INDUSTRIAL HEATING

The International Journal of Thermal Processing
DECEMBER 2018

Vacuum Sintering Benefits 30

INSIDE

industrialheating.com • A bnp media Publication • Vol. LXXXVI • No. 12

Energy Smart Cooling
Start Counting Your Savings

RULE #1.
Optimize your heat rejection technology

When choosing a cooling system consider your climate and the maximum operating temperature of your equipment for optimum efficiency. Lower fluid temperatures increase energy usage and operating costs. Consider using hybrid cooling systems to optimize operation - such as an air cooled exchanger to offload chillers in the winter.

TYPE	OPERATING COST	TEMPERATURE
Air Cooled	$	105°F
Evaporative	$$	85°F
Chiller	$$$$	65°F

Air cooled heat exchanger

Evaporative cooling tower with outdoor mechanical room

Chiller (mechanical refrigeration)

RULE #2.
Specify Safe, Reliable, and Low Maintenance equipment

The Solanus Cooler shown at right is perfect for cooling quench tanks. By using free air for cooling it completely eliminates the need for precious water resources.

NO WATER USAGE for safety and economical operation — self-cleaning tubes for low maintenance

SOLANUS

Quench oil coolers use no water

RULE #3.
Get some expert advice — make it pay to go green!

Dry Coolers Inc.

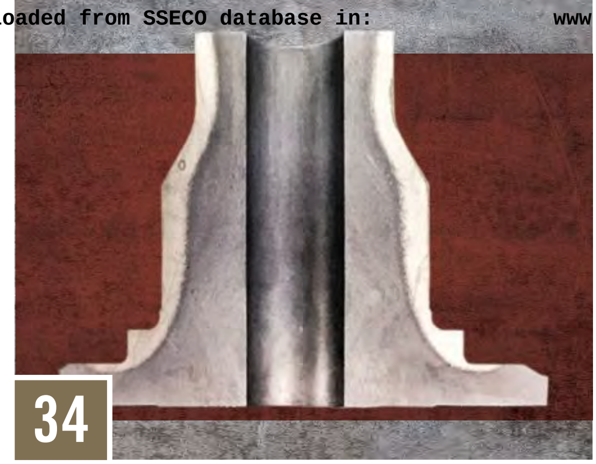
ISO 9001:2008

call **1-248-969-3400**
Fax: 248-969-3401
575 S. Glaspie Street • Oxford, MI 48371
www.drycoolers.com

30 years serving the Heat Treating Industry.

ENERGY-SMART COOLING SOLUTIONS FOR ALL TYPES OF PROCESS EQUIPMENT


Ipsen



CONTENTS

DECEMBER 2018

FEATURES

8

10


11


16

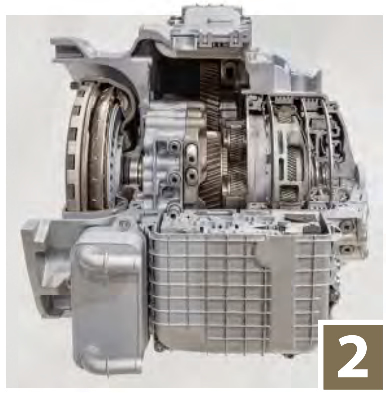
CONTENTS

DECEMBER 2018

On the Cover:
A sintering furnace from TAV VACUUM FURNACES
(p. 30).

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. Copyright 2018, by BNP Media. All rights reserved. The contents of this publication may not be reproduced in whole or in part without the consent of the publisher. The publisher is not responsible for product claims and representations. 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.

MTI & IHEA Associate Member



ONLINE

1 Web Exclusive

Modern Materials to Advance Aviation

Conventional aircraft have typically been built with familiar materials like aluminum. Newer aircraft that the Air Force is flying use a significant amount of composite materials, such as carbon fiber. These are materials that the Air Force knows very little about, at least compared to materials like aluminum.

www.industrialheating.com/aviation

2 Web Exclusive

2018 Feature Article Bibliography

This is a complete list of all the feature articles – by topic – that appeared in *Industrial Heating* in 2018. The month each article appeared in is included with page number. All articles are hyperlinked for your convenience.

www.industrialheating.com/2018articles

3 Social Media

Get Connected!

It's easier than ever to stay connected to the best source of news and information. Become a part of our online communities and access exclusive information, breaking news, event coverage and more. Connect with us on Facebook, Twitter, Google+, YouTube or LinkedIn to receive updates and to network with other industry professionals.

www.industrialheating.com/connect

INDUSTRIAL HEATING

Manor Oak One, Suite 450, 1910 Cochran Rd., Pittsburgh, PA 15220
412-531-3370; Fax: 412-531-3375; Online: www.industrialheating.com

SENIOR GROUP PUBLISHER
Darrell Dal Pozzo dalpozzod@bnpmedia.com; 847-405-4044

EDITORIAL/PRODUCTION STAFF
Reed Miller Associate Publisher/Editor – M.S. Met. Eng., reed@industrialheating.com; 412-306-4360
Bill Mayer Managing Editor, bill@industrialheating.com; 412-306-4350
Linda Becker Contributing Editor, beckerl@bnpmedia.com; 262-564-0074
R. Barry Ashby Washington Editor, askbarry@industrialheating.com; 202-255-0197
Dan Herring Contributing Technical Editor, 630-834-3017; heattreatdoctor@industrialheating.com
Dean Peters Contributing Editor, dean@forgemag.com; 216-570-4537
Karen Talan Production Manager, talank@bnpmedia.com; 248-244-6246
Brent Miller Art Director, brent@industrialheating.com; 412-306-4356

AUDIENCE MARKETING
Hillary Leman – AUDIENCE MARKETING COORDINATOR
Alison Illes – SENIOR INTEGRATED MEDIA SPECIALIST
Carolan Bieniek – AUDIENCE AUDIT COORDINATOR
For subscription information or service, please contact Customer Service at:
Phone: 800-952-6643 or Fax: 847-763-9538; Email: industrialheating@omeda.com

LIST RENTAL
Postal & Email Contacts
Kevin Collopy Sr. Account Manager; Phone: 402-836-6265; Toll Free: 800-223-2194, ext. 684; Email: kevin.collopy@infogroup.com
Michael Costantino Senior Account Manager; Phone: 402-836-6266; Email: michael.costantino@infogroup.com

ADVERTISING SALES REPRESENTATIVES
Kathy Pisano Advertising Director and Online Advertising Manager, kathy@industrialheating.com; 412-306-4357, Fax: 412-531-3375
Becky McClelland Classified Advertising Mgr., becky@industrialheating.com; 412-306-4355
Rick Groves Eastern Sales Manager, grovesr@bnpmedia.com; 248-244-6444; Fax: 248-502-2109
Steve Roth European & Midwest Sales Manager, roths@bnpmedia.com; 520-742-0175, Fax: 847-620-2525
Mr. Arlen LUO Newsteel Media, China; nsmchina@126.com; Tel: +86-10-82160060, Fax: +86-10-62150588
Becky McClelland Reprint Quotes; becky@industrialheating.com; 412-306-4355

SINGLE COPY SALES
Ann Kalb kalbr@bnpmedia.com

CORPORATE DIRECTORS
Rita M. Foumia Human Resources & Information Technology
Vincent M. Miconi Production
Lisa L. Paulus Finance
Michael T. Powell Creative
Scott Wolters Events
Beth A. Surowiec Clear Seas Research

bnp media
BNP Media Helps People Succeed in Business with Superior Information

ACROSS INTERNATIONAL

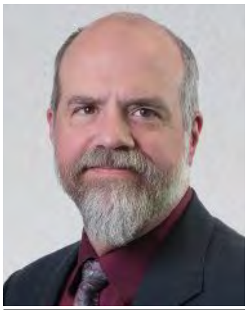
Founded and headquartered in New Jersey, Across International supplies laboratory equipment for heat treatment and material processing. Our equipment can be found in universities, research facilities, and labs all across the world. We have more than 25 years of industrial manufacturing experience, including induction heaters, drying ovens, ball mills, laboratory furnaces, and pellet presses.

Customer satisfaction is always our top priority. We respond to all inquiries within the same business day. We offer lifelong technical support for all of our machines, in addition to our excellent customer support.

Our knowledgable sales team will help you select the perfect equipment for your project. We base our recommendations upon your application's specific requirements, so that you can be certain that the job gets done properly every time.

www.AcrossInternational.com
888-669-3339

Peace (and Love) at Work



REED MILLER
Associate Publisher/Editor
412-306-4360
reed@industrialheating.com

Our holiday editorial finds us considering how we can better get along. Just today, I am reminded of the hatred in the world as a gunman opened fire in a California nightclub. And this tragedy of hate comes hot on the heels of a hate-filled rampage in a synagogue across town from our office here in Pittsburgh. The recent election is another reminder that hate fills even our political process. Why can't we all get along?

At this special season of the year, many of our holiday songs may provide an answer. Songs like "Joy to the World," "Silent Night" and even favorites such as "I'll Be Home for Christmas" and "All I Want for Christmas is You" communicate love. A 1969 favorite by Jackie DeShannon encourages us to "Put a Little Love in Your Heart" because the world will be a better place. How would our workplaces be different/better if we tried to do just that?

I was struck by a couple of recent articles discussing employee loyalty. Loyalty in employees is a particularly valuable commodity these days when it is becoming so difficult to hire good people. We want our employees to stay, and loyal employees want to stay.

Attracting good people is about having a great place to work. Corporate culture that values these employees and their contributions is one of the things that makes your business a great place to work. How can we value our employees? Different corporate cultures reflect this differently, but compensation is definitely part of the discussion.

A recent news story about a company in our industry enforces this, but it also reflects their unique corporate culture. A write-up in the *Waterloo-Cedar Falls Courier* about Advanced Heat Treat Corporation (AHT) talks with employees who say, "AHT truly cares about employee quality of life."

Compensation and benefits are clearly part of the value proposition for these employees. Three-year employee Jennifer Lassen said, "Many benefits are provided, such as competitive wages, extremely lucrative (paid) time-off structure, ongoing professional training and tuition reimbursement."

Adam Dehl, a 22-year veteran at AHT adds, "(AHT) consistently practices our 'core values' of service, integrity, loyalty, teamwork, passion and professionalism." He added that these values are a way of life at AHT. Congratulations, AHT! Keep up the good work.

What can you do to make your company a place where people want to work? What changes can be made to corporate culture to help employees realize they are valued? The challenge is that people in our workforce are the same but different. Everyone wants to feel valued (i.e., loved), but that may look different for the range of people in the workforce – Baby Boomers to Millennials.

