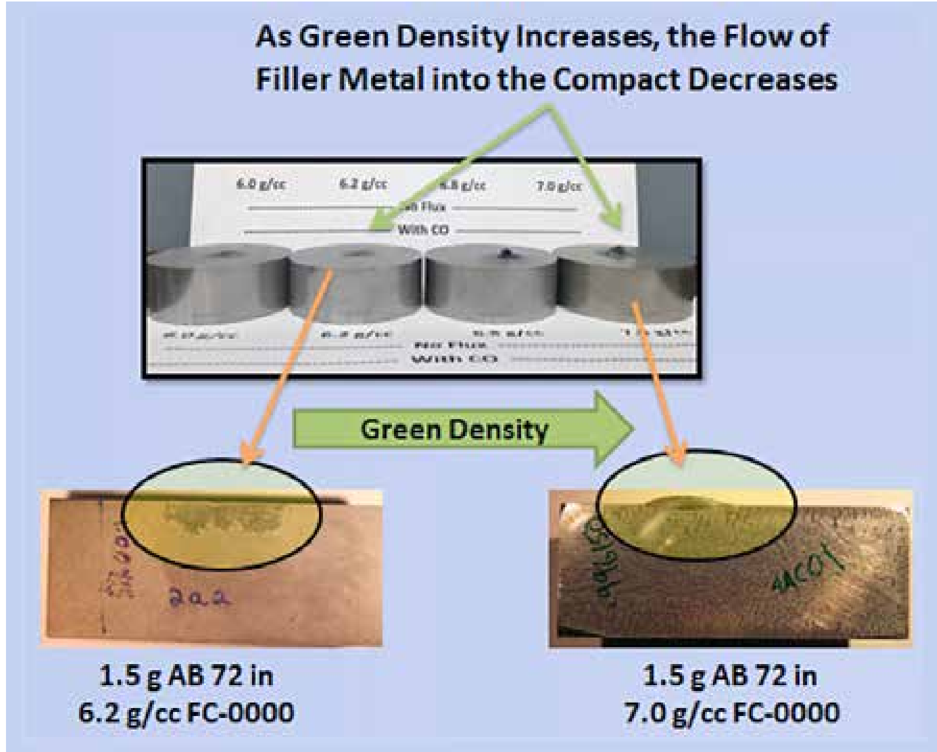

Figure 3: Effect of green density on the flow of filler metal into the compact.

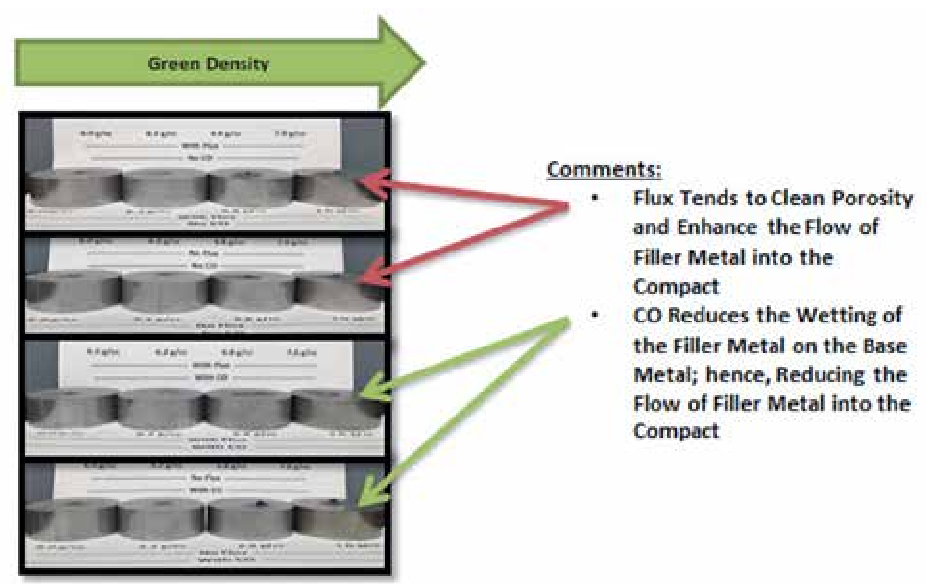

Figure 4: Effect of flux and CO on filler metal infiltration into the compact.

