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The International Journal of Thermal Processing industrialheating.com JUNE 2018

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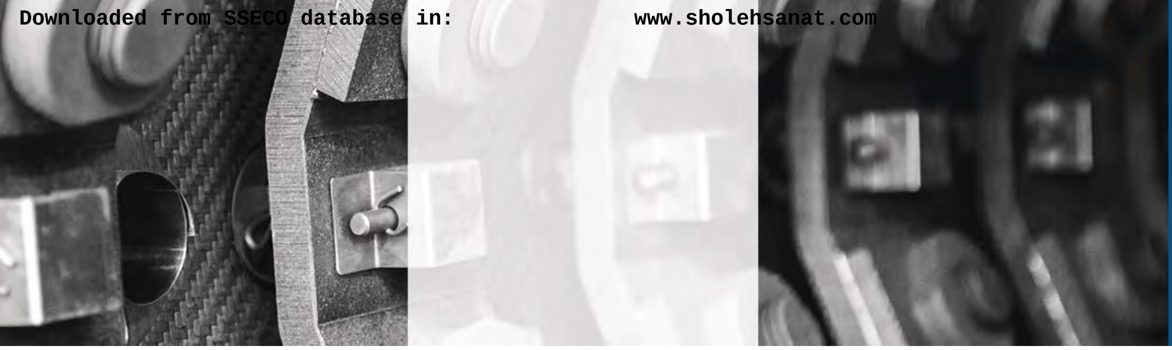

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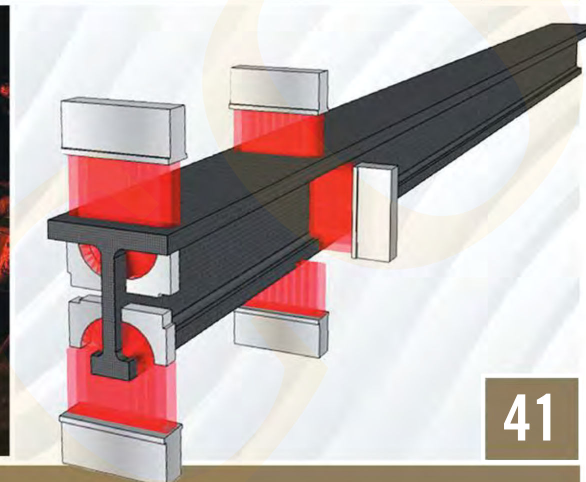

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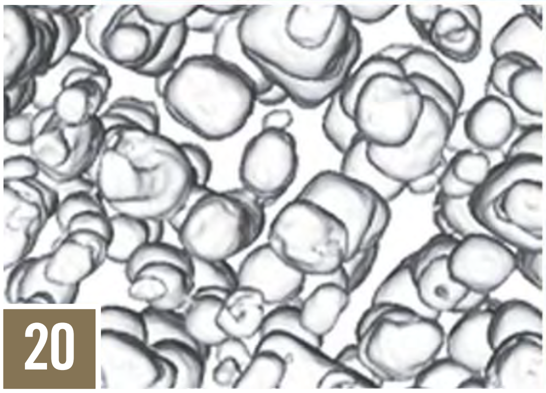
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SPECIAL SECTION

On the Cover:
The steel industry is producing lots of material, and new mills are being built. Our industry is looking up, and you can read more about it in this month's editorial *(p. 11)*.

INDUSTRIAL HEATING (ISSN: Print 0019-8374 and Digital 2328-7403) is published 12 times annually, monthly, by BNP Media, Inc., 2401 W. Big Beaver Rd., Suite 700, Troy, MI 48084-3333. Telephone: (248) 362-3700, Fax: (248) 362-0317. No charge for subscriptions to qualified individuals. Annual rate for subscriptions to nonqualified individuals in the U.S.A.: $142.00 USD. Annual rate for subscriptions to nonqualified individuals in Canada: $177.00 USD (includes GST & postage); all other countries: $202.00 (int'l mail) payable in U.S. funds. Printed in the U.S.A. Periodicals Postage Paid at Troy, MI and at additional mailing offices. For SINGLE COPY SALES OR BACK ISSUES ONLY: contact Ann Kalb at (248) 244-6499 or KalbR@bnpmedia.com. POSTMASTER: Send address changes to: INDUSTRIAL HEATING, P.O. Box 2146, Skokie, IL 60076. Canada Post: Publications Mail Agreement #40612608. GST account: 131263923. Send returns (Canada) to IMEX Global Solutions, P.O. Box 25542, London, ON, N6C 6B2. Change of address: Send old address label along with new address to INDUSTRIAL HEATING, P.O. Box 2146, Skokie, IL 60076. For subscription information or service, please contact Customer Service at: Phone: (800) 952-6643 Fax: (847)763-9538.

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2 New Podcast

Vacuum Heat Treat Minute

Our most recent installment of this Solar Manufacturing-sponsored podcast introduces the subject of eutectics and how to avoid these undesired metallurgic reactions when they are not intended during vacuum heat treatment.

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3 Web Exclusive

Infographic: The Wide World of Welding

Everywhere you look it's easy to see the contributions welding has made to our world infrastructure. In this visual guide created by Tulsa Welding School, you'll discover the history of welding, its rise as an industry and its contributions to society and the economy as a whole.

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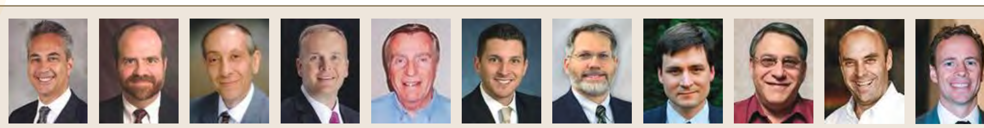

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Looking Up

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This month, we thought we would focus on some of the good news coming across our desks. It certainly seems as though things in our industry and economy are looking up.

Economic Indicators

A good place to start is *Industrial Heating*'s monthly economic indicators. For those who are not familiar, each month we survey industry leaders from our readership who provide their feedback on the following four measures: change in number of requests for quotation (60), change in number of orders (57.9), change in backlog (56.6) and expected change in health of the industry (59.5). A number above 50 indicates growth in that metric. Beginning in December 2016, all four indicators moved into the growth category. Since then, there has been some up and down, but current numbers (in parentheses) are all in the upper-50s to 60, indicating strong growth. In the past month, three of the four indicators were up.

Kiplinger recently reported on 15 industrial stocks poised for gains in 2018. The 15 include eight companies with strong ties to high-temperature thermal processing and vertical industries. These include Caterpillar, Stanley Black & Decker, Carpenter Technology, Gardner Denver, The Timken Company, Emerson Electric, Illinois Tool Works and Honeywell.

A March *Bloomberg* article indicated U.S. factories expanded at a faster rate in February than at any time since 2004. These metrics are similar to our economic indicators, but they apply to all manufacturing. The report indicated that "in addition to firmer overseas and domestic sales, corporate optimism is getting a lift from the recent tax-cut law and reduced regulation." Of the 18 manufacturing industries surveyed, 15 showed growth – led by primary metals and machinery.

Heavy Metal

If you are a subscriber to our daily news item – the IH Daily – you have probably noticed all of the good news in steel. Looking back to the beginning of the year, here are some of the highlights.

- New ironmaking plant in Ohio to employ 130.
- JSW USA invests $500 million in hot-end facility.
- Republic Steel to reopen Ohio facility and bring back 1,000 jobs.
- U.S. Steel to restart blast furnace and steelmaking, calling back 500.
- TimkenSteel at full capacity on new quench-and-temper line.
- voestalpine orders vacuum and retort furnaces.
- JSW Steel orders two reheating furnaces.
- ArcelorMittal invests $56.7 million in two reheating furnaces.
- Commercial Metals Company purchases Gerdau rebar facilities for $600 million.
- Liberty House purchases South Carolina steel plant and will rehire 125.

That's a lot of good news in the steel industry, and we predict there is more to come. Needless to say, many of these moves were in anticipation of or in light of the tariffs announced by President Trump and reported in our IH Daily on March 9 of this year. To keep up with all that's happening in our industry, subscribe to our IH Daily and magEzine newsletters by using this link: www.industrialheating/newsletters.

Employment Gains

The stories bulleted here have resulted in a few thousand new or rehires. The Bureau of Labor Statistics has been showing that manufacturing employment is up every month, in large part accounting for overall gains. Unemployment in the U.S. at 4.1% is in the "full-employment" range. Many in our industry have faced challenges trying to hire qualified or qualifiable people and know the reality of this statistic. While 4.1% is the average for the U.S., eight states are registering unemployment rates below 3%, and 17 more are below the 4.1% average. For the record, the highest rate (7.3%) is found in Alaska.

Good news abounds in 2018, and *Industrial Heating* loves to report it. We will continue to keep you informed on a daily basis, and you can check our website news anytime at www.industrialheating.com/news. Enjoy the summer!

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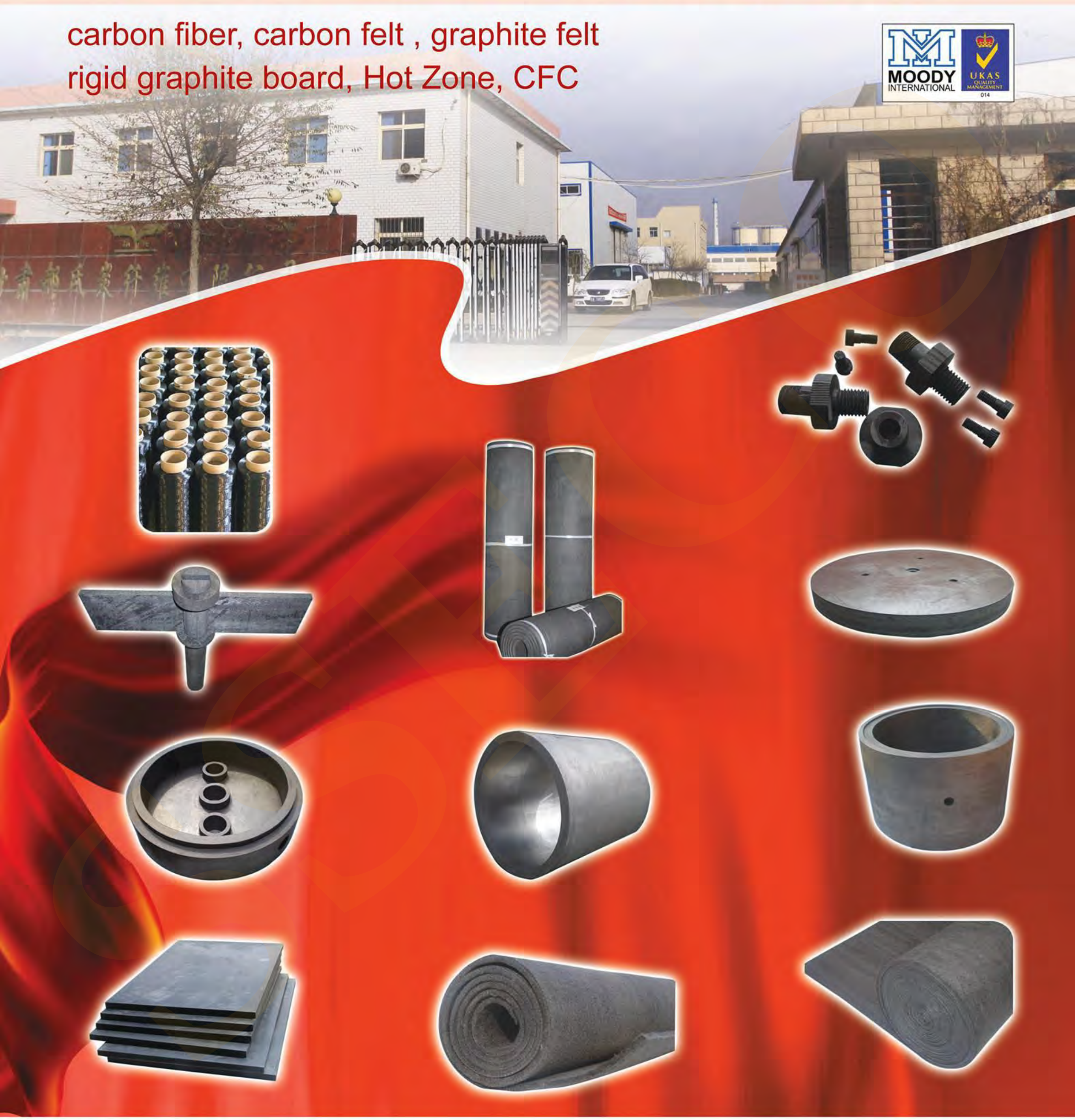

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The Potential China Disaster

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David Goldman, a scholar and writer for *Asia Times*, provides fascinating insights into growing American problems with China, which are unknown and misunderstood by Americans. He wrote that China:

- Is an empire based on coercion of unwilling people
- Is inherently unstable due to many un-cohesive cultures with numerous incompatible languages
- Exists under autocratic rule and is not a state with common popular interests
- Is a merciless meritocracy, under communism, as opposed to democracies that "accept stupidity"

Among China's 1.38 billion citizens, STEM education is revered – 6-7% pursue it in the U.S. but 30-40% pursue it in China. Since 1987 China's population consumes 17 times more goods and services than were formerly available. With the coalescence of population from rural to urban environments, exports of new/high (manufactured goods) technology has risen from 5% of GDP in 1999 to 25% today. U.S. output dropped from 20% to 7% of the total pie in the same time. Now overlay the fact that China, across the board, does not respect or adhere to concepts of ownership of ideas. Intellectual-property rights do not exist with China's corrupt society and government regulation.

It is obvious with these conditions that a trade war, or something such as a battle over tariffs, could provide a net loss for U.S. participation. The mechanism for failure is that such a trade war will "cause global financial markets to unravel," according to an American Enterprise Institute study. This may be what China really wants because it can withstand losses that the U.S. will not tolerate. Just look at existing American trade deficits with sample world nations (from 2017):

- France – $15.3 billion
- Canada – $17.6 billion
- South Korea – $22.9 billion
- Italy – $31.6 billion
- Ireland – $38.1 billion
- Germany – $64.3 billion
- Japan – $68.8 billion
- Mexico – $71.1 billion
- China – $342.8 billion

Also, consider that under Section 301 of the Trade Act of 1974 the U.S. currently has 149 anti-dumping and countervailing duty rulings pending that have had little or no effect on trade relations with China. So, the recent (March 8, 2018) tariffs on steel and aluminum pursuant to Section 232 of the Trade Expansion Act of 1962 have no beneficial impacts on U.S. materials-using sectors.