Millennials, also known as Generation Y, are recognized as people born in the years ranging from 1983-2001. With a current age ranging from 35 down to 17, these folks are moving into the workforce in large numbers. Companies have found that keeping these new employees happy at work requires a paradigm shift to address different expectations.

How do we successfully incorporate (recruit and train) Millennials into our manufacturing companies? Here are some ideas.

- Highlight advanced technologies
- Focus on work-life balance
- Focus on career development
- Open the communication lines
- Provide frequent recognition
- Provide opportunities for learning (e.g., mentoring program)
- Manage cultural clashes
- Let them make their mark
- Offer international experiences
- Allow remote collaboration – flexibility

We began this discussion with how we can all get along and how to help our employees feel valued (loved). At *Industrial Heating*, we want everyone reading these words to know that they are valued by us, and we hope this holiday season and the coming new year bring you peace, joy and love.

HORIZONTAL CAR BOTTOM VACUUM FURNACE

HCB-2EQ SERIES

There is no equal to the Solar Manufacturing Horizontal Car Bottom Vacuum Furnace. The HCB-2EQ Series with our patented* car bottom, is designed to load/unload large, very heavy workloads in a safe and economical manner. We set the industry standard with energy efficient, graphite insulated hot zones, SolarVac® Polaris automation and controls, and 2 bar high velocity external gas quench systems. Matched with our outstanding customer service and reliable Aftermarket support, we will keep your furnace up and running year after year.

** US Patent No. 6,939,792 B2 August 30, 2005*

Solve your heavy workload problems with our HCB-2EQ Series.

SOLAR MANUFACTURING

PROUDLY MADE IN THE USA

P 267.384.5040

W solarmfg.com

HORIZONTAL CAR BOTTOM **HCB**

VERTICAL BOTTOM LOADING **VBL**

THE MENTOR **MIQ**

INTERNAL QUENCH **IQ**

EXTERNAL QUENCH **EQ**

THE BRIGHTEST SOLUTIONS THROUGH INGENUITY

Health Insurance Needs Your Attention

BARRY ASHBY
Washington Editor
202-255-0197
askbarry@industrialheating.com

Although it will be difficult to cover on one page, this column is about employer-supplied health insurance and the costs that are getting out of hand.

Americans spent $2.8 billion on health care in 1930, or $23 per person and 3.5% of GDP. This percentage jumped to 4.5% in 1950, 7.3% in 1970, 12.2% in 1990 and 15% in 2015. U.S. citizens spent $3 trillion on health care, or $9,536 per person, in 2015. Times change – the U.S. had 7,000 hospitals in 1975; there are 5,500 today.

Large employers will see a 6% increase in insurance-plan costs in 2019, similar to the 5.5-7.0% annual increase over the past five years. Putting this in context, $28,000 is total health-care costs for the typical U.S. family annually (annual premiums for employer-sponsored family health coverage reached $19,616 this year, up 5% from last, with workers paying $5,547 toward cost and with $1,573 in average deductibles). Fully 56% of small firms and 98% of large firms offer health benefits to at least some of their employees with an overall offer rate of 57%.

All of this is based on a Kaiser Foundation study of a few weeks ago and studies by PwC Health Research Institute. Actually, large employers contracting with health-insurance providers is effective cost reduction of this employee "hidden pay cut." On balance, families spend an average 10.1% ($6,422) of income on health-insurance premiums and deductibles, varying nationally depending on location from 6.3% (in Massachusetts) to 14.7% (in Arizona, Florida and Texas).

It must be recognized that employers play an outsized role in providing health care nationally. One in two Americans gain health care via an employer benefit plan, and 75% of these through an employer-offered self-insured plan. For perspective, 68 million citizens are on Medicaid, and 58 million are on Medicare. U.S. health-care costs are more than all but the top 13 nations in the world according to gross domestic product.

And the cost of health care is going up on a per-employee basis, rising 75% while median salary was up only 25% over the last dozen years. While employers are heavily reliant on many vendors to manage health-care insurance spending, this area is their largest operating expense after wages. This leads us to the real problem: an about-to-burst bubble of industrial dissatisfaction with health-care inflation that far outpaces other business issues and failed government policies and initiatives.

The public, including employees in this distorted scenario, buy insurance plans to protect against unpredictable medical expenses, including those in or not in hospitals. The problem with this out-of-control spending is that there is little or no competition to keep prices stable or reasonable. The benefits that the public in general derive from their employer-provided health-care insurance, with their own substantial contribution, require dramatic change.

It has long been known that charges for medicines are skewed. It costs enormous sums to develop and test new drugs and technologies, and these sums must be recovered through sales with or without health-insurance contributions. These items, however, are often sold overseas at substantially lower prices than offered in the U.S. markets.

There is valid concern that medical insurance in the health sector, which is massively controlled by insurance companies and abetted by medical providers, exacts requirements on their major customers (industry) and manipulates the pricing systems. This is a very important matter to address before the economy is toppled by this out-of-control imposition by the providers of real medical needs and supplied through an inefficiently "managed" system of supply and demand.

This is really an American industry management issue that needs attention. Product providers as well as insurers must address these matters before the problems are beyond repair. Research and development of new medicines is critical. Honest and uniform pricing worldwide is critical. Health insurers have a role that supports these needs; not those of gaining from higher and higher premium incomes via their largest customer base, American industry.

It is time for private-industry management to have "come-to-Jesus meetings" with medical institutions, developers and providers of drugs, health-care insurers and government regulators.

I see it, but what is it?

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

The human brain is rather good at recognizing a large variety of objects: a chair, a ball, a hang-glider, etc. Recognition is usually almost instantaneous, assuming one learned at some point in the past what each of these objects is called.

When we are faced with an object we have never seen before, things are a bit different. The brain will quickly sort through known objects and may find something that looks similar, but just because two things look similar doesn't mean that they are the same or even related.

That is precisely the situation we are faced with in the field of materials characterization. Each of the instruments in our Materials Characterization Facility at Carnegie Mellon University produces images – sometimes at a truly astounding rate – and the majority of those images represent objects or features that we have never before seen. Thus, we have all these multimillion-dollar instruments producing images, and we (including our students) must essentially start from the beginning and learn what it is we are seeing.

To teach our students how to interpret the images they acquire with electron microscopes, we offer several courses at CMU, both at the undergraduate and graduate levels. Since 1998, we have taught these courses in our Digital Microscope Classroom (see figure) – a large circular room located at the center of the facility. This classroom, which is quite unique in the world, is hard-wired for remote operation of scientific instruments, including scanning and transmission electron microscopes (SEM and TEM), X-ray diffractometers (XRD) and scanning probe microscopes (SPM).

Materials characterization is so fundamental to the materials engineering profession that we require that our sophomore students learn to operate several of these tools.

At the graduate level, we offer courses on SEM and TEM, not only to cover the manual skills of actually operating the instruments but also to cover the underlying theory of how the images and spectra are formed.

The theoretical portion of these courses is where the students learn to interpret what they are seeing. In some cases, this is relatively easy. We have all seen SEM images of insect eyes, spider legs or plant pollen, and we can generally interpret them correctly without having to take an entire course.

For images acquired with a TEM, on the other hand, our intuition and life experience are simply inadequate and offer no help when we try to understand what we are looking at. Fortunately, modern computers allow us to predict what the image should look like. All it takes is having some idea of what might be present in the material (inclusions, lattice defects, pores, etc.) and then applying the image formation theory to generate a simulated image, which can then be compared to the observed image.

This simulation approach is a bit of a roundabout way to gain insight, but it works well, and it has helped generations of students and researchers figure out what they are looking at. At CMU, we have built up significant expertise in the ability to predict microscopy images, thus enabling state-of-the-art materials research.

A Deeper Dive into Professor De Graef's Research

For the past two years, professor De Graef's group has received funding from the Department of Defense (DoD) in the form of a Vannevar Bush Faculty Fellowship. This research program focuses on the prediction of electron microscopy images, covering both SEM and TEM instruments.

We have created new algorithms to automatically index diffraction patterns, and we are currently studying whether or not machine-learning approaches might be helpful in this area. Our algorithms can handle truly massive data sets. The largest data set we have successfully analyzed is a 3-D stack of slices through a nickel-based superalloy microstructure consisting of more than 110 million diffraction patterns.

Heat Treatment of Cast Irons

DANIEL H. HERRING
The HERRING GROUP, Inc.
630-834-3017
dherring@heat-treat-doctor.com

Thinking back to our high-school days often brings a smile to our faces. As a freshman, the daunting task of picking a foreign language to study fell to The Doctor's mother, who immediately chose Latin for him. While perhaps not the most popular of choices today, it was a highly rewarding experience, especially for improving one's understanding of the English language and for making sense out of many scientific and scholarly works of the past. For example, did you know that iron (chemical symbol: Fe) derives its name and symbol from the Latin word ferrum? Its characteristics and heat treatment are equally interesting and much different from steel. Let's learn more.

Table 2. Typical composition of unalloyed cast irons[3]

Element	White iron (%)	Malleable iron (%)	Gray iron (%)	Ductile or nodular iron (%)
Carbon	1.8-3.6	2.00-2.60	2.5-4.0	3.0-4.0
Silicon	0.5-1.9	1.10-1.60	1.0-3.0	1.8-2.8
Manganese	0.25-0.80	0.20-1.00	0.25-1.0	0.10-1.00
Sulfur	0.06-0.20	0.04-0.18	0.02-0.25	0.03 max
Phosphorous	0.06-0.18	0.18 max	0.05-1.0	0.10 max

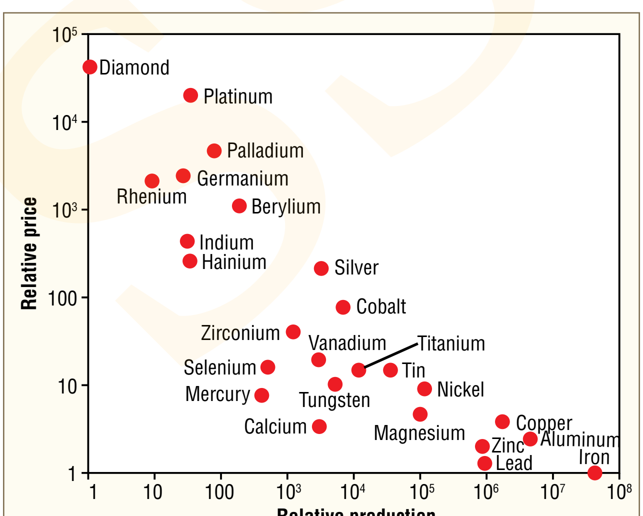


Fig. 1. Price vs. availability of common elements[2]

What is iron?