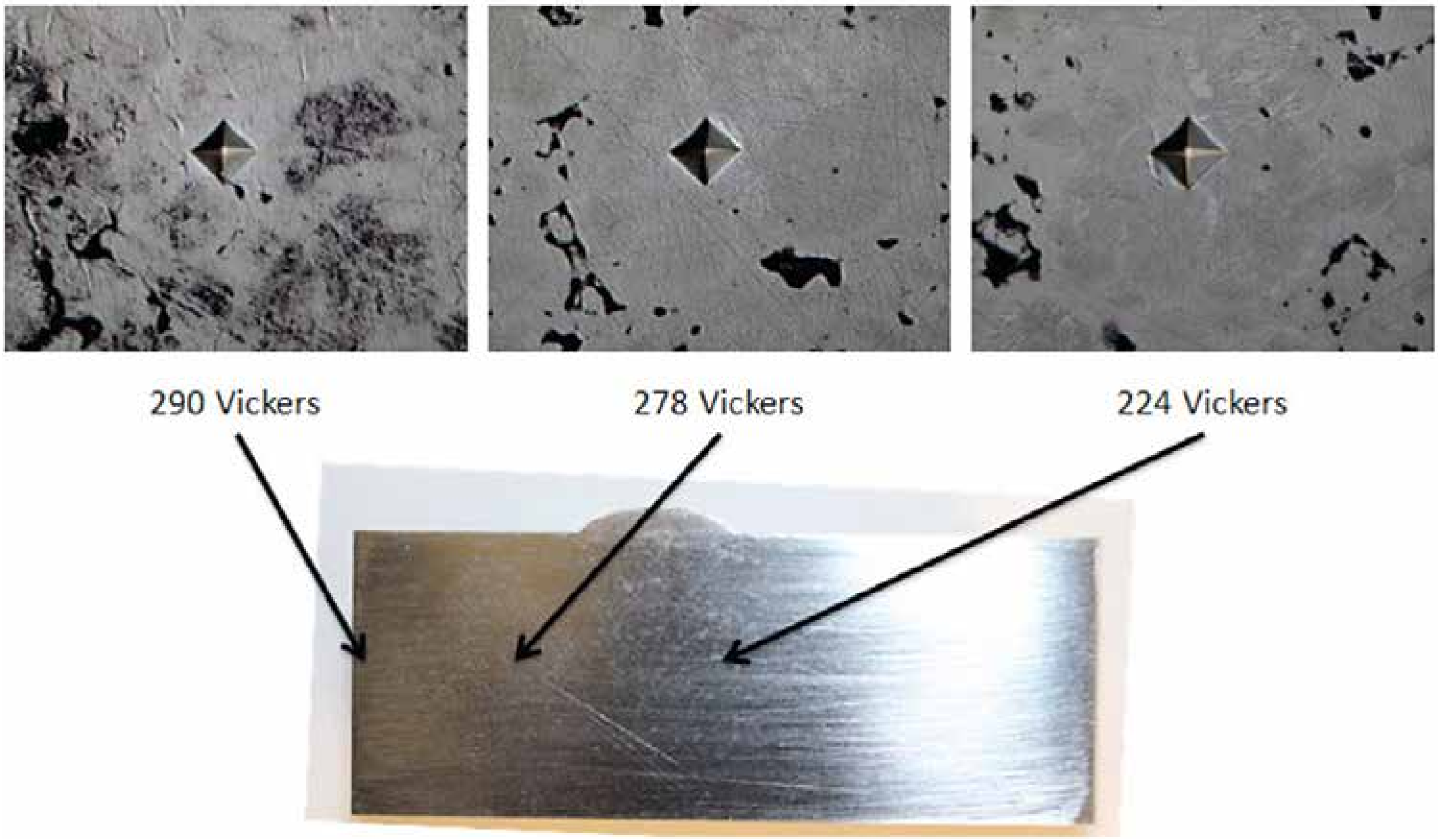

Figure 5: Edge to center hardness and carburization variation due to the presence of carbon monoxide.

surface of the exposed particles on the surface of the material and inside of the pores. This surface contamination reduces the wetting of the pores by the filler metal and results in less filler metal being pulled from the braze joint (Figure 4). Figure 5 shows that, although this material is a F-0000 and contains no carbon, the surface of the particles in along the very edge of the compact were carburized. The particle hardness on the surface is higher, and the microstructure shows the presence of carbon on the surface of the particles.

In comparing the overall impact of the variables (Figure 6), an interesting phenomenon was observed. In the high-density region of the graph (purple), the effects of the flux, carbon monoxide, and density were consistent with what was expected. In the lower density section of the graph (green), the control of the filler metal wetting was not influence by the wettability of the filler metal on the base metal.

To better understand what is shown here, one must consider the relationship between the force due to surface tension that would want to pull the filler metal into the pores of the compact, and the force due to gravity, resisting the movement of the filler metal flow.

Figure 7 illustrates that as the pore size becomes larger, lower density of compact, there reaches a point where the force due to gravity will cause the filler metal to fall and not completely fill the pore.

The result is that the influence of the altered surface tension is reduced and limits the ability of the producer to influence the wetting and flow of the filler metal with flux or carbon monoxide. For this reason, many producers find that they have more consistent results and better quality of sinter brazed products that are 6.9 g/cc and above.