What China wants is control of new technology improvements, and they acquire that through intellectual-property theft and coercion of industries wanting to conduct business with China. The country has done this since entry into the World Trade Organization in 2001 and has succeeded in destabilizing world trading systems ever since. This is not a matter of opinion or bias but is a policy initiative (CM2025) documented by China's State Council.

The top economic advisor to China's President Xi met with U.S. officials over two months ago during a peace-keeping mission to announce China's intention to reduce its trade surplus with America. This was immediately accompanied by both nations issuing tariff hikes and punitive items worth $50 billion on various imported goods. Any trade war with or by the U.S. will only bring disaster to the world economy, Chinese Commerce Minister Zhong Shan has said. You have a lot to learn if you think that a trade war where China intends to relinquish its rising industrial power will happen.

There are numerous threats and actual issues being discussed, such as:

- How to resolve the Chinese position that requires U.S. companies to transfer their patent rights to China before doing business there
- The Congressional bill that broadens powers to stop foreign purchase of U.S. firms prompted by concerns over China's growing efforts to buy American high-tech companies
- Specific curbs on Chinese investments in the U.S. manufacturing economy
- Intent to restrict Chinese students from enrollment in U.S. higher education
- China's "threat" to slow the buying of American government debt instruments

I love the last one. Congress, are you listening? President Trump, do you understand that punitive actions could produce global economic crisis?

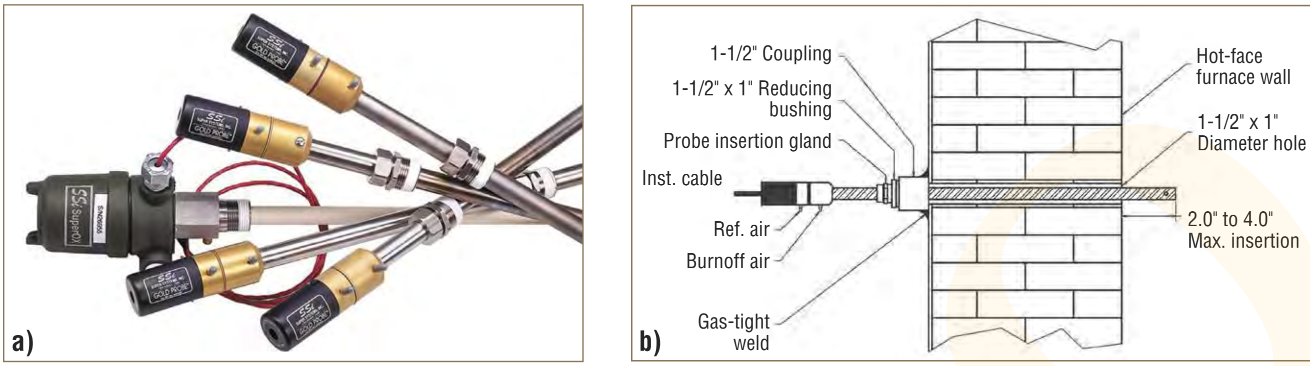

Fig. 1. (a) Typical oxygen (carbon) probes and (b) recommended mounting arrangement *(courtesy of Super Systems Inc.)*

how well a furnace does its job. Throughout the entire cycle it is critical to the process that we control the percentage of carbon dioxide, oxygen and water vapor as well as the ratio of enriching gas (or air) to carrier gas.

For example, surface carbon can be controlled within ±0.05% C during carburizing by measuring one or more of the gases mentioned above and adjusting the addition gases (hydrocarbon and/or air) accordingly.

Oxygen (Carbon) Probes

The oxygen (aka carbon) probe (Fig. 1) is an in-situ device that looks similar to a thermocouple for measuring temperature and typically sits inside the furnace, inside the generator (typically above the catalyst bed or in a separate heated "well" into which the furnace atmosphere is pumped). In whatever location, the oxygen probe measures minute changes in oxygen concentration of the furnace atmosphere.

A difference in partial pressure of oxygen in the furnace atmosphere and the partial pressure of oxygen in the room air induces a voltage across the electrodes in the probe. At any given temperature, there is a known relationship between the probe millivolt output and the oxygen potential of the atmosphere. The oxygen potential can be directly related to the carbon potential. Hence, monitoring the furnace temperature and the probe output can control the carbon potential of the furnace atmosphere.

The oxygen probe uses a conductive ceramic sensor, most often manufactured from zirconium oxide (Zr_2O_3). Operating range of the probe is normally 650-980˚C (1200-1800˚F). Oxygen probes can be used for a variety of atmosphere compositions, but they need to be calibrated for the specific one in use. They are fast-response devices and subject to contamination by carbon, zinc and certain stop-off paint vapors. When used in carbonitriding applications, the presence of ammonia will shorten the life of the probe.

An oxygen probe in a carburizing atmosphere must incorporate periodic air burnouts (Table 2). The carburizing process in use will determine the burnout frequency.

A burnout consists of at least 0.28 m^3/hour (10 cfh) of air piped to the burn-off fitting on the head of the probe. Room air or filtered combustion air are most commonly used. It is important not to use compressed air due to water and oil contamination that can damage the probe. The carbon controller should either control the frequency and duration of the burnout or shut off the gas additions in order to prevent excessive gas from compensating for the flow of air to the probe. Burnout flow and duration recommendations vary by manufacturer based on sheath diameter and tip design.

It is good practice never to exceed 90 seconds of air addition at any one time to avoid overheating the tip of the probe. A consistent way to verify a correct burnout is to monitor the millivolts of the carbon controller during the burnout phase. If a proper burnout is taking place, the output will drop below 200 millivolts. This can also vary based upon the circulation in the furnace and the probe placement.

A possible side effect of extended burnout duration is oxidation of the tip of the sensor. This problem can manifest itself in higher-than-normal millivolt values over the remaining life of the sensor, which will require a lower CO-factor setting for the same calculation of carbon potential. Consideration should be made for the duration of the burnout based upon the carbon level in the furnace.

The current trend is to use oxygen probes in combination with three-gas analysis (CO, CO_2, CH_4) equipment (Fig. 2) to calibrate the probe to a known CO value and to monitor the amount of free hydrocarbon gas in the furnace atmosphere.

Table 2. Recommended burnout frequency[5]

Atmosphere Type	Frequency of Sensor Burnout (hours)	Duration of Sensor Burnout[a] (seconds)	Flow of Burnout Air, m^3/h (cfh)
Neutral	24	90	0.28 (10)[b]
High carbon	8 to 12	90	0.28 (10)[b]

Notes: [a]Recommended burnout time. Maximum time should not exceed 120 seconds before allowing the system to re-stabilize. [b]Minimum recommended flowrate.

The balance of this article can be read online at www.industrialheating.com/ACM. In Part 2, we learn more about measuring and controlling furnace atmospheres.

FREE Webinar

Vacuum Challenges and Solutions in Metallurgy

Vacuum technology used in metallurgy contributes to enormous improvements in product quality and surface finish. The metallurgy industry creates state-of-the-art materials that enable achievements in fields like aerospace, automotive, medical and many others. This presentation will include a brief introduction to vacuum technology in the context of metallurgy and will offer access to a comprehensive guide of current vacuum technologies being used in metallurgical applications today.

Key points we will examine during this webinar:

- Review of vacuum technologies used in high-temperature metallurgical applications
- An understanding of where these technologies are used in the context of flow, pressure range and application
- Common metallurgy applications described, focusing mainly on heat treatment
- Discussion involving the challenges, best practices and recommended technologies


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Simulation Software (Part Three: Nitriding, Nitrocarburizing)

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Last but certainly not least, as the saying goes, is our discussion of gas nitriding and nitrocarburizing process simulators and how they are used to predict and control these case-hardening processes. Let's learn more.

Today, these simulators are available from several original equipment manufacturers and academic institutions for the purpose of determining the nitriding process parameters (i.e., cycle recipes) required to obtain a given case depth, to predict the compound-layer composition, and to anticipate both the final surface and core hardness as well as the hardness distribution throughout the case.

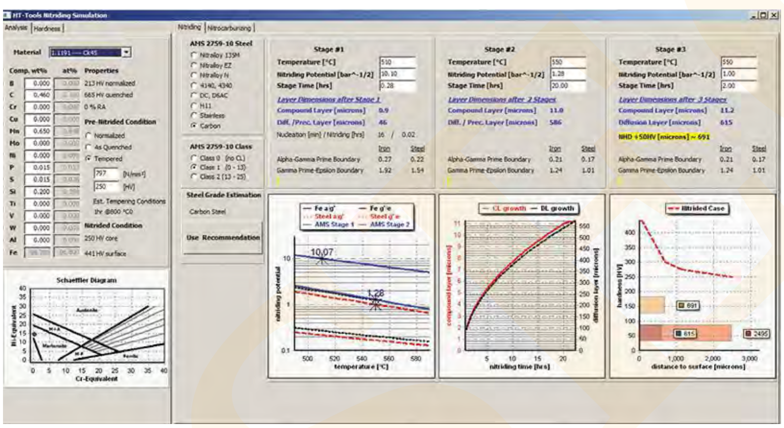

Fig. 1. Typical gas nitriding simulator output screen factoring in compound-layer composition and diffusion/precipitation-layer growth *(courtesy of United Process Controls)*

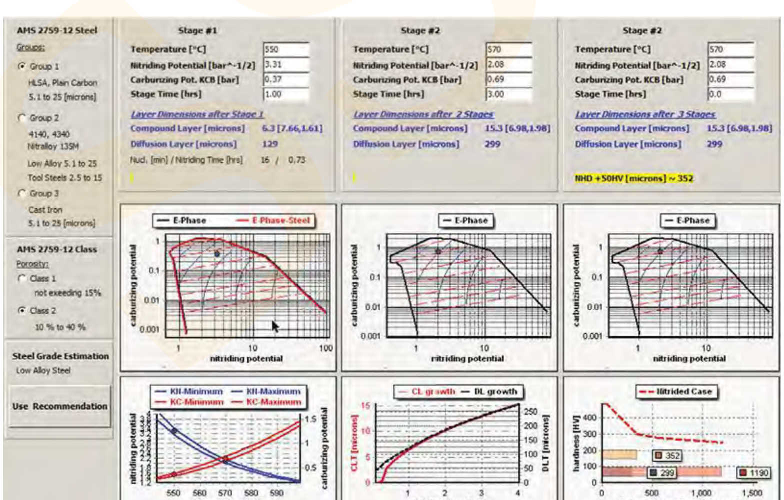

Fig. 2. Typical ferritic nitrocarburizing simulator output screen based on considerations of the iron-nitrogen-carbon phase diagram *(courtesy of United Process Controls)*

Key Challenges[2]

Nitriding simulations are strongly influenced by two preconditions: material composition (i.e., the effect of alloying elements on nitriding activity, solubility, phase boundaries and diffusion coefficients) and prior microstructure (i.e., core hardness and microstructure impacting the final surface-hardness increase, final core hardness and the final hardness distribution) produced by prior heat treatments such as annealing, normalizing, austenitizing and quenching, or quench-and-temper operations.

One of the reasons that the prior microstructure is so important is that simulators need to determine the amount of nitride formers not tied up as carbides. Nitriding processes are ideally performed on quenched-and-tempered steels. Tempering is performed at a temperature of at least 10°C (50°F) above nitriding temperature. Simulators (and most specifications) typically estimate hardness distribution and case depth. Case depth is defined as core hardness plus 50 HV.

Simulators also need to determine hardness changes during nitriding. This is done by assuming that the softening effects that occur with increasing temperature are similar to tempering effects. Other factors that influence the simulator models (and involve an in-depth understanding of kinetics and thermodynamics) are nucleation, compound-layer growth and composition, diffusion/precipitation-layer growth and final hardness distribution.

These factors are incorporated into the output of the various simulators (Fig. 1) based on work by such noted individuals as Sun and Bell (nucleation theory[4]), Hosseini, Ashrafizadeh and Kermanpur (compound-layer growth and composition[5]), Fick (diffusion modeling) and Kunze (precipitation layer growth[6]). While beyond the scope of this article, the reader is encouraged to review these papers to deepen their understanding of how these factors play a role in the inner workings of these simulators.

Ferritic Nitrocarburizing Simulators

Simulators for ferritic nitrocarburizing (Fig. 2) are typically adopted from their gas nitriding


SECO/WARWICK

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To see the latest in Equipment, Technology & Trends

A 3-D View of Modern Engineering Materials

DR. MARC DE GRAEF
Professor of Materials Science and Engineering, Carnegie Mellon University

The human brain is highly capable of interpreting the 3-D world in which we live. Not only do we continuously navigate 3-D spaces, but we can visualize in our mind what an object would look like as we spin it around. This advanced 3-D perception ability has evolved over eons out of the need to be able to function in the complex world around us.

It has only recently become possible to look at the internal structure of engineering materials in a way that is "natural" to our brain (i.e., in 3-D).

Looking inside a material to determine its microstructure – or the arrangement and shapes of phases and grains and the underlying structure of defects – requires some rather advanced characterization tools, but the basic principles are straightforward.

There are two main approaches: one nondestructive and the other destructive. Imagine having a complex but transparent object. Its transparency allows us to look inside to see how things are organized so that we can figure out how the object functions (think of plastic models of combustion engines or the human body). Metals are not transparent to visible light, but we can use high-power X-ray beams to penetrate through the material and thus reveal its interior structure. This is commonly known as X-ray computed tomography, or XCT.

The word tomography has a Greek origin and loosely means "to image by cutting or slicing." By recording images of a material sample as we rotate the sample around an axis, we obtain a series of projections known as a sonogram. Using advanced mathematical techniques, one can convert those projections into a 3-D object representing the material's internal microstructure.

The process is very similar to a medical XCT scan. In our labs at Carnegie Mellon, we have the ability to perform XCT experiments with a spatial resolution of a few tens of nanometers on samples with a volume of only a few thousand cubic micrometers. For larger samples, we often make use of the beam line facilities at national laboratories. The sample is not damaged during a scan, so we can repeat the measurements while changing the external conditions (e.g., heating, cooling, deforming).