Iron is an element that in its pure form is lustrous, silvery, soft and ductile. However, pure iron (<0.008% C) is a poor engineering material, generally not as strong as most plastics. Iron is, however, the fourth-most-abundant element on Earth and one of the most widely disbursed elements in the Earth's crust. In nature, it is found in various compounds with oxygen, sulfur or more complicated ores such as carbonates and silicates (Table 1, online).

Iron has several unique properties that are of interest to metallurgists and engineers. First, iron requires relatively little energy to be extracted from its ore, making it the most cost-effective material choice (Fig. 1). Second, iron has asymmetric rotation of its electrons (that is, the electrons can spin in same directions). This allows iron to more easily combine with alloying elements, thus changing its properties. Finally, it is polymorphic, which means its crystal structure can "flip" or transform into different structures as a function of temperature and carbon content. Together these properties make iron one of the most attractive elements to use for the products we require in everyday life.

What is cast iron?

Cast iron (>2.11% C) is a generic term used to designate a family of metals with a wide variety of properties. All cast irons contain more than 2% carbon and an appreciable amount of silicon (usually 1-3%). The high carbon and silicon content means that they are easily melted, have good fluidity in the liquid state and have excellent pouring properties.

The basic types of cast iron are best differentiated by their microstructure, which is the form and shape in which the excess carbon separates during cooling. This determines the type of cast iron and establishes the nature of its properties – as opposed to their chemical analysis – because the various types overlap (Table 2).

In white iron, the majority of carbon occurs as iron carbide. In malleable iron, the majority of carbon is in the form of irregularly shaped nodules of graphite. In gray iron, the carbon is present as graphite flakes, and in ductile iron, the graphite occurs in spheres. Because graphite has very little (cohesive) strength and reduces the effective metallic cross section of the casting, both strength and ductility are affected.

Heat Treatment of Cast Iron

The types of heat treatments for cast irons involve stress


Chart a Better Course
for your
Induction Process!
Production Ready Inductor
Metallurgical Report
Customer Specification
N
W
E
S
INDUCTION TOOLING, INC.
Metallurgical Evaluation
3D Design
Lab Development
Machining
Assembly
SCAN ME!
12510 York-Delta Drive, North Royalton, OH. 44133
Phone: (440) 237-0711 Fax: (440) 237-7009
Email: sales@inductiontooling.com
www.inductiontooling.com
Commercial Testing
ISO 17025 Cert.#3394.01
LEARN MORE!

relief, annealing, normalizing and hardening (quench and temper). In each of these processes, it is important to understand the materials' response to its heat-treat process parameters (time, temperature and atmosphere).

Stress Relief

The need for stress relief is due to internal (residual) stress in the castings, which is often the result of cooling a complex or intricate shape or one with radical changes in cross-sectional area. In stress relief, the time-temperature relationship plays a significant role (Fig. 5, online), and higher temperatures will affect mechanical properties and often require the use of protective atmosphere to avoid oxidation.

Soak time at temperature is in the order of 1.5 hours per 25.4 mm (1 inch) of cross-sectional area for sections over 50 mm (2 inches) and 1 hour per 25.4 mm (1 inch) of cross-sectional area below this thickness. The cooling rate is also important, with furnace cooling to 260˚C (500˚F) adequate for most castings. However, those with intricate shapes should be cooled to 95˚C (200˚F).

Annealing

The annealing process is applied to castings primarily to improve machinability by softening the material. In the case of ductile iron, increases in ductility and impact resistance often result. Various heating and cooling cycles (Fig. 6) can be used each having a different purpose (Table 4, online).

Normalizing

Iron castings are commonly normalized to obtain a microstructure of fine pearlite. The result is a microstructure with increased tensile strength and wear resistance. Normalized structures respond well to induction hardening. In general, the heating rate is not important, but excessive distortion and cracking must be avoided.

Normalizing temperature ranges vary from 815-870˚C (1500-1600˚F) for high-strength gray irons to 845-900˚C (1550-1650˚F) for low-strength gray irons and 870-925˚C (1600-1700˚F) for ductile irons. The silicon content determines the final temperature because it increases the critical temperature of the material. Cooling rates vary from still-air to fan-assisted cooling for large castings. Tempering is used if the final hardness is too high.

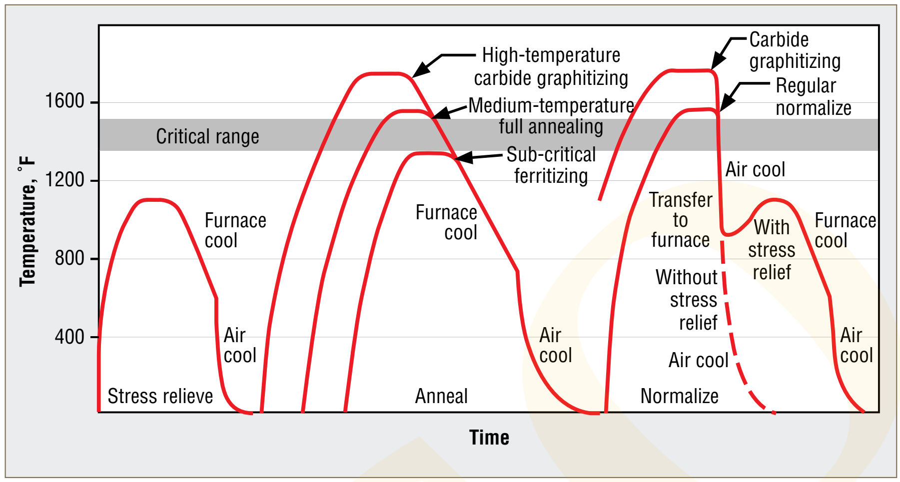


Fig. 6. Stress relief, annealing and normalizing cycles for cast irons[5]

Hardening (Quench and Temper)

It is important to carefully select and control the process parameters when performing these operations so as to avoid problems such as distortion, warpage, overheating ("burning") or quench cracking. The lower-critical temperature for cast irons can be calculated (Eq. 1 and 2) or determined by sample analysis.

Critical temperature (°C) = 730 + 28%Si – 25%Mn (1)

Critical temperature (°F) = 1350 + 50%Si – 45%Mn (2)

In practice, castings to be hardened are austenitized at a temperature of 10-38˚C (50-100˚F) above the upper-critical temperature for one hour per 25 mm (1 inch). Heating should be gradual so as not to induce thermal stresses. After soaking, the parts are quenched. Typically, a severe quench is unnecessary. Oil or polymer quenching can also be used. Tempering follows and can be performed over a wide range, from 120-595˚C (250-1100˚F), to develop proper mechanical properties. Tempering time is typically shorter than for steels.

Cryogenic Processing

Many cast irons are cryogenically treated (-195˚C/-320˚F) to stabilize the microstructure and enhance properties (e.g., dampening and wear characteristics). A typical cycle consists of slowly reducing temperature over a period of 6-8 hours, stabilizing at temperature (typically 8-12 hours) and slowly raising the temperature back to room temperature again over a period of 6-8 hours.

Cryogenically treated gray cast-iron brake rotors (Fig. 7, online) in automotive applications have been shown to improve service life. In police cars, where a combination of high speeds and frequent braking translates to brake-component replacement around 12,875 km (8,000 miles), cryogenic processors report having extended the time between replacement of these components consistently up to 38,625 km (24,000 miles).

References available online


SECO/WARWICK

FNA 2018 Hits Record Attendance

MTI
Metal Treating Institute
904-249-0448
www.HeatTreat.net

If you weren't in attendance at Furnaces North America 2018 in Indianapolis, Ind., you missed everything heat treating. FNA 2018 hosted a record crowd of over 1,700 people from 14 countries who visited more than 170 exhibitors. Countries represented at the show included:

- Australia
- Canada
- China
- Columbia
- France
- Germany
- India
- Italy
- Japan
- Mexico
- New Zealand
- Taiwan
- United Kingdom
- Unites States

The word that most attendees used to describe FNA 2018 was "energetic." Many talked about how informative the technical sessions were, the quality of the exhibits and the optimism within all the social functions.

FNA 2018 began with the opening night reception, sponsored by AFC-Holcroft. MTI President Pete Hushek of Phoenix Heat Treating welcomed the room, which included exhibitors, their teams and attendees.

Day two featured the first of two days of technical sessions sponsored by Gasbarre. Attendees enjoyed focused content on key heat-treating issues in 20 sessions. After the sessions concluded, the FNA crowd converged on the show floor, where they could see the latest in equipment, technology and services.

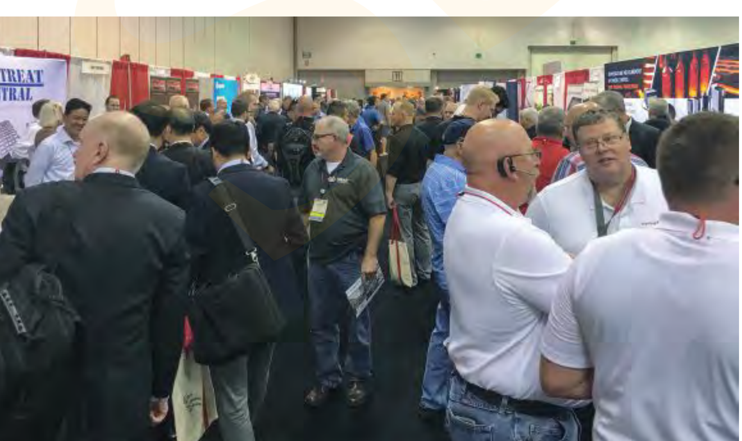
Day two was capped off with the show-floor reception, sponsored by Surface Combustion. During the reception, Metal Treating Institute member and YES Management Training Program student Andrew Muto from Paulo played Pic-Til-You-Win for a chance to win $250, $500 or $25,000. Andrew came close to $25,000 but had to settle for $500. Congrats to Andrew!

Day three featured 15 more technical sessions sponsored by Gasbarre and day two of the trade show.

The three days were capped off with MTI's final night dinner, which featured the YES Management Training Program graduation and the Leadership and Service Awards.

Initial exhibitor surveys of FNA 2018 included great feedback, positive outcomes, numerous leads and takeaways for building a stronger, more profitable business in 2019. One exhibitor near the end of day one shared, "We cannot wait for FNA 2020. We have already obtained over 100 qualified leads … and it's only day one!"