CONCLUSION

The control of the filler metal at the braze joint of a sinter brazed product has significant impact on the quality and yield of complex shapes that cannot be produced by current conventional compaction technology. Maintaining the presence of the filler metal at the sinter braze joint is necessary, or the components will not be bonded. However, the porosity of the powder metal compact results in capillary forces that tend to wick the filler metal away. By pressing the compacts to a density greater than 6.9 g/cc, removing the flux from the filler metal, and adding carbon

The control of the filler metal at the braze joint of a sinter brazed product has significant impact on the quality and yield of complex shapes that cannot be produced by current conventional compaction technology.

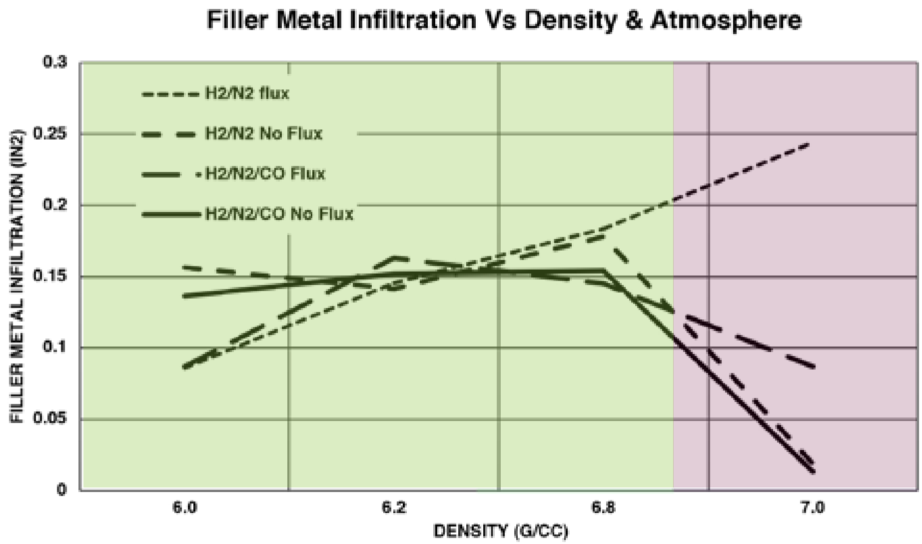

Figure 6: Influence of density, flux, and carbon monoxide on the infiltration of the filler metal into the compact.

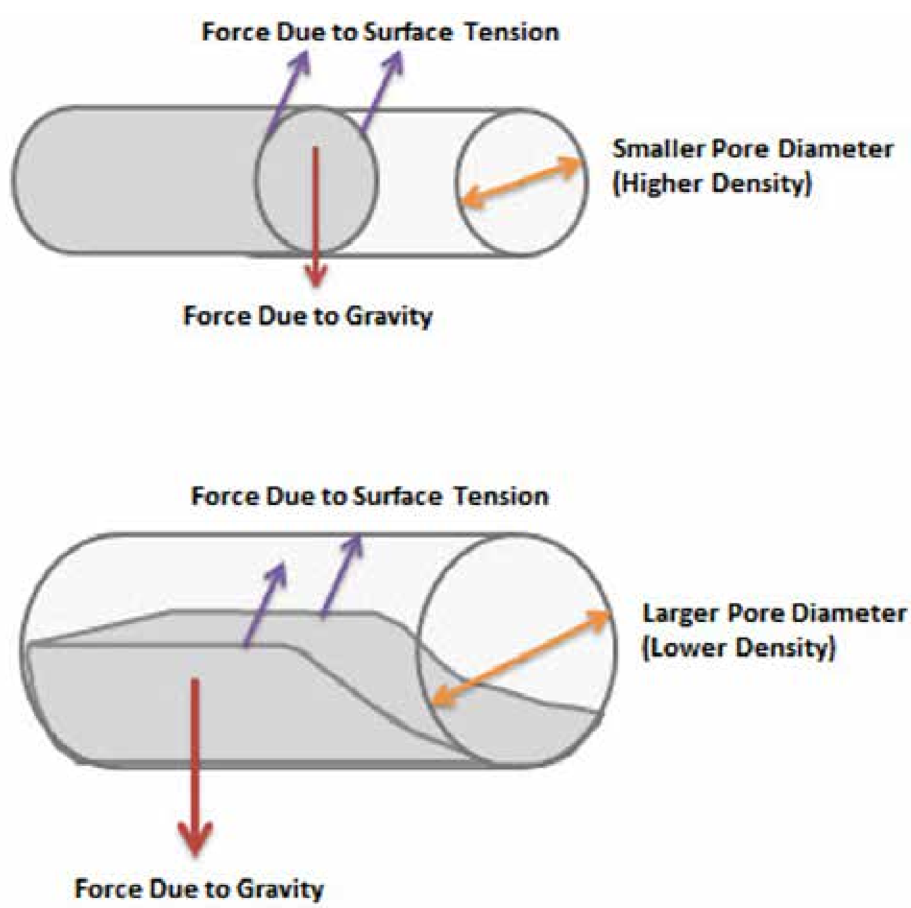

Figure 7: Surface tension versus gravitational force as a function of pore size.

monoxide to the sintering furnace atmosphere, the capillary action of the pore can be reduced, and the flow of the filler metal at the joint can be controlled to produce a better bond.