Another way to look at the internal structure of an object is to cut into it and see what's there. If we want to know the shapes and sizes of the holes in a block of Swiss cheese, we could take a sharp knife and cut parallel slices from the block; if we take a picture of each slice and put those pictures together using an image-editing program, we can then reconstruct what the internal structure of the block of cheese looks like. It is then only a small additional step to determine statistical distributions of hole sizes and densities, or the spatial correlations of the holes.

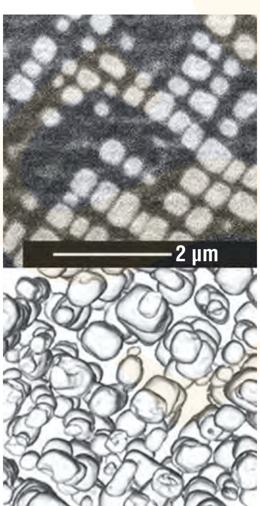
This type of serial sectioning is obviously destructive, but it allows us to obtain very high-quality 3-D reconstructions of complex microstructures. Typically, we use a focused ion-beam instrument, like a scanning electron microscope equipped with a high-energy ion gun that provides the "knife" to cut through the material.

In our facility at Carnegie Mellon, we have two such instruments: one with a Gallium ion beam and the other using Xenon ions. They are in almost continuous use for the study of 3-D microstructures in both metallic (magnesium alloys, superalloys) and ceramic (strontium titanate, solid-oxide fuel-cell components) systems.

A Deeper Dive into Professor De Graef's Research

Over the past two decades, Prof. De Graef's research group has been at the forefront of developing the numerical tools that allow us to convert raw experimental data from serial sectioning experiments into accurate 3-D reconstructions. This requires algorithms to align individual slices and to extract from each slice the different microstructural components, a process known as segmentation.

The figure shows a typical two-phase microstructure in a Ni-Cr-Al superalloy, in which ordered intermetallic precipitates are densely packed inside a disordered matrix. It is this dense packing that gives rise to the outstanding creep resistance at elevated temperature, enabling the use of these materials in the extreme conditions encountered in modern jet engines.



Single-slice image from a Ni-Cr-Al superalloy (top); 3-D reconstruction of the precipitate phase (bottom).

Premier Thermal Solutions

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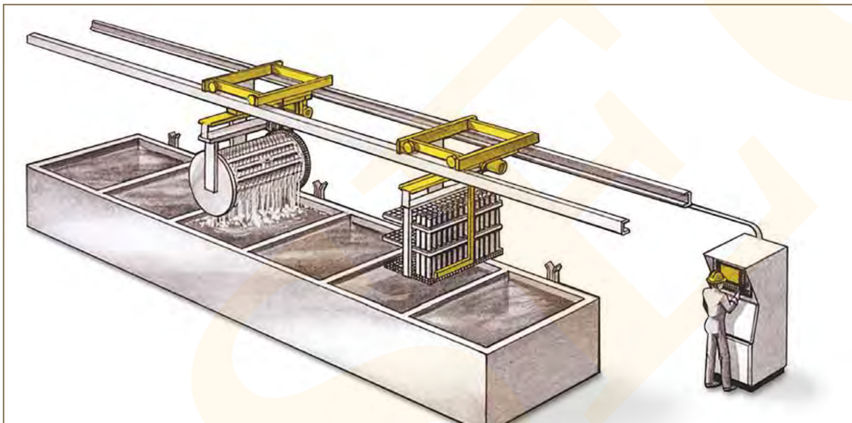
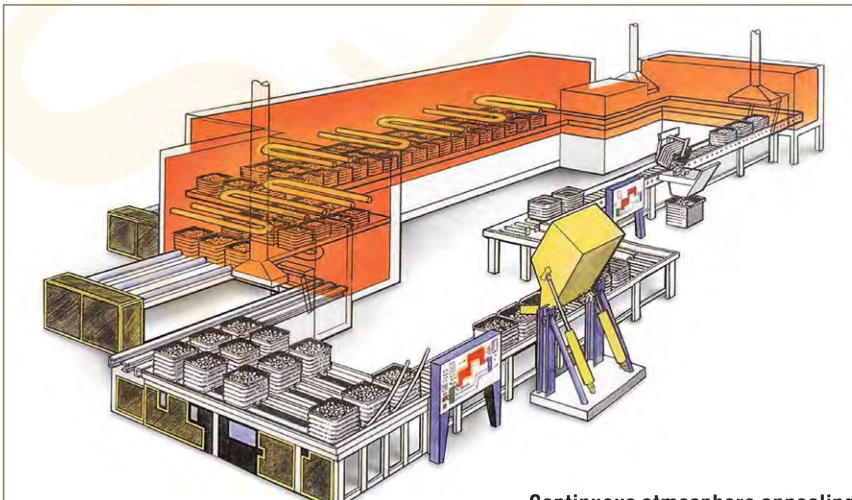
Atmosphere Annealing Inc. was established in 1978 primarily focusing on processing automotive parts through bell annealing furnaces. The original Atmosphere Annealing also operated a phosphate coating line.

Today, the Lansing, Mich.-based MTI member operates as Premier Thermal Solutions (PTS), which is the parent company for Atmosphere Annealing LLC and NitroSteel LLC. Atmosphere Annealing operates four plants (two in Lansing, one in Canton, Ohio, and one in North Vernon, Ind.) that specialize in metal heat treatment and phosphate coating. NitroSteel, meanwhile, specializes in selling ferritic nitrocarburizing for its facility in Pleasant Prairie, Wis.

With approximately 200 employees, PTS mainly serves the automotive, heavy truck, defense, agriculture, energy and heavy equipment industries. The company provides a wide range of services, including: normalizing, isothermal annealing, oil quenching, tempering, ferritic nitrocarburizing (FNC), stress relieving, shot blasting, phosphate coating, sawing and grinding. These services translate to better machinability, uniform microstructures, desired hardness and better formability.



Metal coating



Continuous atmosphere annealing

Having five locations strategically located throughout the Midwest allows PTS to be close to many of its customers, thus cutting down on freight costs. The company also offers trucking capabilities, which gives it an advantage when it comes to turnaround time.

Two aspects of the business really set PTS apart from the competition. One is the vast amount of metallurgical expertise within the company. Their technical team has over 140 years of combined metallurgical expertise. Because of this knowledgeable staff, PTS is able to process very difficult jobs with unique and tight tolerances. NitroSteel's niche, meanwhile – offering ferritic nitrocarburized bar stock – is unique in that it offers a superior alternative to chrome plating.

With recent investments for FNC capabilities in the Lansing plant and additional quench-and-temper capacity, the company continues to grow and look to the future.

One thing will remain the same, however. Premier Thermal Solutions' number-one goal is to ensure the needs of its customers are exceeded.

Visit www.premierthermal.com for more information on Premier Thermal Solutions.

LIFT – Lightweight Innovations For Tomorrow

IHEA
Industrial Heating Equipment Assoc.
859-356-1575
www.ihea.org

Metalworking has existed for thousands of years. However, there is plenty of room to innovate in one of the most mature materials in manufacturing … including making it lighter.

That is why LIFT – Lightweight Innovations For Tomorrow was established – to revolutionize lightweight metals manufacturing through innovation and education.

One of the founding members of Manufacturing USA, a federal initiative to re-establish the United States as the world leader in advanced manufacturing, LIFT was set up in Detroit in 2014. Operated by the American Lightweight Materials Manufacturing Innovation Institute (ALMMII), LIFT is a public-private partnership designed to develop and deploy advanced lightweight materials manufacturing technologies and implement education and training programs to prepare the workforce.

Its 100,000-square-foot facility, which LIFT shares with IACMI – The Composites Institute, opened in late 2017 and boasts an 87,000-square-foot high bay. The facility also includes nearly $50 million worth of full-scale equipment for research and development in both metals and composite materials.

LIFT has set its sights on being best-in-class at its Detroit facility in thermomechanical and power processing, as well as agile forming and Integrated Computational Materials Engineering (ICME) across the aerospace, automotive, shipbuilding and defense industries. Its thermomechanical processing R&D work is performed in Detroit with the support of an extrusion press, hydroforming press and stamping/forming presses.

LIFT will also house a one-of-a-kind linear friction welder. Currently being built by MTI in South Bend, Ind., the machine will be one of the only linear friction welders available for R&D work. Coming online in 2018, the welder has immediate applicability in the aerospace and automotive industries. LIFT is looking forward to exploring how it can support other industries as well.

LIFT's network of academic and industry experts around the country will help it in other areas, such as joining and assembly; coatings and melt processing; life-cycle analysis; validation/certification; and cost modeling. LIFT provides the ability for its members to conduct proprietary R&D work at its facility and across the network and also government and industry-funded collaborative work. It also helps support small and medium-sized manufacturers with services like design and prototyping, engineering and technology assessments.

This new IHEA member is building a unique national asset to focus on building the talent pipeline of advanced manufacturing technicians. The LIFT Learning Lab will provide resources for the entire continuum of talent development, including:

- Students, teachers and faculty from K-12
- Community and technical colleges
- University and graduate degree programs
- Incumbent workers in small, medium and global enterprises

Visit www.lift.technology for more information on LIFT and how you can become a member or work with us on your metalworking problems.

Equipment & Business News

EQUIPMENT NEWS

Gas Nitriding System

Nitrex Metal received a contract from Qatar Aluminum Extrusion Company (Qalex) for the supply and installation of an NX-1015 potential-controlled gas nitriding system. The system is configured for treating various-sized flat and hollow dies used in the production of aluminum extruded profiles for the construction and transportation markets. The NX-1015 furnace has a load capacity of 4,400 pounds (2,000 kg). While this is slightly larger than current production needs, the additional capacity will accommodate future growth when Qalex adds a second extrusion press. www.nitrex.com

Box Furnaces

Lindberg/MPH shipped three natural-gas-fired box furnaces to a parts manufacturer for the oil-and-gas industry. The furnaces will be used to develop process-control requirements for heat treatment and stress relieving of underground mining/drill heads. They utilize automatic chamber pressure controls and space-saving, rear-mounted burners. The furnaces, which have a maximum operating temperature of 2050˚F, have work-chamber dimensions measuring 36 inches wide x 20 inches deep x 24 inches high. www.lindbergmph.com

Equipment & Business News

Vacuum, Atmosphere Furnaces

Ipsen recently shipped 10 furnaces to companies in California, Georgia, Ohio, Washington and Wisconsin, as well as to one location in Asia. This equipment will be used to process parts for companies in the aerospace, commercial heat-treating and medical industries. The shipments included two TITAN vacuum furnaces; two MetalMaster vacuum furnaces; one horizontal, internal-quench, 10-bar vacuum heat-treating and brazing furnace; and several custom-built atmosphere furnaces that will process parts for the aerospace industry.
www.ipsenusa.com

Horizontal Quench System

Wisconsin Oven Corp. shipped an electrically heated horizontal quench system to an aluminum casting company. The system will be used for solution treating aluminum castings for the aerospace and automotive industries. The solution-treating furnace is designed to heat a 2,500-pound load of aluminum, plus basket and work grid, to an operating temperature of 1020˚F. The maximum temperature rating for this system is 1250˚F, sized for a 5-foot-wide x 5-foot-long x 5-foot-high basket.
www.wisoven.com

Box Furnace

Lucifer Furnaces delivered a general-purpose box furnace to a manufacturer of precision metal stampings based in the Midwest. The furnace, which will be used to heat treat D2 and A2 steel under air atmosphere, has chamber dimensions of 12 inches high x 18 inches wide x 24 inches deep and heats to 2300˚F. The roof is lined with ceramic fiberboard to eliminate cracking potential, and a 1-inch-thick cast hearth plate protects floor insulation and provides a flat work surface. www.luciferfurnaces.com

Brazing Line

SECO/WARWICK received an order for a continuous controlled-atmosphere brazing line from RAAL S.C., a manufacturer of automotive parts. The Romanian company will use the line – its third from SECO/WARWICK – for the production of aluminum heat exchangers. The brazing line, which is designed for high-capacity production, will deliver efficient, flexible throughput on a continuous basis.
www.secowarwick.com

Batch Ovens

Epcon Industrial Systems shipped two electrically heated batch ovens to a composite manufacturer in Houston, Texas. The ovens will be used for heating tooling used for composite moldings. The work chamber, which measures 5 feet deep x 5 feet wide x 6 feet high, is constructed with a stainless steel liner with 8-inch-thick insulation. The unique oven design offers high-temperature capability, with a maximum temperature rating of 900˚F. www.epconlp.com

Heat-Treatment Line

SMS group received the final acceptance certificate for a tube-and-pipe heat-treatment line from Romania's TMK-Artrom that was ordered in March 2016. Designed for an annual capacity of 160,000 tons, the line will be used for the production of seamless high-strength pipes up to a wall thickness of 60 mm (2.36 inches) for mechanical applications and OCTG pipes. The line mainly consists of an austenitizing furnace with walking-beam transport system, cooling quenching head, quenching tank, walking-beam tempering furnace and cooling bed. The line allows various process steps, such as quenching, normalizing and tempering.
www.sms-group.com

BUSINESS NEWS

Solar Atmospheres Installs Machining Center to Support Tensile Testing

Solar Atmospheres of Western PA installed a second machining center to support its newest service, tensile testing. The company added a fully programmable 8,100-RPM Haas VF2 milling center to support the machining of flat tensile specimens. This machining ability fully complements the function of the 10,000-PSI hydraulic jaw that is an integral component of the Tinius Olsen 300SL tensile machine. These large hydraulic jaws can grip either threaded-round or flat specimens. Solar Atmospheres is Nadcap and Boeing approved for all room-temperature tensile testing.

continued on p. 26

Industrial Oven Manufacturer Adds Second Facility

JPW Industrial Ovens and Furnaces, an industrial oven manufacturer based near Williamsport, Pa., added a second facility to its operation. The new plant is expected to create 25 new jobs within the next two years. JPW's Plant 2 will manufacture the company's expanding line of standard industrial ovens. Plant 1 will continue to produce custom-made industrial ovens and serve as the company's headquarters. Plant 2 began operation in January with 10 new employees. JPW anticipates that an additional 15 employees will be hired between now and 2020.

Premier/BeaverMatic Breaks Ground on Expansion

Premier Furnace/BeaverMatic started construction of an expansion at its Plant 1 facility in Farmington Hills, Mich. The project will provide space for a state-of-the-art testing and training facility, additional manufacturing capabilities and increased office space to allow Premier/BeaverMatic to accommodate business growth and customer needs. The 22,000-square-foot expansion is expected to be complete by fall 2018.