If you would like to know more about FNA 2020 in Louisville, Ky., visit FurnacesNorthAmerica.com.



Florida to Host 2019 Annual Meeting

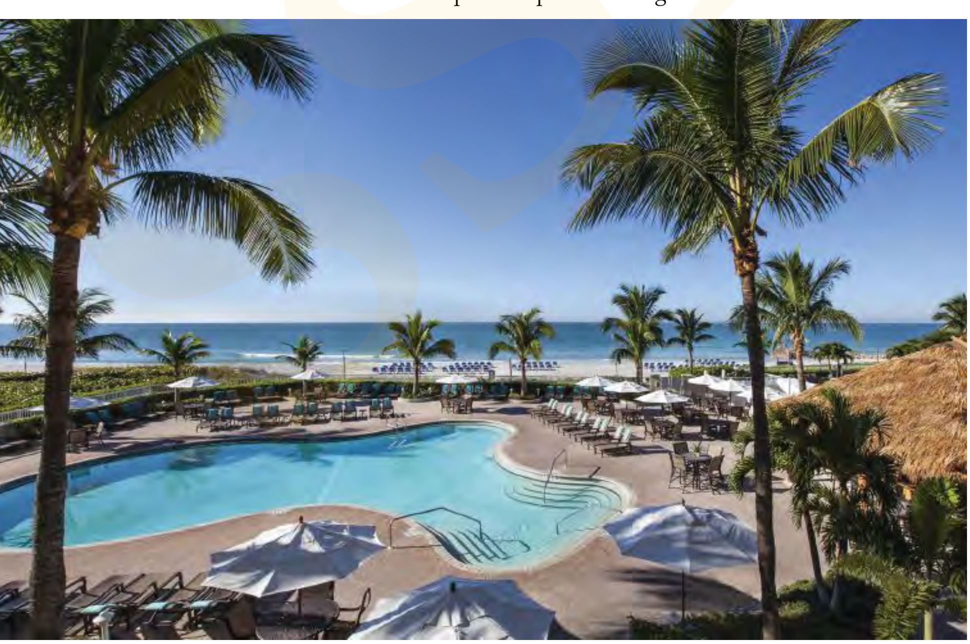
IHEA
Industrial Heating Equipment Assoc.
859-356-1575
www.ihea.org

The Industrial Heating Equipment Association (IHEA) will celebrate its 90th Anniversary at the 2019 Annual Meeting April 29-May 1 at the Lido Beach Resort in Sarasota, Fla.

IHEA members look forward to the camaraderie created by the social events and the thought-provoking topics presented. The meeting provides plenty of opportunity to get involved with important industry-related developments while exploring new business contacts and growing relationships.

The IHEA Welcome Reception will kick off the event on the pool deck overlooking the beach. The program follows with relevant keynote sessions and committee meetings to discuss association business. Sprinkle in the annual president's gala, the IHEA golf tournament and discovering local attractions, and it's the perfect mix of business and pleasure. It's also a great way to keep current with industry trends and keep in touch with peers.

The beautiful resort is located on one of Florida's best beaches. The resort is also close to world-famous Siesta Key beach, often voted the best beach in the country. The Lido Beach Resort is just two minutes from the very popular St. Armands Circle, which is filled with restaurants and shops. Complete meeting details and registration information can be found at www.ihea.org. We hope to see you in Sarasota next April!



IHEA Membership has its Privileges

Don't let another year pass without becoming an IHEA member. Join now and get a multitude of benefits right from the start. The Annual Meeting is just one event. Hear what current members appreciate most about IHEA.

"INEX Incorporated has benefitted greatly since becoming a member of IHEA," said Mike Kasprzyk, president of INEX. "Perhaps the most direct benefit has been enabling our employees to take advantage of the online training programs to broaden their understanding of how our products are utilized by our end users."

"IHEA is all about process heating. Whether it is a vacuum carburizing oven or an infrared powder-coating curing oven, IHEA covers the spectrum of heating in manufacturing processes," said Michael Stowe of Advanced Energy. "IHEA members are oven and furnace equipment OEMs, electrical utilities, combustion burner manufacturers and energy consultants. The widely varied membership provides an excellent opportunity for networking and keeping up with the latest and greatest heating technology developments."

IHEA focuses on driving its members' success by providing the knowledge base and authoritative voice for industrial heat processing. Become a member of IHEA and take advantage of these great benefits and resources: monthly executive economic update; meeting vouchers (contingent on member category); discounts on educational seminars/webinars, Annual and Fall meetings, online training courses, training videos and IHEA publications; ability to post content and participate in community forums on IHEA's website and post resumes and job openings online in the Career Center; subscription to IHEA's INSIDER newsletter; company listing on IHEA's website; and ability to participate on IHEA committees.

EQUIPMENT NEWS

Car-Bottom Air Furnace

Solar Atmospheres of Western PA commissioned a 20-foot-long car-bottom air furnace with a total load capacity of up to 30,000 pounds. The Class 2 furnace, built by Heat Treat Equipment Inc. of Canton, Mich., was installed and fully tested in Hermitage, Pa.

The 60-inch-square x 240-inch hot zone passed the AMS 2750E temperature uniformity survey of +/- 10˚F from temperatures of 300-1450˚F. The furnace passed the survey on the first attempt and was put into production immediately. It will be used to economically process many downstream processes, including multiple tempering operations, which typically follow vacuum austenitizing treatments. www.solaratm.com

Temper Furnace

Gasbarre Furnace Group/J.L. Becker shipped a large-capacity gas-fired temper furnace to a specialty alloy manufacturer located in the northeast U.S. The furnace is designed to temper workloads after hardening. It is capable of processing workloads 32 feet wide x 6 feet long x 4 feet high that weigh up to 40,000 pounds. Temperature uniformity is achieved through five zones of heating, recirculation fans and a custom-designed baffling system. As a result, the furnace is capable of achieving ±10˚F from 800˚F to 1400˚F. www.gasbarre.com

Electron-Beam AM, Welding System

Sciaky Inc., a subsidiary of Phillips Service Industries Inc., received an order from a southeast Asian aerospace parts manufacturer for a dual-purpose electron-beam additive-manufacturing (EBAM) and EB welding system. The hybrid machine will be customized with special controls to switch from 3D printing to welding in a quick and easy process. The company will utilize the system to 3D print metal structures and to weld dissimilar materials and refractory alloys for these structures and other aerospace parts. Delivery of the hybrid system is scheduled for the second quarter of 2019. www.sciaky.com

Hot Isostatic Press (HIP)

Lake City Heat Treating Corp. installed a hot isostatic press (HIP) at its facility in Warsaw, Ind. Manufactured by Sweden's Quintus Technologies, the modular HIP has a work zone measuring 23.62 inches in diameter x 70.87 inches high, an operating temperature of 2552˚F and a pressure of 30,000 psi. The press, the third at Lake City Heat Treating, is designed for advanced materials in the aerospace and orthopedic industries. It is also equipped with patented Uniform Rapid Cooling technology, dramatically reducing processing time. www.lakecityheattreating.com

Melt-Shop Technology

JSW Steel (USA) Inc. selected **Tenova** to supply melt-shop technology for its melt-and-manufacture contiguous plate and pipe facility in Baytown, Texas. The greenfield melting facility will include a Consteel Evolution EAF, two ladle metallurgy furnaces and a twin vacuum tank degasser for the production of high-quality steel slabs. Tenova will also design and supply the entire melt-shop material-handling system for the storage and handling of fluxes and ferroalloys. www.tenova.com

Floater Furnace

Ebner received an order from Northeast Light Alloy Co. Ltd. of Harbin, China, for a continuous floater furnace facility to harden and temper aluminum alloy strip. The heat-treatment facility fulfills all requirements for achieving aerospace-grade material, including optimum strip shape and surface characteristics, high-temperature uniformity throughout the heating and soaking phases, and appropriately high cooling gradients. The floater furnace, which will start operation at the end of 2019, is designed for a maximum strip width of 2,400 mm (94.5 inches) and strip thicknesses of 0.5-4.0 mm. www.ebner.cc