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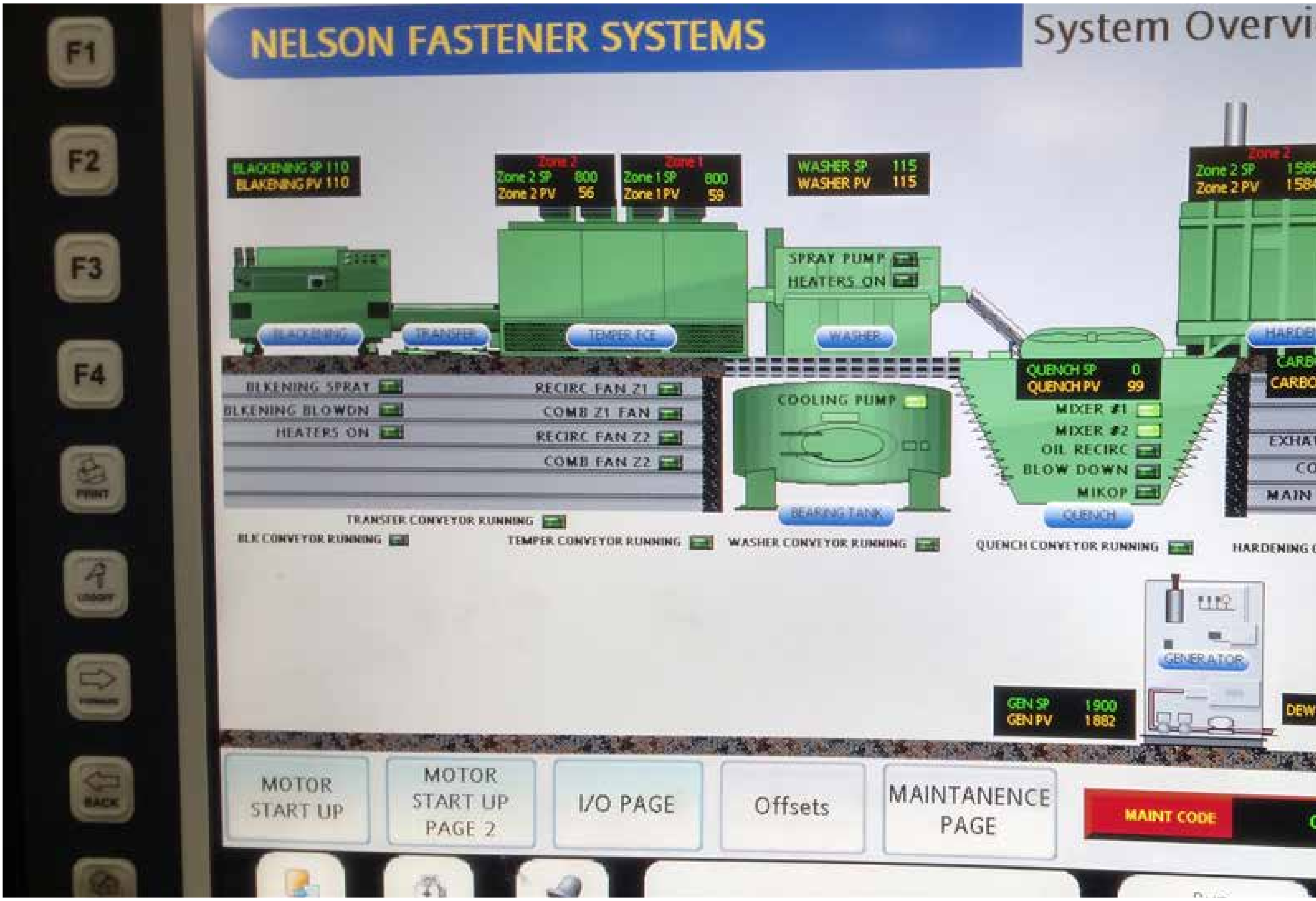
ABOUT THE AUTHORS

Kyle Bear is currently in his junior year of the Engineering, Applied Materials Department of the Pennsylvania State University. He is actively involved in research in the areas of brazing, sinter brazing, infiltration, and lubricant removal from powder metal compacts. Prior to joining the University, Bear was a field medic in the United States Army and retired after 10 years of service.