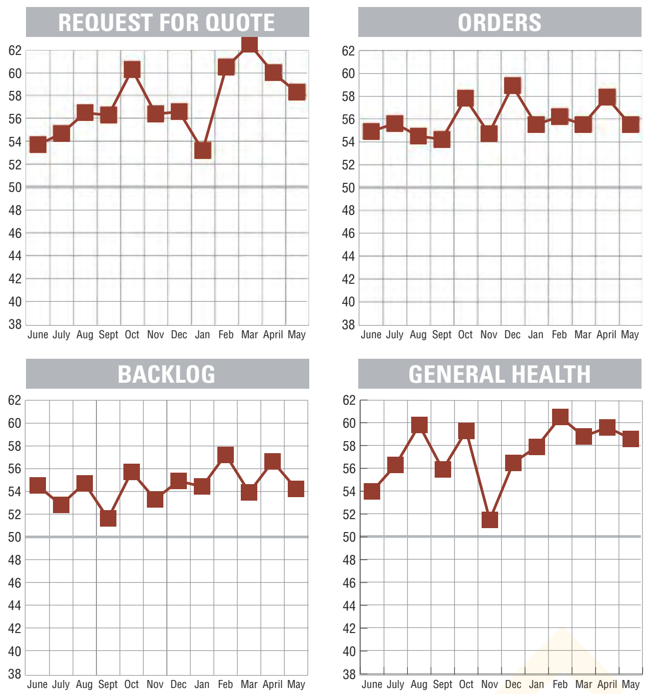
Bodycote Inks Deal with Rolls-Royce

Bodycote signed a 15-year contract with Rolls-Royce's Civil Aerospace business that is expected to be worth over $227.5 million in incremental revenues over the life of the deal. Bodycote will provide thermal-processing services including specialized vacuum heat treatment and hot isostatic pressing (HIP) to support Rolls-Royce's turbine-blade casting facilities in Derby and Rotherham, U.K. The agreement ensures the provision of thermal-processing capacity utilizing Bodycote's high-performance, quality-focused approach to support the growth of Rolls-Royce's large civil engine programs, which include the Trent XWB, Trent 1000, Trent 7000, Trent 700 and Trent 900.

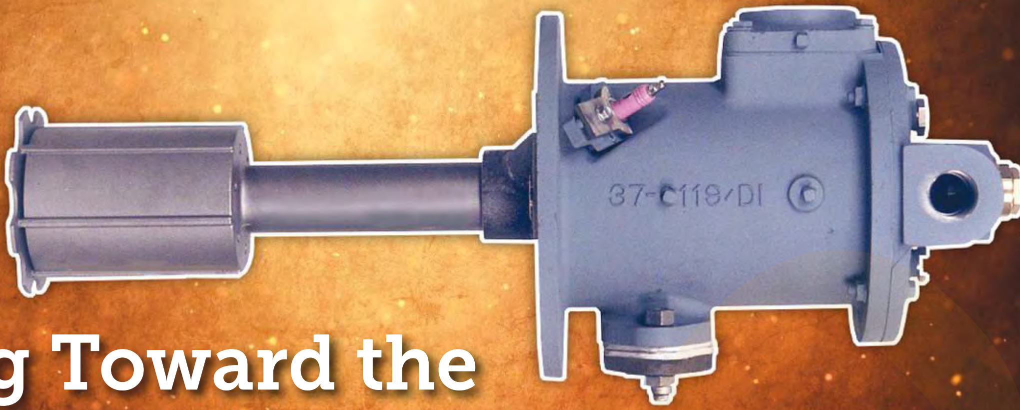
New Company to Advance Powder-Bed Fusion AM

Stratasys Ltd. announced a new spin-off company designed to advance innovation of powder-bed fusion (PBF) additive manufacturing. Vulcan Labs' primary focus is improving the quality, repeatability and efficiency of PBF technology – initially focusing on metals. The company's solutions will be engineered to meet the complex demands of end-use production applications.

ECOMOMIC INDICATORS



Values above 50 indicate growth or increase. Values below 50 indicate contraction or decrease.
To participate in this survey, please contact Bill Mayer at bill@industrialheating.com



Working Toward the Ideal Radiant-Tube Performance

Dennis Quinn – Fives North American Combustion; Cleveland, Ohio

Optimized production and minimized maintenance requirements are desirable conditions in any heat-treating operation. For applications depending on radiant-tube heat, following a few fundamental tips can help you achieve those goals.

For a wide variety of applications where indirect heat is required, as opposed to direct firing, radiant tubes can provide a dependable answer. This indirect heating approach allows many sensitive materials to be processed in the absence of the products of combustion and, in many cases, in the presence of a protective or reactive atmosphere to impart changes to the properties of the heated product. Functioning by means of firing a burner into a tube structure, which then transfers the heat to the application, this method is deployed for processes such as case hardening, galvanizing steel and more.

But like any industrial heating technique, radiant-tube applications require proper selection, calibration and tuning in order to maximize production rates, minimize maintenance and optimize energy use and consumption.

Realizing the operational ideal for radiant-tube applications requires knowing the fundamentals, the ability to recognize common issues, and taking advantage of different methods and available technologies. This article will explore techniques for making the most of your radiant-tube heating applications.

Reviewing the Fundamentals of Radiant Tubes

First, understanding the common types of radiant tubes is critical to knowing how to operate them properly.

Radiant tubes can have many shapes, but for the currently installed industrial base, “W” and “U” tube systems are the most common and will be the primary focus here. A practical starting point to understanding their functionality is to review the tube temperature distribution of a W-type radiant tube (Fig. 1), where a burner is located on one end of the tube and an exhaust system on the other (along with an optional energy recuperator (Fig. 2) – more on that later).

In an ideal state, a radiant tube generates perfectly uniform temperature. This uniformity would result in the optimum use of the tube to transfer heat to the process while respecting the maximum-use temperature of the radiant-tube material. In common practice, however, this isn’t the case for a variety of reasons.

Resulting from the combustion and heat-transfer processes, physics dictates that the tube temperature will vary along its length. The temperature profile is characterized by an increase in temperature from the

Fig. 1. Illustration of a common “W”-shaped radiant tube demonstrates the issue of temperature non-uniformity in a typical application; heat increases near the burner tip but dissipates further along the tube.

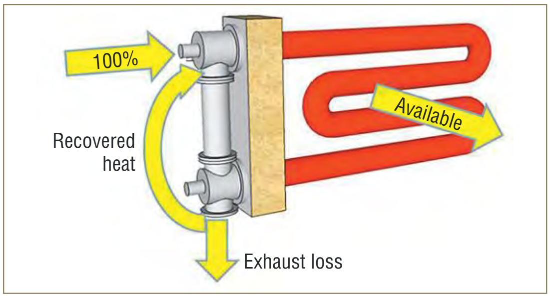


Fig. 2. Energy flows in a typical recuperative radiant tube are shown, indicating the energy input, energy transfer to the load, energy recovered by the recuperator and energy lost from the exhaust.

region near the burner tip to a maximum temperature that is typically located in the firing leg or at the first return bend in U and W tubes. If the tube is long enough, the temperature will decay along the tube's length and is at its minimum at the exhaust end of the tube.

Tube shape, diameter, length, location in the furnace, firing rate and tuning all have an impact on the temperature distribution and fuel efficiency, as does burner type and energy-recovery method. Understanding the influence of these parameters and optimizing their application and use result in optimized operation of the radiant-tube-heated furnace.

Obtaining Better Production, Longevity and Efficiency Through Tuning

Improvements in temperature uniformity can double or triple the service life of a conventional tube of the same material, and that can have a major impact on your operation. So why accept the status quo?

One way to ensure the best-possible performance and longevity of radiant tubes is through diligence in tuning (Fig. 3). Just like any regular maintenance task in a manufacturing environment, tuning helps reduce breakdowns, can improve your production rate and can ensure you are not losing dollars due to inefficiency. In an average radiant-tube furnace, a poorly tuned system using up higher rates of fuel and more regularly requiring failed-tube replacement can cost an organization hundreds of thousands of dollars per year.

When is it time to tune? Some common indicators can include:

- A drop in your rate of production
- An increase in furnace energy consumption
- Increased failures of your radiant tubes
- "It's been a while…"

Of course, there are a wide variety of factors that can limit the rate of production on a typical heat-treating furnace. But in many applications, production rate is determined primarily by the rate at which heat can be delivered to the furnace, and that is determined by your radiant tubes.

There are a couple of ways that regular tuning can impact your production rate. First, your available heat can be dramatically reduced when your tubes are operating at a less-than-optimized fuel-to-air ratio. Available heat is defined as the percentage of the fuel energy that is available to the process – the total energy input to the tube minus the exhaust losses.

Fig. 3. Changes in available heat dependent upon varying levels of oxygen and excess air, highlighting the importance of proper tuning.

Oxygen percentage dry	Excess air percentage	Available heat* percentage HHV
1.0	5	63.0
2.1	10	61.9
3.8	20	59.7
5.2	30	57.8

When comparing systems, it is important to reference the available heat to a standard. For most applications in North America, the available heat is commonly referenced to the fuel's higher heating value, whereas Europe and much of the rest of the world references available heat to the lower heating value.

Take a look at the example table, which uses a 1750˚F tube exhaust with 725˚F combustion air preheat. As oxygen and excess air rise, available heat output to your furnace drops. Consider the impact on production if you're running at 63% available heat versus 57%. It can be significant, wasting fuel not to mention potential production losses for heat-limited products.

It's a case of "little things mean a lot" with tuning. To understand the magnitude of fuel required to heat the furnace, a simple equation can be utilized:

$$\text{Gross input} = \frac{\text{Net heat required}}{\text{Available heat}}$$

or by division

(Expressed as a percentage)

$$\frac{\text{Gross input 2}}{\text{Gross input 1}} = \left(\frac{\text{Available heat 1}}{\text{Available heat 2}} - 1\right) \times 100$$

Consider the implications, from Fig. 3, of an increase in oxygen from 2.1% to 3.8%. The difference in fuel consumption is (61.9/59.7-1) x 100 = 3.6% extra fuel required for the same heat delivered to the furnace. It is not uncommon to find radiant tubes currently operating with much higher excess-air rates.

It's not just production and fuel consumption. Tuning can have a big impact on the life of your tubes. Regular tuning can help you avoid the common-but-inadvisable practice of operating tubes above the maximum material temperature, as described earlier.

One common practice is not reducing the radiant-tube input in the higher-temperature zones, such as within the last heating and soaking zones of continuous-processing furnaces. As the product temperature (or receiver) increases with the same burner input, the tube temperature rises. Figure 4 shows how neglecting input by zone will result in a portion of the tube operating over the material temperature limit. Understanding this reality will allow tailoring the input to the furnace demand. Most burner and furnace suppliers should be able to provide analysis and support to optimize the input profile to your furnace and reduce tube maintenance issues.

It's also important to keep your eyes on the furnace wall when it comes to

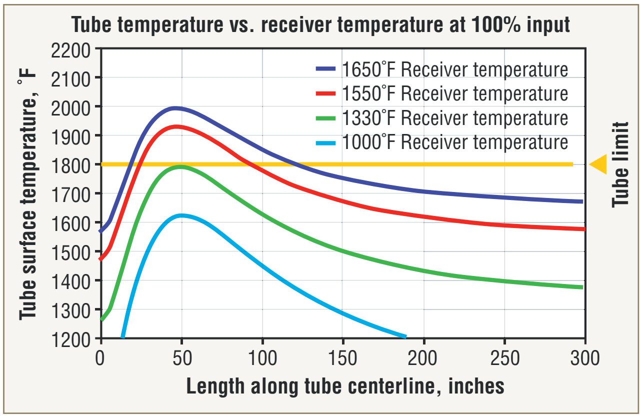


Fig. 4. Operating radiant tubes at 100% input can lead to portions of the tube operating beyond the material temperature limit as the heated product gets hotter.

Fig. 5. A real-world radiant-tube application. One can visually notice areas in the tube glowing brighter than others, indicating temperature non-uniformity.

ideal temperatures. In vertical furnaces, such as for steel strip annealing, there are some tubes that have product on both sides of the tubes and others that have a furnace wall on one side and product on the other. The side of the tube facing the wall will receive re-radiation from the wall, resulting in a higher tube temperature. When analyzed, the fuel input to these tubes should be reduced to 60-70% of the neighboring tubes to maintain a similar tube temperature and prevent overheating.

As a final consideration, care should be exercised with turndown on zones with a zone ratio control system. Maintaining even flow distribution to many burners becomes more challenging as the input to the zone is reduced since the pressure is dropping with the square of the input reduction. Very quickly there is not sufficient pressure to evenly distribute the flow, and the ratio control on each tube suffers as a result. This becomes increasingly complicated if energy recuperation is employed. On/Off firing is often employed as a workaround to maintain distribution at turndown on these systems. However, this should only be

Advanced Radiant-Tube Products from Fives North American Combustion

Fig. 6. Fives North American 4723LNx low-emissions radiant-tube burner

Fig. 7. Fives North American 8480-series high-efficiency radiant-tube recuperator

Fig. 8. Fives North American TBRT III regenerative radiant-tube burner

Fives North American Combustion offers a range of radiant-tube products spanning several product classifications.

The 4723 family of ambient and preheated air burners has spanned decades of service across most radiant-tube application markets. External flame-length adjustments allow tailoring of the flame to the radiant tube, whatever the geometry. In recent years, passive-progressive flue-gas recirculation has been incorporated into the 4723LNx (Fig. 6), an easy solution to lower emissions and improve radiant-tube uniformity.

The 8480-series (Fig. 7) plug-in recuperator perfectly complements the 4723-series burner family. This robust design incorporating high-efficiency, high-grade stainless cast heat-transfer sections has proven longevity while achieving enhanced heat recovery, saving energy while simultaneously eliminating costly repairs of existing equipment.

Depending on requirements, the company's TBRT III (Fig. 8) compact TwinBed® regenerative radiant-tube burner offers increased production, significantly reduced fuel consumption and unequaled radiant-tube life, benefits realized by the users of over 3,000 current and earlier-generation TBRT burners. This high-efficiency bed typically yields energy savings of up to 60%.

Other radiant-tube burner products, air- and fuel-control systems and standard and custom combustion controls round out a full equipment offering for radiant-tube applications.

exercised in conjunction with energy recovery since operating tubes at maximum capacity eliminates the tube efficiency gains as the input is reduced by turning the system down.