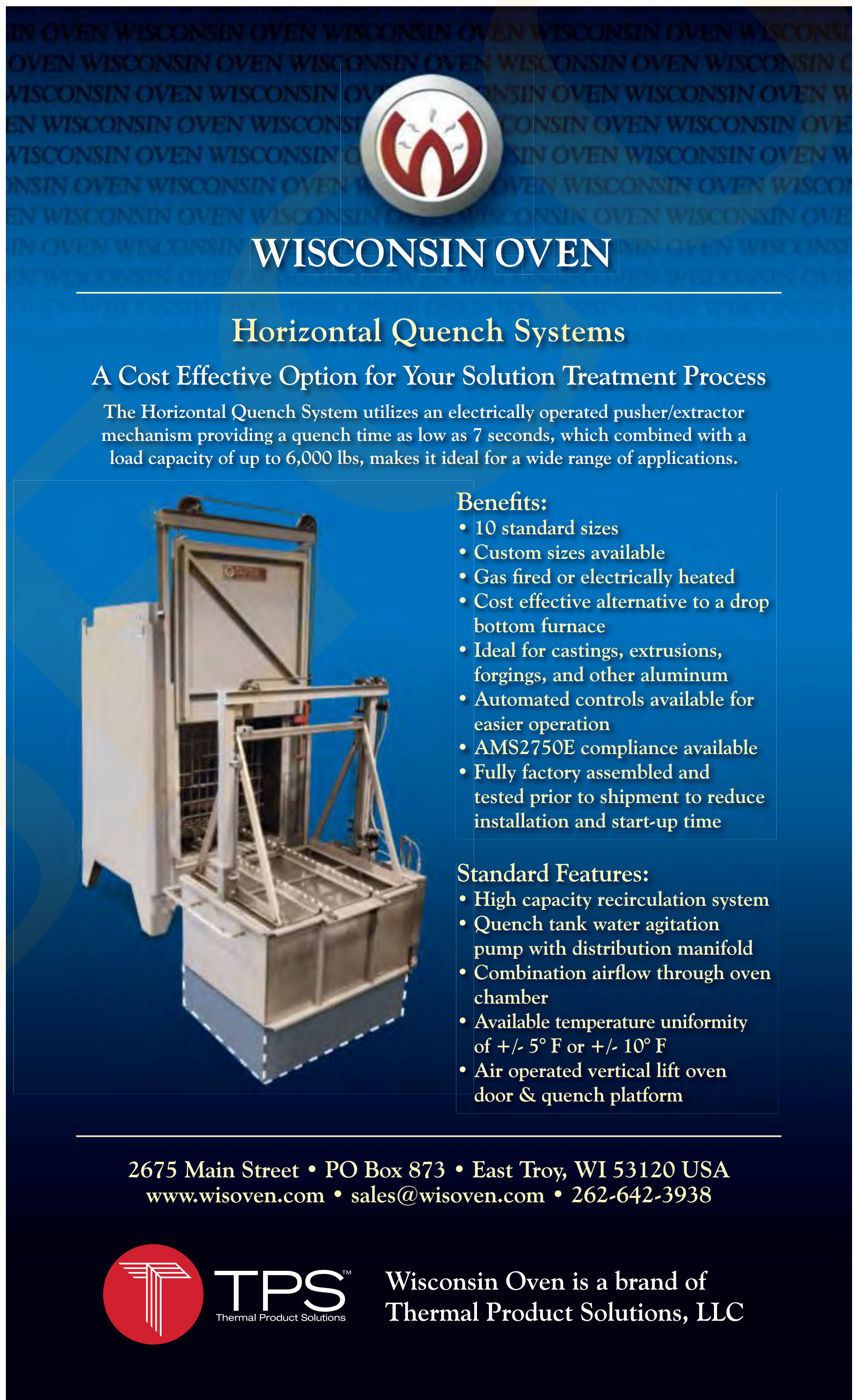
BUSINESS NEWS

Safe Cronite Purchased; Now Cronite

The Safe Cronite business unit of the Safe Group has been purchased by its CEO Pierre Wittmann and a group of managers in partnership with investment funds driven by CICLAD. The company, now Cronite, designs and manufactures fixtures and parts in refractory alloys for the heat-treatment, steel, incineration, power-generation, automotive and aerospace industries. Cronite operates seven plants in France, England, Germany, China, India and Mexico. The company has sales offices in the United States, Japan, South Korea and Sweden. Cronite is known under the names Cronite, Klefisch, Mancelle, North American Cronite and Cronite CZ.

Carpenter Acquires Additive-Manufacturing Company

Carpenter Technology Corp. acquired LPW Technology Ltd. (LPW), a developer and supplier of advanced metal powders and powder lifecycle-management solutions to the additive-manufacturing (AM) industry, for approximately $81 million. LPW is based in Widnes, Cheshire (U.K.) with additional processing operations near Pittsburgh, Pa. The company employs about 80 people. The acquisition combines LPW's metal-powder lifecycle-management technology and processes with Carpenter's technical expertise in producing highly engineered metal powders and additively manufactured components.



SSAB to Increase Q&T Steel Production Capacity in Alabama

SSAB will increase production capacity for quenched-and-tempered (Q&T) steels at SSAB Americas' steel mill in Mobile, Ala. The approximately $109 million investment will increase the annual capacity of Q&T steels in Mobile from 300,000 metric tons to 400,000 metric tons. As part of the investment, a new accelerated cooling system will be installed. This will improve the potential to grow volumes of more advanced premium products while reducing the need for alloys.

Partnership Aims to Bring Metal 3D Printing to Mass Production

In a strategic collaboration, **GKN Powder Metallurgy** will be the first company to deploy the HP Metal Jet, a binder-jetting technology, into its factories. GKN Powder Metallurgy will use HP Inc.'s 3D printer to produce functional metal parts for automotive companies including Volkswagen and for other industrial leaders. The technology will enable GKN Powder Metallurgy to reduce the time-to-market for mass-produced parts from months to weeks, lowering development costs and providing greater design and manufacturing flexibility.

Melt-and-Manufacture Plate Mill Breaks Ground in Texas

JSW USA broke ground in Baytown, Texas, on what it says is the most technologically advanced and eco-friendly electric-arc furnace, slab caster and plate mill in the world. According to the company, it is the only melt-and-manufacture plate mill with a contiguous pipe mill in North America. JSW USA plans to hire 1,000 new workers and invest up to $1 billion to modernize and expand its U.S. operations. The melt-and-manufacture EAF and slab caster, which will feed directly into the soon-to-be-revitalized plate mill, are being built on 111 acres at JSW USA's 700-acre Baytown campus

Pfeiffer Vacuum Opens Facility in New Hampshire

Pfeiffer Vacuum opened a new 27,000-square-foot building in Nashua, N.H. The two-story site will be the home of the company's North American headquarters for administration, sales, product management, marketing and customer care. In parallel, the former 24,000-square-foot administration building has been converted into a Service Center of Excellence, bringing together all service activities for the major part of the Pfeiffer Vacuum product portfolio under one roof. State-of-the-art automated cleaning and testing equipment is being utilized at the facility, resulting in high-quality, fast repairs.

Braidy Industries Acquires NanoAl

Braidy Industries Inc. acquired NanoAl, a leader in the science of nanocrystalline strengthening technology applied to sheet aluminum, as a third wholly owned subsidiary. NanoAl was founded out of the Department of Materials Science at Northwestern University to commercialize the science of developing stronger aluminum alloys through control of key structural features at the nanoscale. Braidy believes the technology has the potential to significantly enhance the specific strength of aluminum to be produced by its Braidy Atlas mill in Ashland, Ky.

Materials-Testing Lab Opens on College Campus

Shimadzu Scientific Instruments and Oklahoma State University (OSU) joined forces to establish The College of Engineering, Architecture and Technology's (CEAT) Mechanical and Physical Properties Testing Lab. The new 72,000-square-foot lab is part of the ExxonMobil Testing Laboratory in the new ENDEAVOR facility on OSU's campus in Stillwater, Okla. Equipped with a collection of Shimadzu's materials-testing instruments, the space will allow students to characterize materials by utilizing an array of scientific techniques. Shimadzu's suite of instruments includes an energy-dispersive X-ray fluorescence spectrometer and six fully loaded, high-capacity universal test machines.

Steel Dynamics Acquires Kentucky Electric Steel Assets

Steel Dynamics Inc. completed the acquisition of substantially all of the assets of Kentucky Electric Steel (KES), a wholly owned subsidiary of Specialty Steel Works Inc., for $5 million. The acquired assets are located outside of Ashland, Ky., and are comprised of a rolling mill with an annual capacity of 250,000 tons. Steel Dynamics plans to reopen the rolling mill, which was closed earlier this year by the prior owner, in November 2018. The facility will be operated as part of Steel Dynamics' Steel of West Virginia (SWVA) operations, which is located within 20 miles of Ashland. The acquisition will provide product diversification for SWVA through the addition of flats and specialty alloy bars.

Equipment & Business News

INDUSTRY EVENTS

Feb. 25-27
MIM 2019 – International Conference on Injection Molding of Metals, Ceramics and Carbides; Orlando, Fla. www.mpif.org

March 10-14
TMS 2019 Annual Meeting & Exhibition; San Antonio, Texas www.tms.org/tms2019

April 9-13
Aluminium Two Thousand – 11th World Congress on Aluminium; Treviso, Italy www.aluminium2000.com

April 27-30
CastExpo & Metal Casting Congress 2019; Atlanta, Ga. www.afsinc.org/tradeshows/castexpo-2019

April 29-May 1
Ceramics Expo; Cleveland, Ohio www.ceramicsexpousa.com

May 6-9
AISTech 2019; Pittsburgh, Pa. www.aist.org/events/aistech-2019

May 6-8
Aeromat 2019; Reno, Nev. www.asminternational.org

May 13-16
Interwire 2019; Atlanta, Ga. www.wirenet.org/events/interwire

May 20-23
Rapid + TCT 2019; Detroit, Mich. www.rapid3devent.com/

June 23-26
Powdermet 2019; Phoenix, Ariz. www.mpif.org

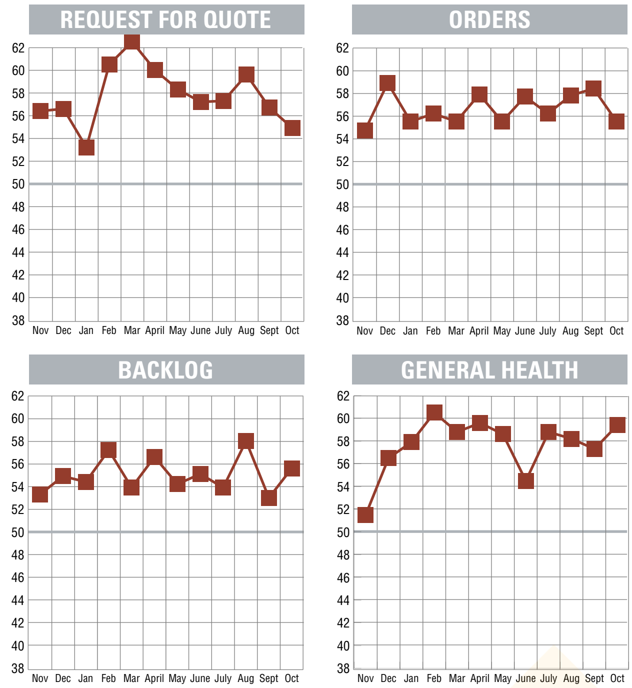
June 25-29
Thermprocess 2019; Düsseldorf, Germany www.thermprocess-online.com/

Sept. 24-27
PMTi 2019 – Powder Metallurgy and Additive Manufacturing of Titanium; Salt Lake City, Utah www.pmti2019.org

Oct. 8-9
MEITECH 2019 (Heating Technology Expo); Queretaro, Mexico www.meitechexpo.com

Oct. 15-17
Heat Treat 19 – 30th Heat Treating Society Conference & Exposition; Detroit, Mich. www.asminternational.org

ECONOMIC 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

Deep Cryogenic Treatment for Marine and Oil-and-Gas Applications

**Jack Cahn – Deep Cryogenics International;
Nova Scotia, CANADA**

Cryogenic treatment of metal offers breakthrough reductions in wear and corrosion to users of marine components – lowering maintenance and capital replacement cost and increasing operational uptime. The technology has languished in the starting gate since WWII, however, and only recently emerged as a way to address wear and corrosion in post-heat-treated items.

This article will explore the benefits of deep cryogenics, why the technology stalled and where it can be next used by the oil-and-gas (O&G) and marine communities.