Glenn Rishel earned his B.S. in Business Management and A.S. degrees in Mechanical and Plastics Engineering, along with Certificates in Nano Technology Fabrication from Penn State University. Rishel focused in plastic injection molding processing, strength of materials, and materials characterization and testing of powdered metals, along with Oracle database administration while working in the private sector. In 2008, Rishel joined the Penn State DuBois Material Engineering program as a Research Technician. While at Penn State, Rishel worked nearly exclusively on powdered metallurgy. In addition to industry and academic research and running the materials labs, Rishel also has been an adjunct faculty for several Strength of Materials and Production Design laboratory courses.

Brian Smith has been in manufacturing and engineering for more than 20 years with an emphasis on product and process development, manufacturing, and feasibility. He is currently an applications engineer with Abbott Furnace Company. Smith's primary areas of expertise are powder metal and thermal process metallurgy and processing. He has been a member of APMI International since 2006. Brian can be contacted at bsmith@abbottfurnace.com.

Dr. Stephen Feldbauer received his Ph.D. in 1995 from Carnegie Mellon University in Materials Science and Engineering. He joined Abbott Furnace Co. in 2002 where he is the director of Research and Development. Feldbauer is also a senior adjunct faculty member in Engineering at Pennsylvania State University. He is the author of numerous articles and publications and has been awarded eight patents. He is an active member of the MPIF and the American Welding Society's C3 Committee.



Customized, modern process control system saves time, money

When a manufacturer of fasteners and fastening system components needed a more reliable process control system, it turned to Conrad Kacsik for an upgrade that would work with its older hardware.

By Patrick Dunn

Nelson Fastener Systems makes fasteners and fastening system components for some of the world's most demanding customers. The company requires precise temperature control throughout the manufacturing process, and it needs to be able to verify and document all of its work.

THE CHALLENGE

Nelson had a programmable logic controller (PLC) on one of its lines that was so antiquated that it had a note on it saying, *"Do not turn off."* That's because there was no tech support or parts available to service it. When a power outage rendered it inoperable, the need to upgrade became urgent.

Nelson turned to Conrad Kacsik for a cost-effective upgrade that would work with its older furnaces, saving the company time and costly hardware expenses.

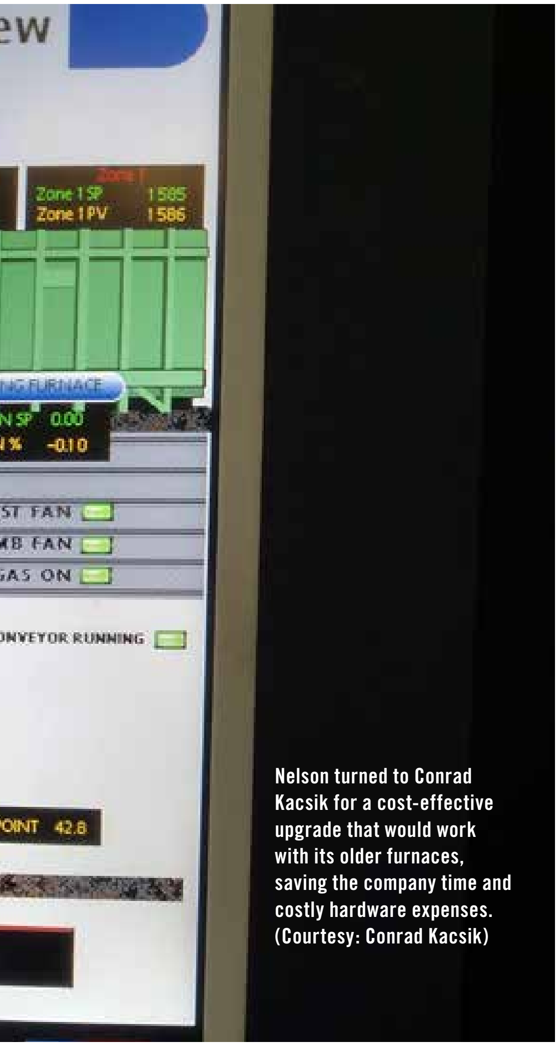
THE PROJECT

Conrad Kacsik's engineering division completed a full-system upgrade of Nelson's automated hardening and tempering line. Conrad Kacsik removed the existing control system, variable frequency drives, limits, and control wiring.

Conrad Kacsik then installed a new control system comprised of a Honeywell HC900 process automation controller with a 15-inch operator interface terminal that is seamlessly integrated with a computer running SpecView HMI software.