There are many other potential interactions with radiant tubes that could be mentioned, but they are beyond the scope of this piece. In order to better understand your process, get in touch with your combustion-systems expert.

So, how often should you be tuning? There isn't a one-size-fits-all answer. It can depend on available manpower, your furnace's ratio control system, type and resolution, and other reasons. But you should be tuning once per year at an absolute minimum. Better yet, do it twice per year – even if you aren't noticing any immediate issues.

A simplified tuning process might look like the following:

Step 1: Set your maximum fuel rate to the burner according to design conditions.

Step 2: Adjust combustion airflow rates by oxygen concentration. Typically, this will range between 2-4%. Set at hot if there is no air-temperature compensation.

Step 3: If you're working with a modulating system, reduce it to the minimum setting. Be sure to watch the minimum pressure to your tubes for distribution. Also, try to set limits according to your process requirements.

Step 4: Adjust your system flow/pressure to deliver target oxygen at turndown. Typically, this will range from 4-6% to maintain even distribution. Lower is better if your ratio control system is up to the task.

Improving Performance Through Technology

Beyond tuning best practices, any heat-treating application can provide additional improvements through the application of newer technologies and combustion styles.

One of the easiest improvements to implement (as well as to economically justify) is the addition of a plug-in recuperator in the exhaust leg. When applied with burners utilizing flue-gas recirculation, both efficiency improvements and tube temperature profile improvements are achievable.

Perhaps the most effective technologies are compact regenerative burners, which can be installed directly onto existing single-pass "U" and "W" tubes. In this system, one burner will fire into the radiant tube while the companion burner at the other end operates in exhaust mode, collecting energy in a regenerative heat-storage bed.

The firing/exhaust mode of each burner is reversed at regular intervals, thereby recovering energy previously stored in the exhaust cycle and delivering it as preheated combustion air to the firing burner of the radiant tube. Regenerative systems typically deliver available heat around 85%, but the greatest benefit is tube temperature uniformity, potentially increasing production rates and helping promote the longevity of your entire system.

Another advanced technology for existing straight tubes is a variant of the classical single-ended recuperative radiant tube. With this system, a burner and center tube are installed into one end of an existing (or new) straight-through radiant tube, with the other end capped. A high-efficiency recuperative burner initiates combustion in the annulus between the inner tube and the radiant tube to transfer energy directly to the outer tube, which radiates into the furnace. This method, combined with integral flue-gas recirculation, provides enhanced temperature uniformity and enables greater average heat input.

If you're looking to make a more significant investment, another combustion style involves complete replacement of the single-pass tubes with recirculating radiant tubes, such as "P" or double "P" forms. These replacement tubes utilize high-velocity burners to recirculate high volumes of spent combustion products through the tube, helping to dilute the combustion temperature and increase the temperature uniformity.

No matter your system, there are a number of best practices that should be followed to maximize your efficiency, improve your furnace production and avoid costly breakdowns and downtime.

For more information: Contact Dennis Quinn, burner and blower products engineering manager, Fives North American Combustion, Inc., 4455 E 71st St, Cleveland, OH 44105; tel: 216-271-6000; e-mail: dennis.quinn@fivesgroup.com; web: combustion.fivesgroup.com/.

Combustion Technologies Improve Melting-Furnace Productivity

Fig. 7. Roof-mounted Transient Heating burner directing heat downward and toward the melt bath

Shailesh Gangoli, Anup Sane, Xiaoyi He, Kyle Niemkiewicz, Bruce Kenworthy and Russell Hewertson – Air Products; Allentown, Pa.
Jerry Evans and Ben Haiflich – SDI La Farga, LLC; New Haven, Ind.

New combustion technologies offer metals producers the ability to adjust the energy distribution profile and customize heat release to the requirements of a given melting operation. This article discusses how the unique capabilities of two new burners helped SDI La Farga increase productivity, decrease specific fuel consumption and significantly reduce burner maintenance time in its secondary copper-melting furnace.

SDI La Farga, LLC (SDILF) is a recycling operation that refines all types of processed copper to produce Cu-FRHC (fire-refined, high-conductivity) products. In 2014, SDILF had challenges with non-uniform heat distribution in their melting furnace, which led to uneven wear of the furnace lining and limited productivity. Their burners were also susceptible to frequent and prolonged maintenance delays from molten metal splashing and wear due to the corrosive atmosphere in the furnace.

SDILF's desire to address these challenges and achieve aggressive productivity targets led to the evaluation and implementation of unique combustion technologies capable of adapting to the diverse needs of the operation.

Forming a Baseline Using CFD Modeling

Figure 1 shows a schematic (top view) of the original configuration of the SDILF melting furnace. In the baseline operation, nearly 75% of the total energy input was delivered by two main burners (MB1 and MB2, located on the south side). The remaining energy (25%) was supplied using two auxiliary burners (A1 and A2, located on the east and west sides). The main burners used natural gas as fuel and oxygen-enriched air as the oxidizer, while the auxiliary burners used natural gas as fuel and pure oxygen as the oxidizer. All burners were aimed at the copper scrap (referred to as charge) located at the center of the furnace and introduced from the roof.

Given the single-pass flue-gas configuration (from south to north) of the furnace, it seemed logical to concentrate more energy on the south side of the furnace through the main burners. However, copper scrap is piled up at the center of the furnace during melting, which led to the main flames reflecting onto the refractory walls. The south side of the furnace was overheated, while the north side witnessed relatively colder zones, which slowed down slagging operations.

The reflection of the flames and overheated refractory required SDILF to reduce both the firing rate and oxygen-enrichment levels to minimize refractory wear – a change that lowered the production significantly below design capacity. At lower firing rates, the problem of metal splashing and wear on the burners became more serious.

Researchers at Air Products conducted computational fluid dynamics (CFD) simulations to gain an understanding of flue-gas patterns and energy distribution during the melting process. The temperature distribution calculated by the CFD modeling is shown in Figure 2. The hot spots seen on the east and west sides of the furnace matched initial feedback from SDILF about high-erosion zones in the furnace.

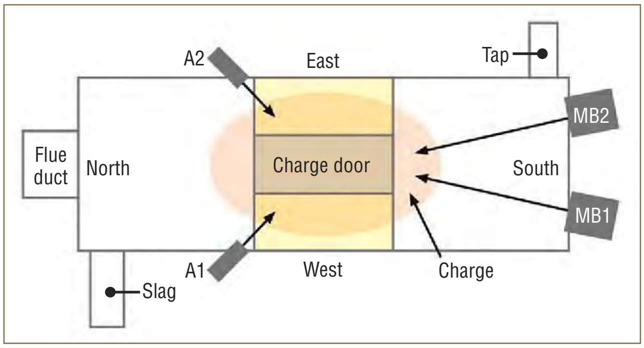


Fig. 1. Top view of the original configuration of the SDILF melting furnace

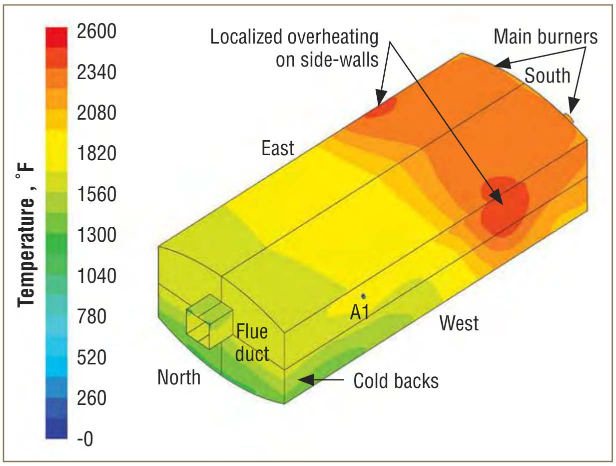


Fig. 2. CFD calculation of baseline SDILF operation (walls)

Fig. 3. Range of oxygen-enrichment operation of TEB technology

The modeling results were consistent with recurring maintenance needs experienced during operation, as well as refractory wear patterns observed during furnace outages. The flame impingement and uneven heat distribution caused aggressive refractory wear, especially on the south side of the furnace. The agreement between CFD results and observations during operation and outage gave SDILF confidence that implementing Air Products' technology could increase furnace performance.

Implementing Unique Combustion Technologies

Based on the understanding derived from CFD modeling, it was determined that the operation needed a combustion technology that provided a high degree of flexibility to adapt to the varying operating conditions within the furnace. The combustion technology needed to be capable of:

- Adjusting heat distribution to minimize overheating and limit flame reflection onto the walls and roof of the south side of the furnace
- Providing high gas velocities to minimize nozzle clogging from metal splashes
- Allowing ease of maintenance in the case of metal splashing causing blockage
- Adjusting oxygen enrichment and flame shape to allow optimal performance with both charge-pile and flat-bath conditions

Air Products' patented Tunable Enrichment Burner (TEB), which uses a combination of natural gas, air and oxygen, was selected because it addressed these requirements. The ability to adjust the oxygen enrichment to affect the flame shape is shown in Figure 3. Figure 4 shows the ability of the burner to modulate the heat-distribution profile, allowing for optimal operation both while the charge pile is being melted and at flat-bath conditions.

The burner design also minimizes direct interaction of oxygen with the melt, ensuring lower yield losses due to oxidation. The TEB is considerably smaller and easier to remove from the furnace in comparison to SDILF's original burner, which allowed them to reduce burner maintenance downtime by 80% when splashing necessitated it. Additionally, the TEB's

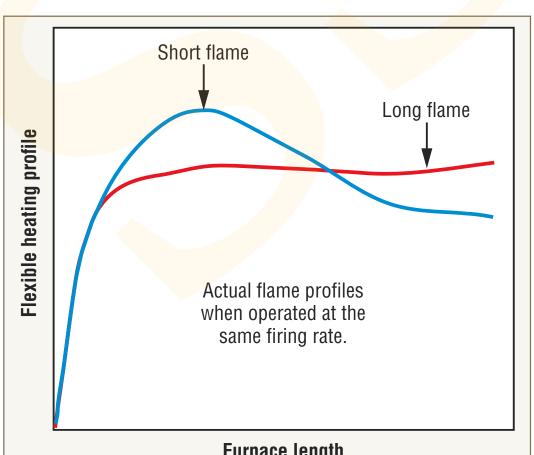


Fig. 4. Flexible heating profile of TEB technology

Fig. 5. TEB firing at Air Products' Combustion Lab in Allentown, Pa.

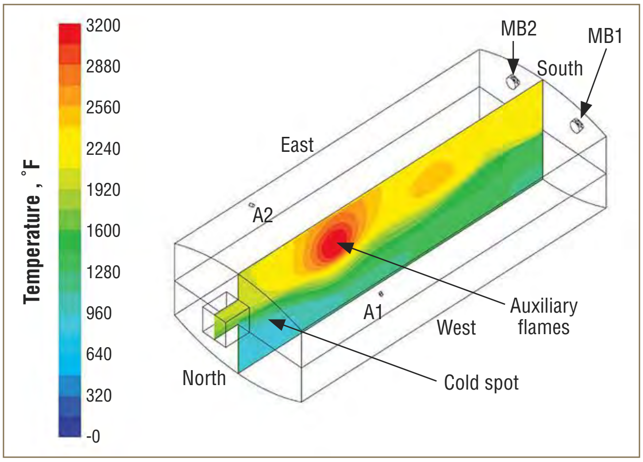


Fig. 6. CFD calculation of flue-gas temperatures inside the furnace during baseline SDILF operation

higher gas velocities significantly reduced the frequency of clogging due to metal splashing.

Figure 5 shows the momentum and well-defined structure of the TEB flame. Following deployment, the TEB delivered a 10% increase in overall productivity and a 15% reduction in specific fuel consumption.

SDILF originally considered a change of technology to improve the downtime associated with burner and refractory maintenance. The TEB accomplished both objectives. Burner maintenance, which was originally difficult and time consuming, turned into a 15-minute job that simply involved pulling the burner, clearing any obstruction and putting the burner back into operation.

Both SDILF and Air Products worked closely on burner modifications to create a design that facilitated easy removal and installation. The two teams worked well together to address each hurdle that arose in a timely manner. The reduction of burner maintenance time, reduced refractory wear and improved production were the key successes achieved by the TEB.

During the evolution of the TEB and installation designs, Air Products and SDILF discussed other concerns that the SDILF team had with the original auxiliary burners. These issues were related to inefficient energy utilization and high burner maintenance. With the measured success of the TEB, SDILF personnel were confident there was opportunity for further improvement.

Despite the flue being on the north side of the furnace, the baseline operation had constant problems with slag freezing and overheating of the roof of the furnace. While the orientation of auxiliary burners was effective at melting the charge pile, it did not allow SDILF to direct heat toward the north side of the furnace. The auxiliary burners also had maintenance and safety challenges because of the need for water cooling and frequent clogging from metal splashing due to their proximity to the melt bath.

The CFD modeling showed the interaction of the auxiliary flames with each other, the scrap pile and the main flames, which created localized stagnation zones (shown by the red spot in Figure 6). This drove heat to the roof and away from the melt bath on the north side of the furnace.

To address these challenges, a burner was needed that would be capable of:

- Operating without water cooling
- Being mounted away from the melt bath to reduce maintenance needs due to splashing, without compromising the performance
- Directing energy to the pile and toward the north side of the furnace
- Eliminating the stagnation zone by directing heat toward the bath and away from the furnace superstructure

Air Products selected the patented Transient Heating Burner (THB) to replace SDILF's two auxiliary burners. The THB is a roof-mounted, non-water-cooled, multi-flame oxy-fuel burner that can direct energy to different parts of the furnace as required (Fig. 7 on p. 33).

The burner was programmed to operate as shown in Figure 8, where two flames are directed toward the centrally located scrap pile (mode A), and two flames are directed toward the north side (mode B), but always downward and toward the melt bath (Fig. 7). During melting, the burner was operated sequentially with more time in mode A compared to mode B, such that 75% of the total energy was directed to the scrap pile and the rest was directed to the north side.

The TEB and THB technologies firing in tandem, combined with operational improvements made by SDILF, resulted in a significant increase in the output from the operation, with 15% higher productivity and 25% lower specific fuel consumption compared to 2014 baseline operations.

The original intent of the THB phase of the project was to replace the high-maintenance auxiliary burners (A1 and A2 in Figure 1). The THB dramatically reduced the time and effort associated with burner maintenance. Once the THB was installed, SDILF also noticed improved performance of the furnace from a melt-efficiency and slagging perspective. The auxiliary burners caused issues with furnace refractory because of their orientation and location. Replacing them with the THB alleviated this problem by removing those issues in the operation.