The Problem

Increasing the tensile and yield strength of carbon-steel wires and fasteners without increasing hardness is a constant challenge faced by heat treaters who support marine, wind and O&G industries. Subsea bolts, risers and umbilicals used on Christmas trees, BOPs, offshore platforms and tethers are constantly exposed to salt-water corrosion and wear. Although these items often fail due to assembly over-torquing or manufacturing defects, insufficient mechanical strength and stress corrosion cracking (as a result of hydrogen embrittlement) are frequently the root cause.[1]

A common solution to improve ultimate tensile strength is to increase the hardness of carbon-steel wire and fastener hardware via the austenitizing and quenching process. This assumes that higher hardness is beneficial to carbon steel operating at high temperatures, where it generally fractures in a high-toughness, ductile manner. But carbon steel operating in low-temperature marine environments fractures in a low-toughness, brittle manner. Therefore, increasing hardness is counterproductive to deep-water material longevity.

Exotic-alloy substitutions help, but the higher price and limited supply chain present barriers. Carbon steel is cheaper and widely available, but the alloy is often entrained with hydrogen, which is diffused along grain boundaries and can't meet longevity or performance requirements in subsea environments.

The Solution – Deep Cryogenics

Deep cryogenic treatment (DCT) is a cold-temperature process that reduces corrosion, wear, fracture and fatigue in most metal items by 20-70%. Thermo-kinetic exchange occurs during a prolonged time and temperature exposure to -310°F dry-nitrogen vapor (Fig. 1) and imparts mechanical improvements.

The resulting metallurgical changes are retained austenite to martensite conversion (ferrous materials) and a non-reversal precipitation of primary and secondary eta carbides at the grain level. Despite multiple attempts using scanning electron microscopy, TEM, EBSD and nano-characterization, the mechanistic origins of the deep cryogenic phenomena behind

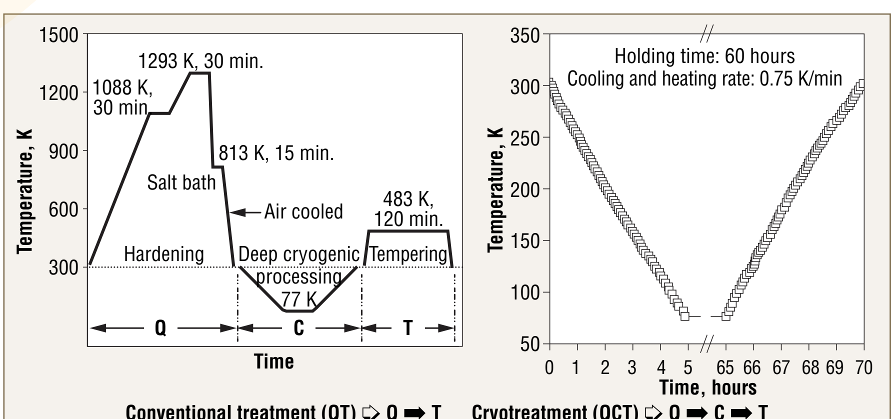


Fig. 1. Sample deep cryogenic treatment process. Each material requires a different procedure.

this improvement are unknown.

What standard ASTM destructive and nondestructive testing does show is that DCT:

- Increases tensile and yield strength in carbon- and bearing-steel alloys by 10-20% (Fig. 2)
- Reduces corrosion in high-carbon steel by 20-60% (Figs. 3 & 4)
- Reduces low- and high-carbon wear effect on some steels by a minimum of 30% (Figs. 5 & 6)

Industrial applications include oil and gas, marine, turbine, almost all additive-manufactured items, automotive, electric vehicles, wind and tidal energy. DCT addresses the greatest challenge facing all manufactured items — extending operational life.

How It Works

Items are placed in a specially designed tank and slowly cooled from ambient temperature down to -310˚F, cold soaked in a dry atmosphere over an 18- to 60-hour period and then slowly returned to room temperature before one to three annealing steps (needed to eliminate hydrogen embrittlement). The entire process takes three to four days, costs approximately 5% of the original item to double the wear and corrosion life, can be performed in bulk and can treat parts weighing up to several thousand pounds. The DCT process is nontoxic, uses no chemicals and generates no hazardous or environmental waste.

Effective on raw material, castings, forgings and additive-manufactured and fully machined parts, it affects the entire through-core material, as distinct from surface treatments or applied coatings – maintaining wear protection even after coatings have eroded. The process generally (but not always) follows heat treatment and improves steel, aluminum, copper, titanium, refractory alloys and metal-matrix composites. The effect is more pronounced in single- versus dual-phase steels. DCT is fast, effective, low-cost and green. It is supported by over 25 years of quantitative scientific research from leading international universities. The process is currently at TRL 3-5 and is scalable to large industrial use.

History and Equipment

DCT has evolved greatly since WWII, when liquid nitrogen was experimentally poured on aircraft forging dies in primitive attempts to increase wear life. This often initiated fatigue cracking and fracture in those die sets when exposed to thermal shock. Between 1980 and 2000, technology advancements

	Yield KSI	Peak % strength		Strain stress	Reduction elong. @ break
		KSI	%	%	%
No cryo 52100, baseline	268	359	2.5	3.9	6
Cryo 52100, cryo then tempered	317	382	1.6	3.5	1
Cryo 52100, tempered then cryo	320	376	1.8	3.8	4.5
No cryo 4340, Baseline	221	295	15.3	12.5	51.7
Cryo 4340, cryo then tempered	240	300	14.2	11.6	51.3
Cryo 4340, tempered then cryo	221	287	15.9	12.3	51.6

Fig. 2. Deep cryogenic treatment of 52100 and 4340 steels showed a 20% increase in yield strength for cryo-treated steel.

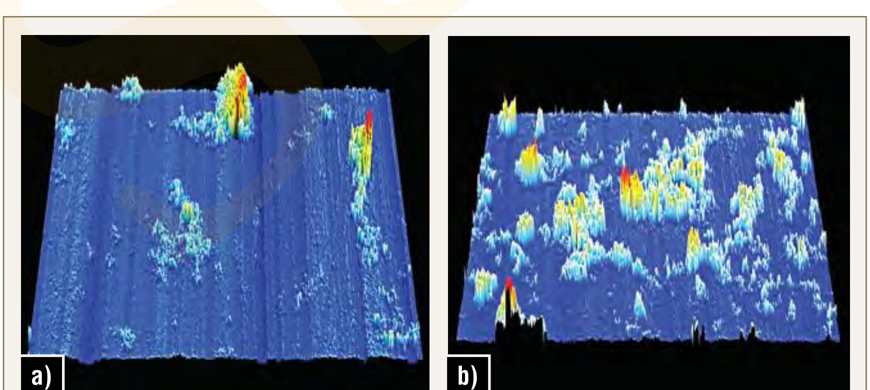


Fig. 4. Uniform surface-corrosion test of 4340 steel. Test was 18 hours in 3.5% NaCl with a result of 64% (volumetric) reduction in corrosion with cryo (a) vs. non-cryo (b).

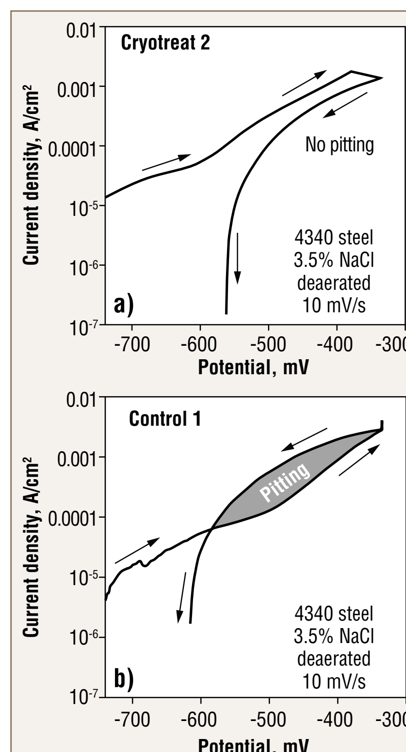


Fig. 3. Potentiodynamic pitting-resistance test of 4340 for 36 hours in 3.5% NaCl for three cryo-treated coupons (a) and three non-cryo coupons (b).

including digital-controlled liquid N_2 supply, use of dry-nitrogen vapor, PID optimization and in-situ annealing capability vastly improved DCT processing results. However, small-size tanks are the norm – the largest commercially available being 3 x 3 x 6 feet. Among other reasons, small equipment size has effectively throttled industrial use.

Barriers to Entry

Until recently, widespread adoption of deep cryogenics has been hampered for the following reasons:

- No known test or qualification methods
- No engineering-based standards for deep cryogenic qualification or acceptance
- No large-capacity DCT tanks available to treat industrial size or quantities of parts
- No providers of scale-up treatment tanks or treatment services

Out of approximately 130 DCT captive or job-shop providers in the world, no facility offers on-site test, validation or certification documenting authenticated DCT of parts or actual measurement of the wear/corrosion improvement.

Unlike heat treating, which performs in strict accordance with hundreds of ASTM, Nadcap, AMS and MIL-STDs, nothing of the kind exists in the deep cryogenic industry. Instead, customers must rely on the DCT service provider's word and a receipt for payment as anecdotal proof of treatment, hence the lack of industry acceptance when no formalized test, qualification or acceptance occurs. Imagine the outcry if parts in an airplane, car or power plant were not built to standards or process testing never occurred!

As a result, almost all end users are individuals with small-size parts and small-scale demands – not military or industrial companies that drive large R&D efforts or downstream commercialization. Consequently, scale-up equipment has only recently emerged, and these large tanks almost certainly require on-site liquid-N_2 production as well as test equipment to be effective in remote locations. These barriers to market entry are high.

Qualification

Qualification agencies DNV-GL and Lloyd's have both issued proposals charting the future application of this technology within the O&G community. Because use of DCT doesn't change sources of supply, material type, manufacturing method, dimensional tolerance or even end use, qualification time can be compressed in the traditionally conservative energy industry.

A key benefit is that DCT can be added to existing manufacturing processes without changing, modifying or eliminating any of the prior steps. A recent USPTO patent issuance may further change acceptance protocols by advancing both destructive and nondestructive testing of artifact coupons that accompany each DCT lot, the use of established ASTM tribology and corrosion procedures to qualify the proxy coupons, and

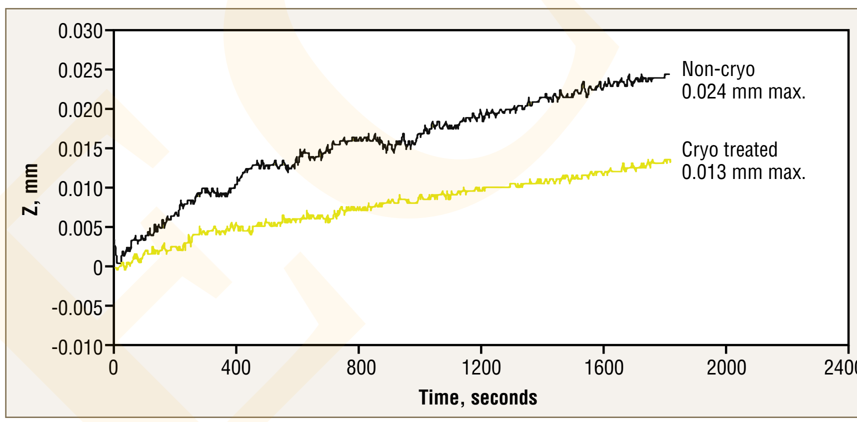


Fig. 5. Pin-on-plate wear-depth comparison. Test showed 84% reduction in wear depth during 30-minute self-mating test.