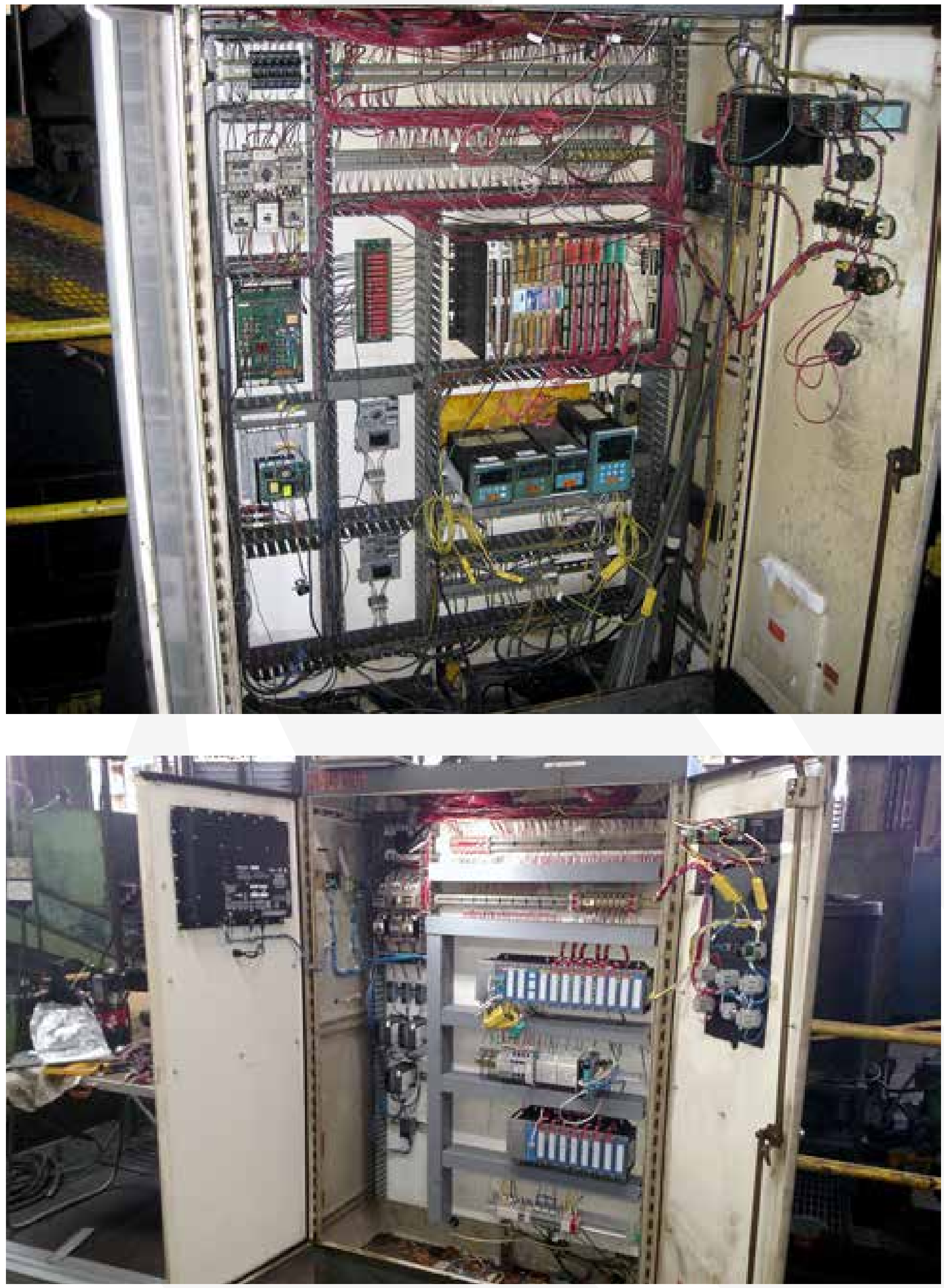
The new system included three control panels and operator station. As part of the project, Conrad Kacsik reviewed the control of all of Nelson's devices. Everything needed rewiring to a PLC with three racks — one master and two slaves. The team installed six new drives and tied them all into the PLC as well.

Nelson's prior system had variable frequency drives that did not communicate with a programmable logic controller or easily integrate with modern software. It wanted a new system programmed with safety features, so that in the event of a



Nelson turned to Conrad Kacsik for a cost-effective upgrade that would work with its older furnaces, saving the company time and costly hardware expenses. (Courtesy: Conrad Kacsik)

The new process control system allows the operator to type in a number for a job to be done accurately while being tracked and having data automatically saved and accessible any time. This allows for easy record keeping and critical accountability and traceability.


Nelson's prior system had variable frequency drives that did not communicate with a programmable logic controller or easily integrate with modern software. (Courtesy: Conrad Kacsik)

chain break or a conveyor jam, the system would sound an alarm and automatically shut off the other conveyors.

The final project controls a two-zone hardening furnace, generator, quench tank, water cooling tank, washer, two-zone tempering furnace, and a blackening unit — all of which are integrated with six conveyors. The equipment was wired into four control panels, which were completed by Conrad Kacsik's engineering team.