Additionally, Air Products collected and analyzed relevant process data during both trials by installing supplementary data-collection capability to augment what SDILF already had in place. The data analysis suggested the

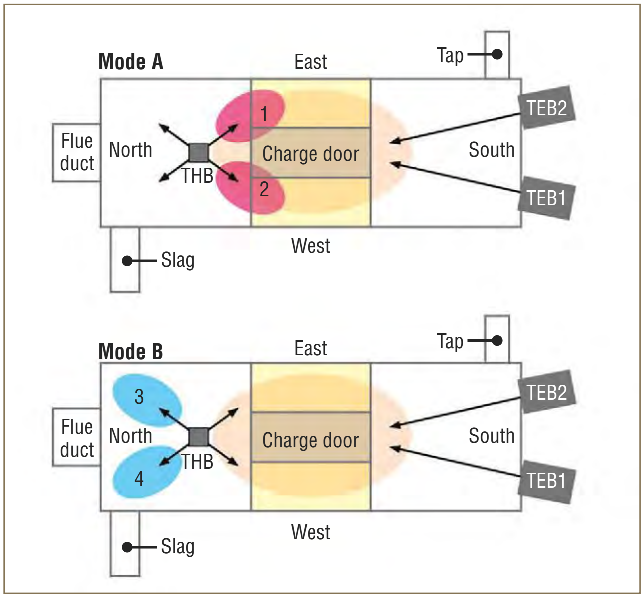


Fig. 8. Schematic of TEB and THB in operation at SDILF

use of less-dense material, which influenced feedstock-material charging practices. The data also advised SDILF on how to run the burners during the changes in the feedstock material.

The information revealed by the data analysis and CFD modeling convinced SDILF to place additional sensors to optimize performance. This provided added benefit because it helped improve all aspects of the furnace operation.

Summary

SDILF had many limitations in the early years of their furnace, including inefficient use of gas, downtime of the furnace due to refractory wear and long maintenance delays due to inadequate access and ability to maintain burners.

Tunable Enrichment Burner and Transient Heating Burner technologies were proposed for implementation in SDILF's secondary copper melting furnace. Though the burners were replaced in kind, the unique capabilities of TEB and THB technologies were leveraged to address challenges and drive operational improvements.

Specifically, productivity increased by 15%, specific fuel consumption decreased by 25%, burner maintenance time decreased by 80% and furnace relines decreased by 20%. The implementation of TEB and THB technologies have made a significantly positive impact on SDILF's mill operations.

Despite the unique features of the SDILF furnace, the challenges it presented are relevant to other more-conventional reverberatory furnace operations. The TEB provided the flexibility to tune the flame and oxygen enrichment for charge-pile to flat-bath scenarios. In addition, its high gas velocities helped to minimize nozzle clogging from metal splashes, and the ease of maintenance ensured minimum downtime.

The THB also provided heat in the furnace where it was needed, eliminating cold zones. Each of these technologies enabled optimization of the overall process, proving the importance of choosing the right burner for the right application.

For more information: Contact Air Products, 7201 Hamilton Boulevard, Allentown, PA 18195; tel: 800-654-4567; web: www.airproducts.com/metals.

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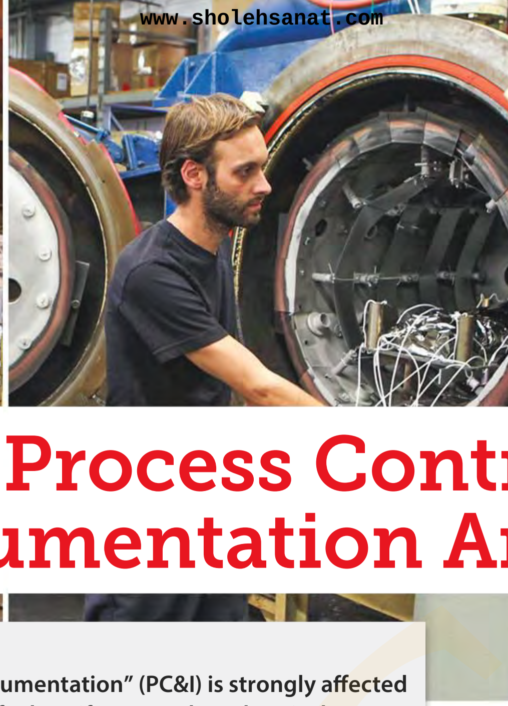


Top-8 Process Control and Instrumentation Articles

Reed Miller – Editor

The topic of "Process Control and Instrumentation" (PC&I) is strongly affected by technology changes. Sometimes it feels as if you need an electrical-engineering degree to wade through it all. Changes in specifications such as AMS 2750 also create uncertainty as to what is required and what is simply a nice-to-do. Check out the reader-chosen articles in this list to find some help.

Topics such as AMS 2750 always generate lots of reader interest. So, it's not surprising there are several AMS 2750-related articles on our favorites list. This, along with keeping up with new technologies, is what readers seek. Let's take a look at the current favorites from first moving to number eight.

The Latest on AMS 2750 Rev. E

Illustrating the industry's need for AMS 2750 information, an article written in January 2014 still leads our PC&I list. The article discussed the top-10 Nadcap nonconformances at that time, eight of which involved pyrometry. Apparently, the industry's attempt at clarifying the requirements for aerospace primes has created new auditor fodder. Check this article out to see how you can avoid some of the traps that have ensnared others. Find it using this easy link *www.industrialheating.com/AMS2750*.

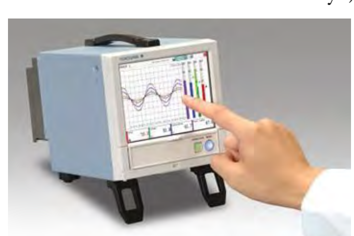
Troubleshooting Thermocouple Failures in High-Temperature Applications

Thermocouple (T/C) failures can be a huge problem for manufacturers, and this relates to some AMS 2750 requirements. How do you know when it failed, and how much product might be affected by the failure? Find out which T/C materials are best for your application and how design can affect longevity of the probe.

System wiring and electronics play a role in failures. It's important to understand probe life in your application because you may choose to replace a T/C early rather than risk failure and its associated costs. Finding the true root cause for a thermocouple failure and eliminating it is important. It can lead to cost savings and reduce system downtime. Read more at *www.industrialheating.com/TCfail*.

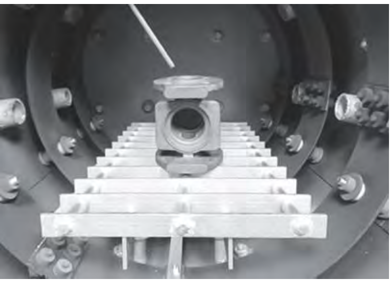
New Technologies in Instrumentation

Are we using the instrumentation technology that will save us the most time and money and make it easier to meet requirements such as AMS 2750? This type of question causes readers to seek out information. As a result, this article from 2013 continues to be a reader-favorite. It discusses topics such as wireless technology, touch screens and cybersecurity. Part of the article's conclusion says, "When deciding on new instrumentation, it is critical that newer technologies are considered because they may become mainstream in the future." You can find this article at *www.industrialheating.com/newtech*.



Dew Point vs. Oxygen Content in Vacuum Processing

Accurate measurement of any heat-treating atmosphere is critically important for the quality and process yield of heat-treated components. Dew-point analysis has been a traditional measure because moisture parameters can impact carbon potential. However, a better, more-robust instrument was



needed to analyze endothermic or exothermic atmospheres. Oxygen probes or three-gas analyzers are now the industry's preferred analytical instruments to determine carbon potential.

The article's conclusion states, "When vacuum heat treating metal alloys that oxidize readily in the presence of small concentrations of water vapor or oxygen, data suggests that dew point should not be the stand-alone gas purity analyzer. Dew point only measures the water vapor, not oxygen in the gas line. Including an oxygen analyzer as an additional quality tool provides the heat-treat shop greater assurance that the process gas entering the furnace is of the highest purity and meets the specifications of the customer." Find out what's drawing readers by reading this article online at ***www.industrialheating.com/DPvO2.***

AMS 2750E: What does it mean for your temperature sensors?

Another AMS 2750 article from May 2013 remains in the top-8. One of the challenges with AMS 2750 throughout the years is that changes are typically not highlighted from one rev to the other because they are too numerous. The latest revision is no different. SAE includes numerous technical changes to resolve issues determined in usage. However, one of the challenges as specifically noted in this latest revision is that the "Changes are extensive and not marked." As a result, users who are subject to compliance with AMS 2750E must take the time to review the most recent revision thoroughly.

This article provided and continues to provide assistance by highlighting some of the more significant changes in AMS 2750E as they relate to temperature sensors. You can benefit from this work at ***www.industrialheating.com/2750revE.*** Another article from 2013 provides additional assistance at this link: ***www.industrialheating.com/2750E.***

Are You Measuring the Correct Temperature?

Many factors, including pyrometer choice, emissivity and temperature calibration, influence accurate temperature measurement from a pyrometer. This May 2016 article looks at the common influences on inaccurate temperature measurement.

The following questions are answered: What wavelength of detector is used for a given temperature range? What detector wavelength should be used for an application? Why calibrate pyrometers? Why do pyrometers drift? How often should

pyrometers be calibrated? Why calibrate to a traceable national standard? To learn these answers and more, read this article at ***www.industrialheating.com/Tcorrect.***

Uniformity Surveys: Make Your Data an Investment in Profitability

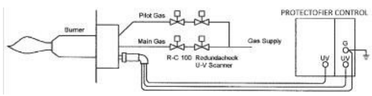
As some of our other PC&I favorites discuss, oxygen probes, PLC and microprocessor controls, digital charts and even database management have seen technology improvements. One area that has not experienced this is the temperature uniformity survey (TUS). This periodic test determines the ability of the furnace to be able to process work for CQI-9, Nadcap and other quality-system requirements.

As already discussed, meeting the requirements of AMS 2750 has become the bane of quality departments and the focus of auditors for decades. While data loggers have replaced the tedious task of recording individual temperature readings over time, they do not fit into the advanced world of Big Data. Real-time data collection of part dimensions, tool edge wear and even Rockwell hardness is quickly moving ahead, but the TUS is lagging behind.

Check out this November 2016 article to learn about the Virtual Visual Survey and why it may transform TUSs and make them compatible with the industrial internet of things (IIoT). You can link to the article here: ***www.industrialheating.com/VVS.***

Automated Control of Heat-Treating Processes: Technology, Data Acquisition, Maintenance and Productivity Gains

Furnaces are built and tuned for a variety of heat-treating processes, including: carburizing, carbonitriding, ferritic nitrocarburizing (FNC), annealing, tempering, nitriding and vacuum heat treating (among others). These processes require different types of gas generation; soak and quench times; and atmosphere and temperature control. In spite of the different



requirements, control of these processes can be divided into two general categories: traditional and automated.

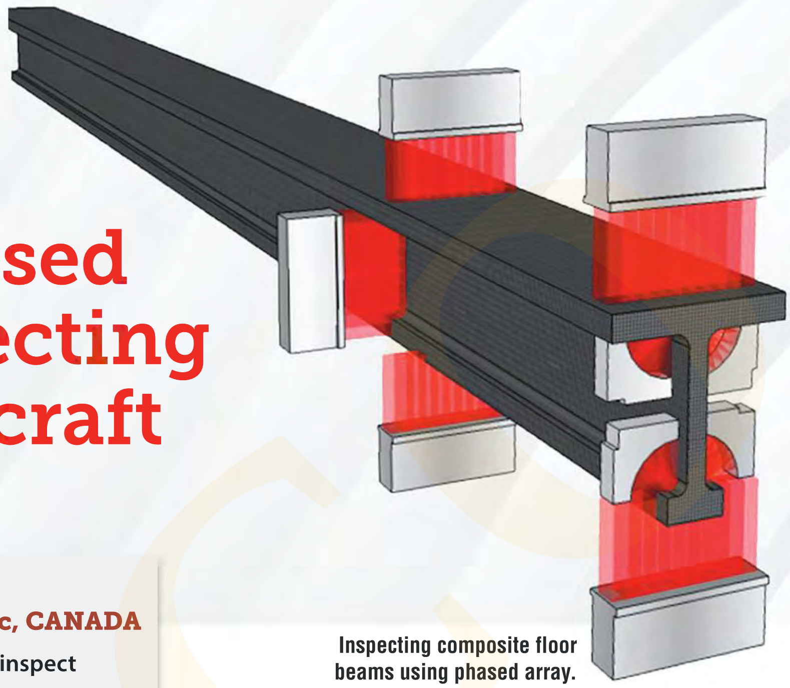
This August 2014 article discusses automated heat-treat processes, breaking it down into technology and productivity gains, data acquisition and benefits to maintenance. Should you automate your traditional control? The authors believe you should, and you can learn why by reading this article at *www.industrialheating.com/htcontrol.*

There are some very helpful articles in this selection. Especially if you missed them the first time, you owe it to yourself to have another look. If another PC&I topic is of interest, simply use the search function on our website to read more about it.

INDUSTRIAL HEATING

Use this QR-Code to read more on the topic of Process Control & Instrumentation or use this URL: https://bit.ly/2Finj0M

Adaptive Ultrasonic Phased Array for Inspecting Composite Aircraft Components



Inspecting composite floor beams using phased array.

André Lamarre and Etienne Grondin – Olympus NDT Canada; Quebec City, Quebec, CANADA

Ultrasonic phased-array technology is widely used to inspect composite components in aircraft.

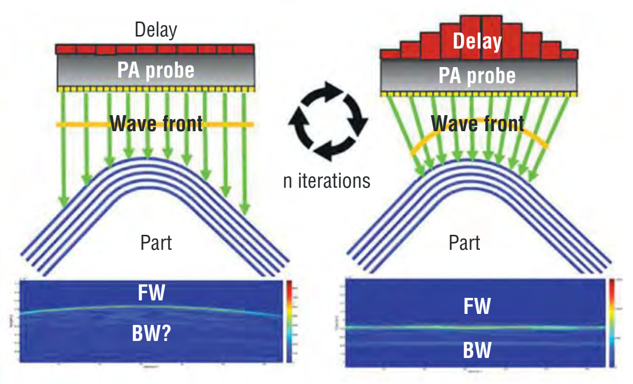
Composite components are used extensively in the design of new-generation aircraft. During manufacturing, the aircraft's structural components must be inspected with ultrasonic technology to ensure their integrity. However, this inspection can be challenging. Some components have very complex shapes where the surfaces are constantly changing. In addition, some manufacturing processes have loose production tolerances that result in components with slightly different shapes than the original design. In these varying circumstances, complex automated scanners are commonly required for ultrasonic inspections to maintain an ultrasonic beam normal to the component's changing surface. However, even then there is no guarantee that the ultrasonic beams will remain perpendicular to the part's surface.