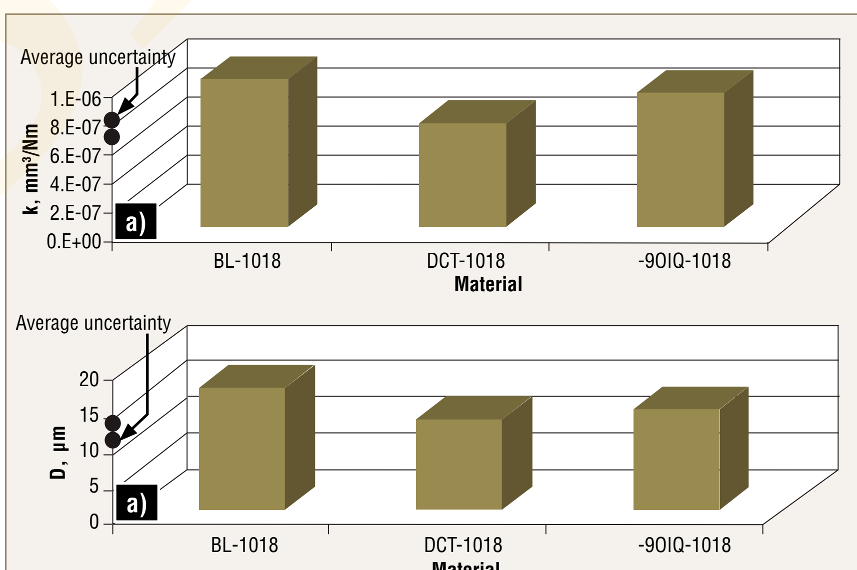


Fig. 6. High-load ball-on-disk tribological testing for 1018 steel showed an average wear rate (a) reduction of 30% for cryo vs. non-cryo. Similar trends were observed for average wear depth (b).

reliance on high-quality optical profilers and tribology testers to provide absolute and parametric certification data.

Opportunities

Numerous marine assemblies – such as power plants, transmissions, subsea risers, umbilicals, drill string and pipe – are an excellent match for improvement by deep cryogenics. But DCT of abrasive wear components including drilling bits, valve and erosion sleeves, thrust bearings, injector nozzles and gears are even better insertion points because they allow the substitution of low-cost carbon steel for expensive superalloys and tungsten-carbide products.

Mining operations can expect significant uptime increase and maintenance decrease by DCT of crusher teeth, mill liners, pump-box nozzles and slurry pipe – items that often fail due to erosion corrosion, rolling-contact fatigue, mechanical-induced fatigue or gouging/high-stress abrasion.

Summary

Deep cryogenics will allow heat treaters and end users to sharply reduce wear and corrosion effect on marine and industrial items. The technology has now come of age with the introduction of engineering-based acceptance standards, known destructive/nondestructive testing, large-size tanks and certification protocols.

The first companies to purchase and implement a scale-up DC tank and test/certification protocols will likely gain the first-mover advantage. This step-change in thermal treatment of metals will pass on to customers reduced operational downtime, lower maintenance/capital-replacement cost and increased net profitability. A disruptive technology that has finally arrived.

For more information: Contact Jack Cahn, president, Deep Cryogenics International, 5266 Highway 329, Hubbards, Nova Scotia, Canada B0J 1T0; tel: 902-329-5466; e-mail: jack@deepcryogenics.com; web: www.deepcryogenics.com

Reference

1. "QC-Fit Evaluation of Connector and Bolt Failures - Summary of Findings," BSEE Office of Offshore Regulatory Programs, Aug. 2014

Use this QR-Code to read more about heat & corrosion resistant materials/composites. Or visit www.industrialheating.com/topics/2657

7 Ways a Data Logger Can Cut Your Costs

Stew Thompson – CAS Dataloggers Inc.; Chesterland, Ohio

Data loggers are devices that collect data by taking physical or electrical readings from external or internal sensors over an extended period. They're an ideal way to monitor, record and alarm temperature and other measurement values, removing the need for personnel to spend time taking measurements themselves.

We answer some helpful questions and offer seven ways in which you can save money and time by using automated data collection.

What does a data logger do?

Data loggers are an ideal way to record temperature, humidity, current/voltage and many other types of data. If you need to log more than one measurement value or analyze the data in detail, there are many multichannel models available for your specific needs.

Additionally, intelligent data loggers (more on these later) can even perform command functions, such as telling a PLC to shut off at a certain time. For example, Series 3 dataTaker data loggers feature universal input channels to connect with almost any sensor type.

Why use a data logger?

Data loggers are typically used to monitor furnace/process temperature, particularly on the weekend or outside of work hours. However, data loggers are also used for more complex tasks such as recording data from machines for diagnostic purposes or to identify areas for energy savings.

Another major reason to use a data logger is to comply with specifications such as CQI-9, Nadcap and AMS 2750. Data loggers document product temperature data for use in electronic documentation, proving to inspectors and auditors that your heat-treat process maintained the required temperature tolerance.

Data-Logger Types

Broadly speaking, industrial temperature-monitoring data loggers can be divided into two categories.

- Single-input data loggers are designed to measure one specific parameter, such as temperature. These loggers are available with one to eight channels and are ideal for simple applications where cost is a concern.
- Universal-input data loggers are available with channel capacity in the hundreds. Combined with their ability to accept multiple sensor types, they can be used to record data from multiple points on a piece of equipment or within a process.

What do you need to measure?

Now ask yourself, "What type of data do I need to measure?" Most commonly, the answer is temperature. But what if you need to log humidity instead, or what if you need to log both temperature and carbon dioxide levels? Fortunately, there are a wide variety of devices on the market with internal or external sensors to measure whatever data you need.

While some data-logger models are designed to log just one measurement value, such as temperature, there are models recording two, three or more types of data. For example, data loggers are available for the following types of signal inputs: temperature, relative humidity, voltage/current, pressure, event/state, frequency, PH, pulse, serial and more.

How can data loggers save costs?

1. Remote notification/alarms via email or text message
2. Ability to trigger actions from external events (i.e., PLC, SCADA)
3. Ability to measure most types of sensors using only one device
4. Stand-alone operation allows it to log on by itself.
5. Local alarm outputs to notify operators or to trigger other equipment
6. Gauge worker and machine productivity by shift, week or month

7. Gather data on your industrial process. For example, heat-treatment processes can improve process quality by using temperature data to create furnace temperature profiles.

Remote Alarms Save Your Products

By continually monitoring product temperature, data loggers ensure that you will get an e-mail or text alarm the instant that your process goes outside designated temperature tolerances. This feature alone can pay for the logger by helping to avoid a disastrous loss of product or a costly process delay.

How technical do I need to be?

Good news! Most data loggers are easy to use. Data loggers typically use Windows-based software to handle setup and configuration. Simply connect your data logger to a PC, follow the simple configuration wizard, and pick your recording rate and start time. All of this normally just takes a few mouse clicks.

Designed for simple operation, many compact data loggers require minimal to no maintenance or IT department involvement. That makes them ideal for use in nearly every industry and application.

Easy Data Retrieval

Typically, data loggers save their measurements to a memory card or flash stick for convenient retrieval. More advanced models can also transfer the data automatically over your choice of communications. These include but are not limited to:

- USB
- Ethernet
- Cellular modem
- FTP (file transfer protocol)
- Wireless
- Bluetooth
- Cloud storage servers

Intelligent Data Loggers

Today's intelligent loggers also incorporate the ability to perform calculations on the measured values. This can be as simple as calculating and recording the difference between two measured values – for example, the temperature of fluid coming into and flowing out of a heat exchanger or integrating the output of a flow-rate sensor to compute total flow volume. Combining this with flexible scheduling capabilities enables an intelligent data logger to capture instantaneous flow rate plus flow volume totalized on an hourly, daily, weekly and/or monthly basis. Of course, this could be done in a spreadsheet, but wouldn't it be much easier to download a file once a month that already had all the data summarized in a form ready for presentation or archiving?

Finally, a very powerful feature of intelligent data loggers is flexible alarm programming. While many data loggers allow simple alarms based on whether a value is above or below a preset limit, intelligent data loggers provide greatly expanded capabilities including alarms that are based on the value of multiple inputs, rate of change of an input, calculated values, time of day or a combination of all of these. These alarms can do much more than simply throw up a flag. They can enable or disable other measurements, turn one or more outputs on or off, send an email or text, or change the operating mode of the logger.

By using the capabilities of a modern intelligent data logger, it is possible to minimize the amount of raw data that must be manually analyzed and to maximize actionable data that contains the essential information that the user was after when they installed the logger. Alarms can be configured to provide immediate notification of out-of-limit conditions while minimizing the number of false trips.

How do you get started?

We work every day with callers to provide them with the ideal solution for their businesses. We want to help you select the most appropriate product for your application, no matter what field. Free technical support is also standard on all of our products.

For more information: Contact CAS DataLoggers, 8437 Mayfield Rd. Unit 104, Chesterland, OH 44026; tel: 440-729-2570; e-mail: sales@dataloggerinc.com; web: www.dataloggerinc.com

The Benefits of Vacuum Sintering

Andrea Alborghetti – TAV VACUUM FURNACES SPA; Caravaggio, ITALY

Vacuum sintering is one of the unsung heroes of industrial metallurgy. In this crucial process, materials are heated in a vacuum environment until they are almost at the point of melting. As heat is applied, the materials become compacted, creating new materials with completely different properties.

Fig. 1. Sintering furnace *(courtesy TAV VACUUM FURNACES)*

What is the right way to carry out the sintering process? This quick run-through of vacuum sintering will provide a solid grounding for companies that want to introduce it into their operations.

First Things First: Why use vacuum sintering?

At its root, vacuum sintering involves two things: a vacuum furnace and a combination of metallic powders. By using one properly and mixing the other in the right proportions, several useful properties can be promoted.