THE OUTCOME

The project allows Nelson to complete jobs more efficiently and reliably while collecting all necessary data in a seamless manner. Thanks to SpecView, data can be accessed securely from anywhere with an internet connection.

Conrad Kacsik worked with Nelson to learn exactly how it wanted the system to operate. The new system includes an operator interface on the floor for ease of use, and with SpecView software tracking everything, it collects data for anything that records temperatures. This was important for Nelson because it had to complete different jobs with a variety of batching systems.

The new process control system allows the operator to type in a number for a job to be done accurately while being tracked and having data automatically saved and accessible any time. This allows for easy record keeping and critical accountability and traceability. Nelson management can access that data at any time with remote licenses through SpecView, allowing them to track jobs and see how the system is operating.

The final job even included some unexpected upsides: Listening closely to the customer, Conrad Kacsik learned that

The new system includes an operator interface on the floor for ease of use, and with SpecView software tracking everything, it collects data for anything that records temperatures. (Courtesy: Conrad Kacsik)

Nelson shut down its system at 4 p.m. daily, but it had to wait until 6:30 p.m. to complete the shutdown process — something that required an employee on the clock to do. The new system allows for automated shutdown, saving time and adding convenience.

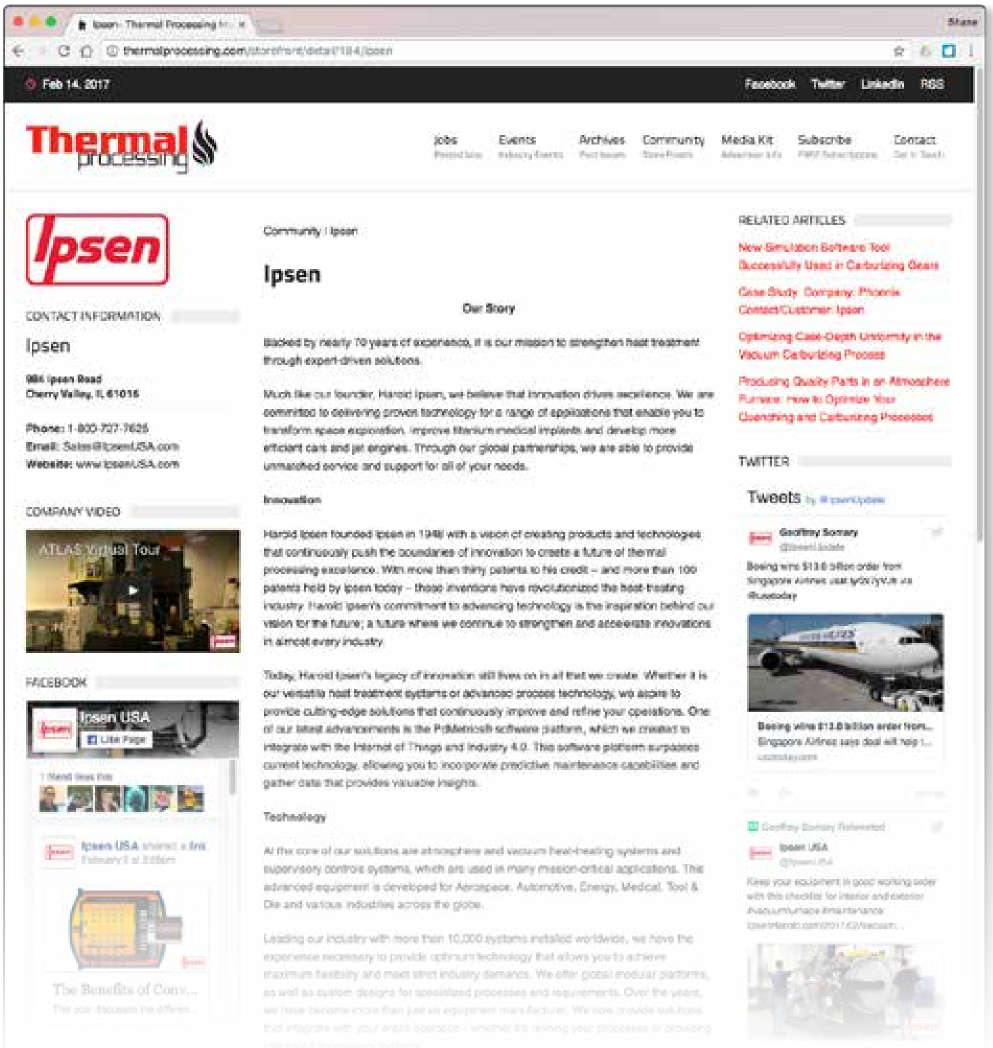
Because Nelson is still operating older equipment that needs consistent maintenance, troubleshooting is another important factor. SpecView allows Conrad Kacsik to log in any time to troubleshoot remotely, which saves on service charges.

Nelson got even more than they expected.