The use of an adaptive ultrasonic method with phased array is a solution to inspecting components with complex shapes. This setup locally applies a correction to the ultrasonic beams, helping ensure the beams propagate normal to the surface at each inspection position.

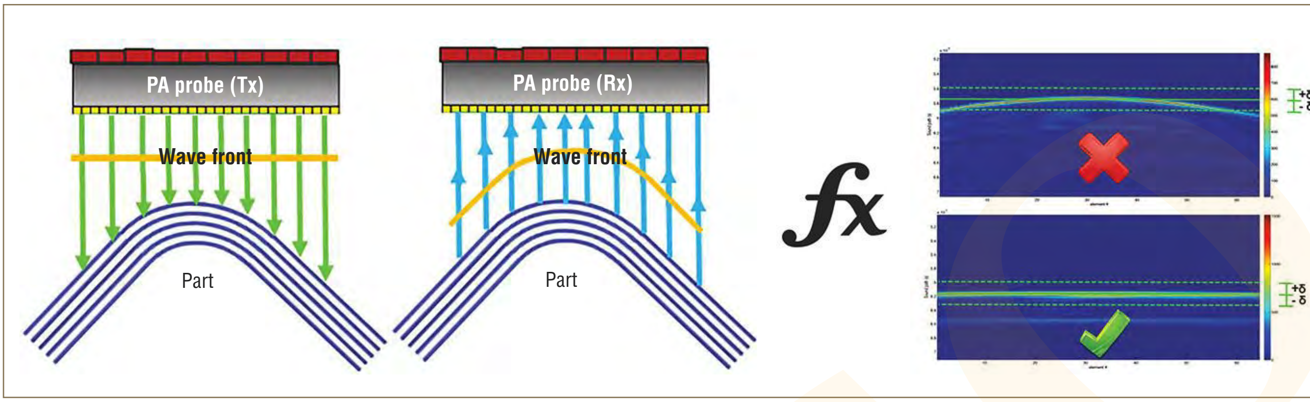
Ultrasonic Phased Array

Ultrasonic phased-array technology is widely used to inspect composite components in aircraft. The main advantage of the phased-array technique is the use of a large array where the ultrasonic beam is generated by a group of elements using time delays (focal laws). The beam is then multiplexed over the length of the array. This electronic scan enables coverage of a large area while maintaining high resolution. In addition, modern electronics are scalable and can drive multiple phased-array probes in parallel for increased productivity. Because of these benefits, phased-array technology is widely used by most of the composite component manufacturers worldwide.

The process of generating ultrasonic beams using predefined focal laws is deterministic. This means that the time delays are calculated using a known geometry, a measured distance between the probe and the component, the curvature of the component, probe orientation, etc. During the inspection, the beams are generated based on the model input during setup and cannot adapt to changes in any of these parameters. For most flat or nearly flat components, the effect is negligible. However, this limitation is important when the component being inspected has a severe curvature or irregular tolerances. In



The process of adaptive ultrasound. On the left, the front wall of the component appears as a curve; the back wall is not detected, showing that the part was not properly inspected. On the right, after multiple iterations, the beams are corrected in such a way that the front wall is a line and the back wall is properly detected. As a result, all indications located in the component can be properly detected.



The three steps of the adaptive process

these instances, an adaptive ultrasonic phased-array solution is required.

Adaptive Ultrasonic Phased Array

Adaptive ultrasound is an acquisition strategy that has gained popularity in the aviation industry because it facilitates ultrasonic inspection of the increasingly complex parts manufactured for new aircraft.

Adaptive ultrasound enables the transmission of a wave front parallel to the surface of a part with complex geometry. The adaptive ultrasound process can be divided into three steps. First, a plane wave is transmitted using all available elements on the phased-array probe, and the elementary A-scans are recorded.

The second step is an iterative process that adapts the front wave to the geometry of the part. This process adjusts the delays for each transmission event until a convergence criterion, based on the time of flight from each element, is reached. Once the convergence criterion is reached, the third step is to generate summary A-scans, just like in a standard phased-array inspection, using the elementary A-scan received from the last transmission event.

L-shape component inspection

Benefits of Adaptive Phased Array

In the aviation industry, adaptive ultrasound helps address the following inspection challenges:

- Components with varying radiuses and twists
- A manufacturing process leading to components with non-uniform radiuses (weighted radius)
- Misalignment of the phased-array transducer relative to the inspected part

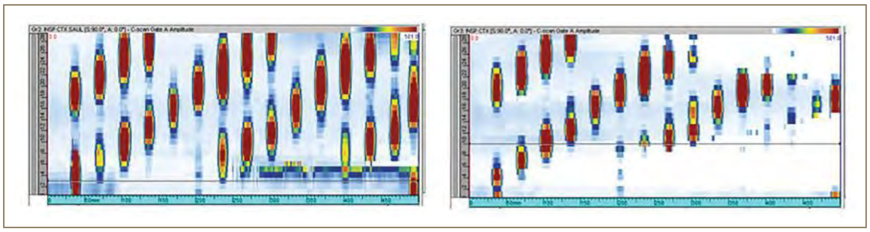
In this section, we illustrate the benefits of adaptive phased array using three examples. The first two examples were performed on an L-shaped component. The radius of the component was inspected using a 5 MHz curved phased-array probe with a local immersion-probe holder. In these two examples, the radius of the component varied from 0.2 inch to 0.5 inch over its length, but the first component has a uniform radius and the other has a non-uniform (weighted) radius. Delaminations are embedded in the components at different positions. Scans were performed with and without the adaptive algorithm.

The result shows the C-scan mapping of the components' radiuses. In both cases, all the delaminations are clearly visible with the adaptive algorithm, while the C-scan without the adaptive method has zones containing undetected flaws.

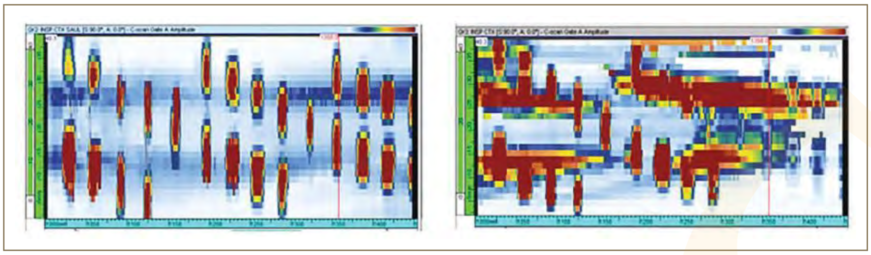
In the third example, a 5 MHz linear-array probe was intentionally misaligned. The test was performed in an immersion tank. We can see the effect of a misaligned phased array probe, while the C-scan obtained using the adaptive method corrected the beams, enabling the components to be properly inspected.

Considerations

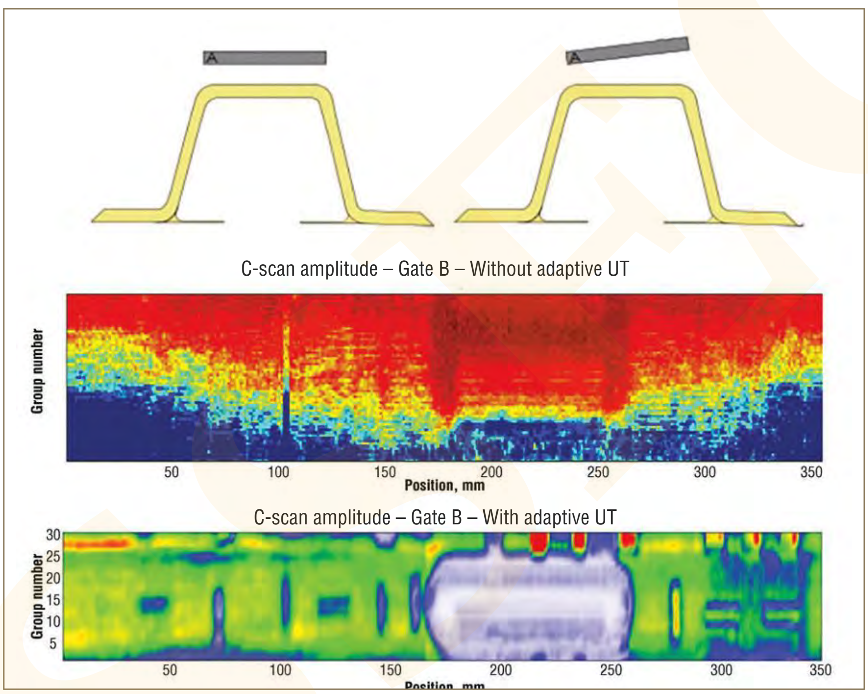
Adaptive ultrasound can be implemented in such a way that it does not impact productivity when compared with conventional phased array. In addition, a live data display is required during the inspection, so the algorithm for adaptive ultrasound has to be directly implemented in the inspection instrument to obtain real-time data visualization.



Inspecting uniform varying radiuses with (left) and without (right) adaptive focusing.



Inspecting non-uniform (weighted) varying radiuses with (left) and without (right) adaptive focusing.



Misalignment with (bottom) and without (center) adaptive focusing.

Conclusion

Adaptive ultrasonic phased array is an excellent method to improve the ultrasonic inspection of composite components with complex shapes. The ability to adapt the ultrasonic beams to the component's actual shape brings more confidence and reliability to the inspection process and reduces the quantity of rescans, improving productivity. Also, compensating for the misalignment of the phased-array probe minimizes the need for extremely precise mechanics.

Used manually or with a high-performance scanner, this method enables users to quickly inspect large surfaces with high resolution because its implementation does not compromise productivity. Adaptive phased array is used successfully for complex aircraft components inspection, and it is becoming common in other industries, including automotive, energy and petrochemical.

For more information: Contact André Lamarre, M.Sc., business development manager – aerospace and power generation industries, Olympus NDT Canada, Quebec City, Quebec; email: andre.lamarre@olympus-ossa.com; web: www.olympus-ims.com. Etienne Grondin is the product line manager – integrated instrumentation.

Energy-Saver Update

This section showcases energy-saving products and technologies from some of this month's advertising companies.

Across International

Induction Heaters

Across International offers a complete line of all solid state energy-saving induction heaters for various purposes. High-frequency induction heaters are good for powder, small parts and surface heating, as well as

ith high efficiency. heaters are good for ace heating mid- cy induction heaters arge-sized parts, requires deep heat penetration. They are also great for large amounts of gold, silver, copper or melting. .across national.com

Ajax TOCCO

There are many design elements in induction heating that need to be considered in order to maximize efficiency. The relationship between the workpiece and the diameter of the coil has a much greater impact on efficiency than any other factor in the system. This is especially true for forging lines, bar lines and pipe-and-tube systems. Ideally, the coil should be closely coupled to the workpiece, providing just enough

air gap to allow for sufficient refractory and space so that the refractory or coil will not be damaged by an errant billet, bar or tube. Sometimes it becomes a trade-off between efficiency and productivity. These are best considered prior to purchasing an induction system during the analysis and vendor-selection phase. Good communication with a vendor like Ajax TOCCO can help you plan for a new system or look at modifications to existing equipment. www.AjaxTocco.com

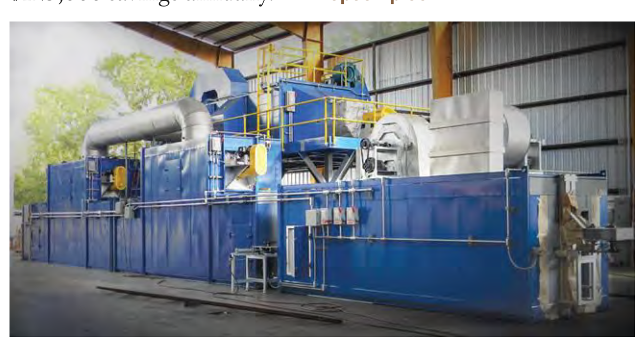
DMP CryoSystems

The CryoFurnace is the first and only cryo processor available with a temperature range of 1200˚F to -300˚F. The CryoTemper (550˚F to -300˚F) continues to set the standard for which all other systems are judged. It remains the most efficient and versatile cryogenic tempering equipment on the market. To maximize energy-efficiency, LED indicator lights, high-efficiency Baldor Motors and variable-frequency drives are standard on all models. The CryoFurnace and CryoTemper maximize temperature efficiency with 6 inches of multilayer insulation. Using liquid nitrogen as a cooling medium keeps maintenance costs low and reduces the need for rust inhibitors and cleaning. Eliminate paper waste with the onboard digital recorder available in the Level II control system.

www.cryosystems.com

EPCON® Industrial Systems

EPCON® Industrial Systems shipped an integrated "thermal de-oiler" system, for cleaning residual oil present in HVAC coils, combined with a thermal oxidizer consisting of primary and secondary heat recovery. The equipment is designed to destroy toxic solvents evaporated during a thermal cleaning process. The Primary HE preheated oven exhaust air in the oxidizer and the Secondary HE supplied hot air to the oven, minimizing overall energy demand. The optimized system reduced energy consumption by 5.5 MMBTU/hr, resulting in $125,000 savings annually. www.epconlp.com



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Quantum Quench™ four-directional gas flow without internal moving parts is a breakthrough in controlled and uniform cooling while controlling distortion. Generally, gas flow direction affects how heat is extracted from the part:

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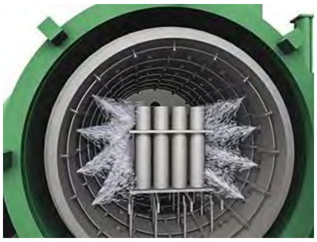
- A side-cooled part will be cooler on the gas admission side

www.gmenterprises.com



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www.IpsenUSA.com/PdMetrics

Lindberg/MPH

The Lindberg/MPH rod overbend electric box furnace provides flexible, efficient performance in a variety of heat-treating applications. The fast heating rate, heavy load capability and reliable operation help you achieve fast turnaround and high productivity. The rod overbend box furnace utilizes energy-efficient components, is simple to operate and is available in a wide range of sizes. Common applications range up to 2000°F (1850°F with fan) with endothermic, exothermic, dissociated ammonia or nitrogen atmospheres.