"This project exceeds our expectations," said Ron Utterback, SMI process manager at Nelson. "Conrad Kacsik took the time to really understand our needs and our systems, then built the best possible solution tailored to those needs."

ABOUT THE AUTHOR Patrick Dunn has been in the industry since 1990. Working on equipment from all aspects such as OEM, design, engineering, start-up, wiring, and programming gave Dunn the ability to understand the fundamentals of the equipment. Born in Cleveland, Ohio, Dunn has spent most of his life traveling abroad working on projects similar to the one featured in this article.

ARE YOU MAXIMIZING YOUR EXPOSURE?



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MARKETPLACE

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AD INDEX

WHAT ARE YOUR DUTIES WITH CAPSTAN ATLANTIC?

My essential duties include managing: design and development, engineering, R&D ,and specific laboratory functions, in addition to supporting marketing efforts to facilitate company growth.

WHAT PRODUCTS AND SERVICES DOES CAPSTAN ATLANTIC OFFER?

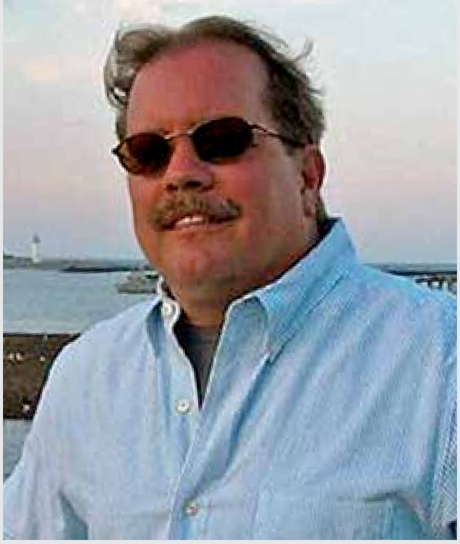
Capstan offers a wide variety of custom engineered products using powder metallurgy technology. We offer a mix of material/process systems targeting the more precise applications in the marketplace with difficult to achieve material properties, often targeting conversions from wrought steel. These technologies can be particularly useful when converting high strength gears to PM from materials such as AISI 8620.

WHAT ARE CAPSTAN ATLANTIC'S GOALS AS THEY PERTAIN TO THE HEAT-TREATING INDUSTRY?

Capstan offers many different hardening methods to the end user. These include:

- Sinter-hardening (atmosphere quenched) and through hardening.
- Carburizing (quench and temper) case or through hardening.
- Induction hardening — localized regional hardening.
- Stress relieving/annealing.
- Steam treatment (black oxide sealing).

We are also evaluating additional hardening technologies to offer to the market.



This is a 60-foot-long continuous belt furnace consisting of three zones: pre-heat 1,550°F, high heat 2,075°F, and cooling zone. In the first zone, the lubricant is removed (burnt out of) from the powder and slight particle bonding occurs; in the high heat zone, the alloying constituents, i.e. copper, nickel, molybdenum, diffuse into the iron base, and full particle bonding is achieved. Finally, the cooling chamber "cool down rate" can be varied to achieve the desired component hardness. (Courtesy: Capstan Atlantic)

WHAT ARE SOME OF CAPSTAN ATLANTIC'S PROUDEST ACHIEVEMENTS?

Capstan is a frequent award winner in the Annual MPIF (Metal Powder Industries Federation) Powder Metallurgy Design Competition — for unique, innovative components.

We also recently completed a plant expansion increasing manufacturing capacity by 40 percent to produce large, complex multilevel components.

We enjoy a first-class workforce that understands the concept of "customer" and does everything to ensure that our customers remain satisfied at all times.

We are also recently registered to the latest IATF 16949 Quality Standard and ISO 9001; 2015 Quality Standard.

Employee-driven continuous improvement is key to our success in meeting aggressive quality objectives.

WHAT SETS CAPSTAN ATLANTIC APART WHEN IT COMES TO WHAT YOU CAN OFFER A CUSTOMER?

Capstan's reputation for being a top-rated PM supplier as it relates to customer collaboration, product design, component precision, and product quality is unsurpassed in our industry. Shipping perfect quality product, on time, to our customers is what drives us. Our customer satisfaction, as measured by "customer scorecards," reflects our core belief that happy customers are the key to our survival.

WHERE DO YOU SEE THE FUTURE OF CAPSTAN ATLANTIC AND ITS PLACE IN THE HEAT-TREATING INDUSTRY?

In our new expansion, Capstan is facilitized to install a minimum of six new furnaces. These include accelerated cooling furnaces for sinter-hardening, continuous belt tempering, and continuous belt steam treating (black oxide sealing) as well as newer technologies that we are currently exploring.

We look forward to significant growth over the coming years as we introduce newer technologies to the marketplace.

FOR MORE INFORMATION www.capstanatlantic.com