www.lindbergmph.com

Otto Junker

Energy efficiency and excellent process reliability are key characteristics of Otto Junker's heat-treatment line for wheels. In this line – which features a solution annealing furnace, a quench and an artificial aging furnace – hot flue gas generated in the solution annealing process is injected into the artificial aging furnace for energy-saving purposes. For situations where this heat input is insufficient, process reliability is guaranteed by a so-called booster providing backup heating capacity. The wheels pass through the furnace on a walking-beam conveyor, which offers significant advantages over traditional conveyor concepts. It eliminates the need for product carriers and thus saves the energy needed to heat them up. The walking-beam concept is also capable of handling different wheel sizes while providing highly accurate positioning without relative movements. The equipment is low maintenance, user-friendly and offers high availability.

www.otto-junker.com

Praxair

OPTIFIRE™ burners may improve overall reheat furnace performance while lowering NOx emissions with oxy-fuel

Continued on p.46

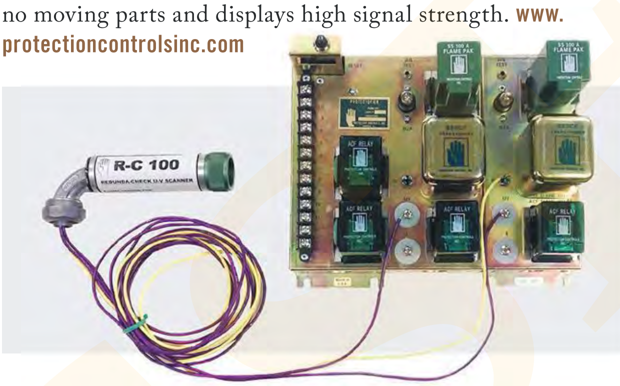
Continued from p.45

combustion. They can also deliver on-demand production increases. The burners use the Dilute Oxygen Combustion (DOC) principle, where fuel and oxygen are injected into the furnace through separate ports. The reactants mix with the hot furnace gases before reacting with each other. This dilution effect helps prevent the high peak temperatures that are responsible for NOx generation. OPTIFIRE burners have been installed on over 500 furnaces, including steel reheat furnaces, forge furnaces, nonferrous furnaces and ladle preheaters. www.praxair.com

Protection Controls Inc.

Combustion Safeguard

R-C 100 provides safety on continuous, 24-hour burner applications for single burner as well as multi-burner applications. The dual/redundant self-check ultraviolet flame sensor and combustion safeguard control may be used only with 6642 Protectofiers, which have a 180-degree phase power supply. The system contains two UV tubes in one ultraviolet sensor to monitor one burner flame. Each UV tube is powered during a different time cycle to eliminate interference between the two UV tubes. It has no moving parts and displays high signal strength. www.protectioncontrolsinc.com



Safe Cronite

Heat-Resistant Alloy Furnace Parts

North American Cronite, a division of Safe Cronite, is a manufacturer and designer of cast and fabricated heat-resistant alloy furnace parts. The company specializes in handling fixtures, cast base trays and baskets, radiant tubes, rolls and corrugated boxes. www.safe-cronite.us

SECO/Vacuum Technologies

CaseMaster Evolution Vacuum Furnace

SECO/Vacuum Technologies' unique CaseMaster Evolution (CMe) multi-chamber vacuum furnace can be equipped for both oil and gas quenching, delivering increased productivity and efficiency versus atmosphere furnaces. It operates with shorter carburizing cycle times. With no CO or CO_2 emissions, very low consumption of processing mediums and no additional energy-consuming equipment such as endothermic generators, the CMe is the perfect furnace to help growing firms transition into vacuum while reducing energy costs at the same time. www.secovacusa.com

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Wisconsin Oven is proud to offer their E-Pack™ Oven upgrade. This optional energy-efficient package, which includes thicker wall panels, high-efficiency motors, a door limit switch and a few other energy-saving items, will reduce operating costs, which saves thousands of dollars! Not only will the E-Pack reduce operating costs, your return on investment will be measured in months, not years. A typical payback for the initial investment is in the 9-15 month range. www.wisoven.com

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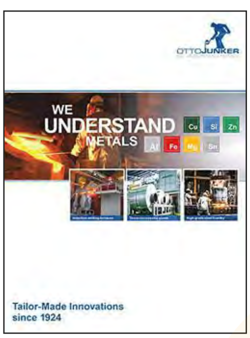

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12" × 32" × 12"	L&L (Retort)	Elec 2000°F
13" × 24" × 12"	Electra Up/Down	Elec 2000°F
17"×14.5"×12"	L&L (New)	Elec 2350°F
18" x 30" x 13"	Hevi-Duty	Elec 1850°F
18" x 36" x 18"	Lindberg (Fan)	Elec 1850°F
20" x 48" x 12"	Hoskins	Elec 2000°F
24" x 48"× 24"	Hevi-Duty	Elec 2350°F
36" × 48"× 36"	CEC (Atmos-N_2)	Elec 2000°F
36" × 72"× 42"	Eisenmann (Car Bottom)	Gas 3100°F
60"×216"×48"	IFSI (Car Bottom)	Gas 2400°F
60"×156"×60"	Lindberg Car Bottom	Gas 1850°F
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126"×420"×72"	Drever "Lift-Off" (2) (Atmos.)	Gas 1450°F

PIT FURNACES

14" Dia × 60"D	Procedyne Fluid Bed	Elec 1850°F
28" Dia x 48"D	L&L Nitrider	Elec 1200°F
72" Dia x 72"D	Flynn+Dreffein (2) (Atmos.)	Elec 1400°F
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48" x 48" x 24"	Surface (2-Bar)	Elec 2400°F
Just Added 48" x 60" x 48"	Abar (HR-66)	Elec 2400°F
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24" × 40' × 18"	Despatch	Elec 500°F
32" × 24' × 12"	OSI Slat Belt	Gas 450°F
36" × 24' × 8"	Surface Cast Belt (Line)	Gas 1750°F
36" × 28' × 22"	Lewco (2)	Elec 350°F
60" × 40' × 14"	GE Roller Hearth (Atmos)	Elec 1650°F
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MISCELLANEOUS

Combustion Air Blowers (All sizes)

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30" × 48"	Surface Charge Car (SE-ER)	

SBS Air/Oil Coolers (4)

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MISCELLANEOUS (continued)

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AFC Pusher Line (Atmos.) Gas 1750°F

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30" x 48"	Surface Roller Table	
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14" × 14" × 14"	Gruenberg	Elec 1200°F
14" × 14" × 14"	Blue-M	Elec 650°F
14" × 14" × 14"	Gruenberg (solvent)	Elec 450°F
15" × 24" × 12"	Sunbeam (N_2)	Elec 1200°F
20" × 18" × 20"	Blue-M	Elec 400°F
20" × 18" × 20"	Despatch	Elec 650°F
20" × 18" × 20"	Blue-M	Elec 650°F
20" × 18" × 20"	Blue-M (2)	Elec 800°F
22" × 18" × 15"	Precision Quincy	Elec 1000°F
24" × 20" × 20"	Blue-M	Elec 1000°F
24" × 24" × 24"	Grieve	Elec 650°F
24" × 24" × 36"	New England	Elec 800°F
24" × 24" × 48"	Blue-M	Elec 600°F
24" × 36" × 24"	Grieve	Elec 500°F
24" × 36" × 24"	Demtec (N_2)	Elec 500°F
24" × 36" × 24"	AFC (N_2)	Elec 1250°F
24" × 36" × 24"	Trent	Elec 1400°F
25" × 20" × 20"	Blue-M	Elec 650°F
24" × 36" × 48"	Gruenberg	Elec 500°F
25" × 20" × 20"	Blue-M (Inert)	Elec 1100°F
26" × 26" × 38"	Grieve (2)	Elec 850°F
30" × 30" × 60"	Gruenberg	Elec 450°F
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30" × 38" × 48"	Gruenberg (Inert) (2)	Elec 450°F
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30" × 48" × 36"	Surface (Atmos)	Elec 1400°F
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48" × 48" × 48"	L&L (Atmos) (Just Added)	Elec 1250°F
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48" × 48" × 72"	Despatch (Just Added)	Elec 650°F
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68" × 72" × 72"	Gruenberg (4)	Elec 450°F
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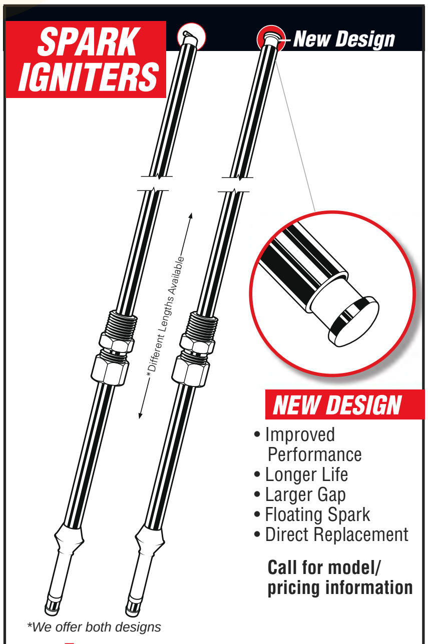

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2017 Buyers Guide Online at:
www.industrialheating.com/buyersguide

EQUIPMENT FOR SALE

2 Locations to Better Serve You

We Have Over 500 Pieces of Equipment in Stock
If your needs are not listed below, please let us know and we will locate a furnace/oven to suit your needs. We have all the ancillary equipment available for the above such as Tempering Furnaces, Washers, Charge Cars and Endo Generators.

Price is what you pay. Value is what you get. –*Warren Buffett*

CAR BOTTOM FURNACE
Gas Fired Car Bottom Furnace, 10' wide x 25' long x 8' high, 1,650°F, 18,000,000 BTUH, 16 North American Burners, 3 zones of control, 440V, 3 Phase, 60 Cycle complete with controls.

BEAVERMATIC
Beavermatic Gas Fired Car Bottom Furnace, 4' wide x 6' long x 4' high, 1,400°F max., 15,000 LB capacity, finer lined, powered car complete with ceramic piers, exhaust, blower and Honeywell controls.

BEAVERMATIC
Beavermatic Gas Fired Car Bottom Furnace, 5' wide x 12' long x 5' high, 1,400°F max., 30,000 LB capacity, fiber lined, powered car complete with ceramic piers, exhaust, blower and Honeywell controls.

ABAR
ABAR HORIZONTAL VACUUM FURNACE, 2 BAR, 24"W X 18"H X 36"L, 2,400°F, 1,000 LBS, 150 KW complete with Nitrogen or Argon Atmosphere, Spencer Blower, Varian Diffusion Pump, Stokes Mechanical Pump, Roots Blower Moly Elements, controls, circular hot zone and loader.

ABAR
ABAR HORIZONTAL VACUUM FURNACE, 2 BAR, 24"W X 24"H X 36"L, 2,400°F, 1,000 LBS, 150 KW complete with Nitrogen or Argon Atmosphere, Spencer Blower, Varian Diffusion Pump, Stokes Mechanical Pump, Roots Blower Moly Elements, controls, circular hot zone and loader.

HOLCROFT
Holcroft Gas Fired Mesh Belt Furnace, 24"W x 9"H x 14' 8"L, 400,000 BTUH, 750°F c/w controls.

HUBER
Huber Gas Fired Car Bottom Furnace, 10'-4"W x 8'H x 12'-8"L, 1,800°F, 5,200,000 BTUH and controls.

INDUSTRIAL HEATING EQUIPMENT
Industrial Heating Equipment Gas Fired Mesh Belt Furnace, 24"W x 10"H x 22'L, 500,000 BTUH, 950°F c/w controls.

PARK THERMAL
Park Thermal Gas Fired Box Furnace, 3' W x 3' H x 4' L, 1,200°F, 500,000 BTUH, pneumatic vertical rising door, powered rollers and controls.

PARK THERMAL
Park Thermal Electric Salt Bath Nitriding System complete with 30" Dia. X 36" deep Pre-Heat Furnace, Nitriding Salt Bath, 38" x 38" x 30" deep Oxidation Quench Tank, 30" x 40" x 36" deep Oxidation Quench Tank, 2 Wash Tanks, 3 Rinse Tanks, 4 Air Cool Stations and Controls.

PARK THERMAL
Park Thermal Gas Fired Mesh Belt Furnace, 17-1/2"W x 7"H x 15' 8"L, 375,000 BTUH, 900°F c/w controls.

PROCESS HEAT
Gas Fired Furnace, 7'W x 5'H x 7'L, Max. Temp. 1,250°F, 10,000 Lbs capacity, Excellent Temp. Uniformity Profiles and controls.

SALT BATH TRANSFORMERS
WPI Main Aluminum Scott T Dry Type Transformer, 250 KVA, 460 VAC 3 PH Primary, 60 HZ, 25/28/31/34/37/40 VAC 2 PH Secondary
WPI Teaser Aluminum Scott T Dry Type Transformer, 250 KVA, 460 VAC 3 PH Primary, 60 HZ, 25/28/31/34/37/40 VAC 2 PH Secondary

SURFACE COMBUSTION
Surface Combustion Snap Hearth Atmosphere Heat Treat Line, 300 lbs/hr including automatic loading, snap tray Nitrogen/Natural Gas Hardness Furnace (1,700°F, 18" W x 2.5" H) with inline Salt or Polymer Quench Tanks (1,000 gallons each), Parts Washer/RI (200 gallons) , Draw Dry Furnace (40 KW, 1,000°F), Unload Conveyor and controls with Allen Bradley PLC, controller, high limit etc.

SURFACE COMBUSTION
Surface Combustion Gas Fired Mesh Belt Furnace, 42"W x 12"H x 36'-6"L (heated), 1,350°F, 2,000,000 BTUH, 2 zones, 3 fans and controls.

SURFACE COMBUSTION
Electric Batch/Oil Quench Furnace, 30" W x 30" H x 48"L, Max. Temp. 1,950°F, System 1 Rear Handler, 3500 Gal. Quench Tank, 2 Agitators & Controls.

★ Visit us online at: www.parkthermal.com ★

Park Thermal International (1996) Corp.
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