For instance, sintering can create metallic compounds that reduce the incidence of component failure in machinery or vehicles. And it is also very useful in creating components that demand high porosity – such as in plumbing or systems involving ball bearings. So if you need to strengthen a product or alter its porosity, sintering is often the best option available.

However, it's important to remember that sintering generally cannot happen before another important process has taken place: debinding. And the two processes go together when planning purchasing decisions.

Debinding: An Essential Preparation for Sintering

Debinding prepares materials or components for vacuum sintering, and it needs to be done thoroughly. All components will have impurities, often as a result of injection-molding processes. When these impurities are left on the surface of the component, they can easily contaminate the binding process.

Debinding refers to the removal of "binders," which are deposited during production processes. Done poorly, it can result in blistering of component surfaces or the creation of pores that cannot be removed during the sintering phase.

That's why it really matters how debinding is carried out. The exact process used depends completely on what type of binder is present. It could involve the use of specialist solvents but almost always involves decomposition of organic binders through heat treatment, generally at temperatures of 150-600˚C (300-1110˚F). Multiple passes through the furnace are often needed to ensure that all binder has been removed, and it pays to be cautious because even trace amounts can contaminate the sintering phase.

At this stage, an important consideration enters the equation: Should you use the same vacuum furnace for

Fig. 2. Open sintering furnace *(courtesy TAV VACUUM FURNACES)*

sintering and debinding? This is a vital question because it influences the cost of the process and the likelihood of success. So it's definitely worth considering in more detail.

Should you combine your sintering and debinding furnace?

Several factors come into play when making the decision about whether to combine your sintering and debinding furnace.

First, it's important to bring the fragility of your components into the picture. When components undergo debinding, the stripping of binders and the heat involved can leave them much more frail and prone to breakage than before. Moving many components between furnaces can result in losses as these parts fail, making a single furnace more advantageous. However, it's important to note that this can often be resolved by applying a presintering stage in the debinding furnace.

Ensuring a clean process is also absolutely essential. At no stage do you want contaminants interacting with the sintering chamber. So, on the face of it, sintering and debinding appear to be in conflict. Debinding removes impurities, making it inherently "dirty," but that isn't the end of the story. In many cases, the binders being removed can be kept separate from sintering powders when proper processes are followed (see the section on boxes).

Cost concerns also matter. Not all factory owners can afford to run both sintering and debinding furnaces, particularly when the volume of material being processed is relatively low.

Time comes into play as well. In general, sintering is far quicker than debinding, but the gap varies depending on the materials being used. If the gap is large, then a far-larger debinding furnace will be needed so that the production line can maintain a steady pace. In those cases, having separate furnaces makes sense.

Manpower has to be considered too. In smaller production facilities, combining sintering and debinding furnaces can allow companies to make best use of their human resources. When staff doesn't need to move components around or manage two furnaces, they can be much more productive.

Fig. 3. Sintering furnace *(courtesy TAV VACUUM FURNACES)*

Finally, energy costs matter. In many cases, combining the two vacuum furnaces results in energy-efficiency gains, driving down costs. If done properly, there will be far less need to cool and heat the furnace – the main consumer of energy in the process.

So, there are arguments for or against using separate debinding and sintering furnaces. In general, if you have challenging debinding requirements or you are particularly concerned about the fragility of components, a separate furnace will be advisable. However, if these don't apply, you may be able to realize cost and energy savings by combining furnaces without compromising the quality of the product.

How to Choose the Right Furnace Insulation

When choosing your sintering furnace, insulation is one of the most critical factors. There are two major types of insulation to pick from – metallic and graphite – and both have their own special properties.

The shielding on metallic chambers is usually made from molybdenum, tungsten or stainless steel. They can cater for a range of temperatures (with tungsten useful for high-temperature processes and molybdenum better for lower-heat levels). But the real strength of metal chambers is purity. Unlike graphite alternatives, they have a much lower risk of contamination caused by carburization or wafer degassing. That's why metal chambers are often favored by aerospace firms or medical organizations – where exact purity is essential.

Another strength is cost. Metal chambers often come with a higher initial cost, but this disappears when you factor in shorter pump-down times, quick heating and cooling times, and uniform heat distribution. But molybdenum has its problems. Most notably, it can become brittle at high temperatures and is vulnerable to oxidation, which can compromise the vacuum. So that needs to be considered as well.

Graphite is the other option. Again, it has its own strengths and weaknesses. On the plus side, graphite can operate at very high temperatures (up to 3000°C), has a low density and weight, has excellent emissivity and produces a high degree of uniformity. You can easily replace graphite hot zones and repair shields when needed, while laminate CFC can be added for extra protection. Graphite is useful for most conventional sintering tasks, but it has its negatives. Most importantly, graphite tends to absorb vapors and release micro-particles, particularly if bonded layers are used, so contamination can be a factor.

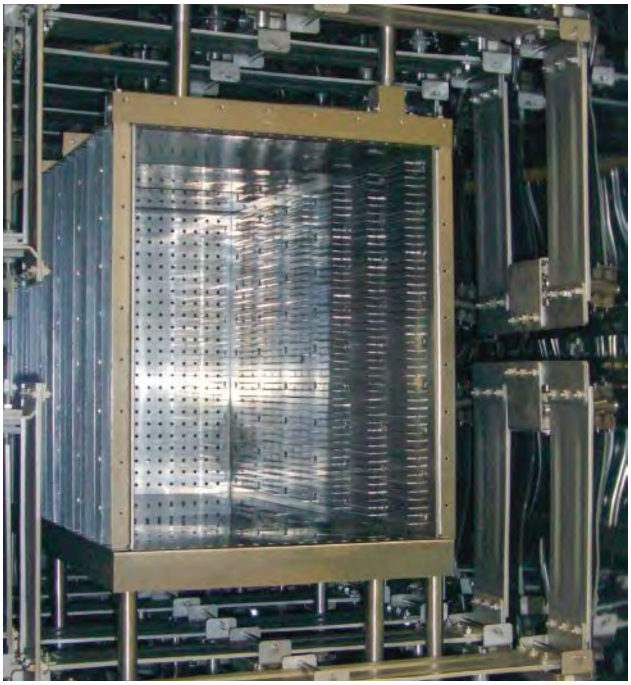


Fig. 4. MIM box *(courtesy TAV VACUUM FURNACES)*

Of course, there's another side to the equation as well: the requirements of the sintering stage. Let's consider that process in more depth.

Pick the Perfect Configuration for Your Sintering Furnace

Aside from insulation, the hot zone also needs to be brought into the picture. Generally, it's important to think about keeping the mass of the hot zone low and finding a system that operates at the right temperature range, with low operating costs and efficient operation at peak power levels.

In terms of dimensions, a square cross section ensures optimal gas flow through the hot zone and also tends to reduce costs when compared to useful volume. You can be flexible here, depending on what needs to be processed. If very high temperatures are needed, however, you will have fewer options. In these cases (over 2000°C), a suspended cylindrical resistor supported by current feed-throughs is often the only option.

Gas-flow distribution is also something to consider, and here you have three broad options: gas-flow distribution with a box, without a box or no distribution at all.

Distribution with a box allows operators greater control over gas flows. Keeping a slightly higher pressure outside the box helps to prevent contamination of the heat zone by debinding products. By pumping gas directly into the box, users can keep the gas flowing over sintered components as pure as possible, resulting in fewer failures and a purer result. This tends to be the best solution for setups where debinding and sintering take place in the same furnace.

However, vacuum sintering can also take place without a box. In this case, gas distribution can be achieved via a series of points within the chamber, ensuring uniformity during the sintering process. This system tends to enlarge the usable volume of the chamber and heats and cools faster than boxed versions. It also means that the furnace can be adapted for other tasks such as tempering – a major plus for smaller workshops.

Finally, systems without gas distribution exist as well. These basic systems can be created by upgrading conventional furnaces but are not suitable for high-end specialist sintering tasks.

Choose the Optimal Loading Strategy

If you've chosen a boxed gas distribution system, loading is the final thing to think about (if not, you're ready to make a furnace purchase or arrange an upgrade). The main issue here is whether to use a fixed or removable box to hold the load during sintering.

As usual, the right solution depends on your needs. Removable boxes suit operations with a single-flow mode and loads that can be cooled in static gas. In these cases, boxes can be mounted on trolleys, making removal simple and safe.

In more complex furnaces where multiple flows are employed, removal of the box may well be impractical. In these cases, boxes need to be fitted with removable shelves, allowing you to remove the load without disturbing the sintering box. Hybrid solutions are also available that feature removable head frames that slot into fixed casings, providing a middle ground. Be aware that these hybrid systems can occupy more chamber space with effects on its thermal efficiency and usable volume, however, so they aren't common.

Start Planning Your Debinding and Sintering Operations Today

Hopefully, you now have a clearer idea of whether you want to combine debinding and sintering processes, the size of the furnace you require, the kind of insulation you need for your thermal chamber and whether you need a boxed or non-boxed configuration.

All of these factors feed into the decision about choosing a sintering furnace, and they all matter. Choose wisely, and you can easily create a cost-effective, efficient sintering process for almost any industrial application.

For more information: Contact Andrea Alborghetti, Vice General Manager, TAV VACUUM FURNACES SPA, Via dell'industria 11-24043 Caravaggio (BG) - ITALY; tel: +39 0363 355711; e-mail: info@tav-vacuumfurnaces.com; web: www.tav-vacuumfurnaces.com

Opportunities Abound in Induction Heat Treatment

Collin A. Russell – Inductoheat Inc. – An Inductotherm Group Company; Madison Heights, Mich.

The utilization of electromagnetic induction for heat-treatment purposes is no longer a novelty. However, the current excitement associated with induction heat treatment may suggest otherwise.

A combination of factors including efficiency and environmental initiatives in automotive and aerospace manufacturing, innovations in induction power supplies and advancements in the simulation of induction heat-treatment processes suggests a "golden age" of induction heat treatment is on the horizon.

Efficiency and Environmental Advantages

In an era of environmental consciousness and cost reduction, the fundamental physics of electromagnetic induction make it a highly attractive heat-treatment (and general thermal-processing) method. Induction heating is a direct heating method in which thermal energy is generated within the heated component – as opposed to transferred to it from the environment. Because induction heating results in both surface and subsurface heat generation, rapid heating and high thermal efficiency are generally achievable.

Induction heat-treatment processes also typically deliver high electromagnetic efficiency. For hardening ferromagnetic materials such as carbon steels and martensitic stainless steels, this efficiency is often on the order of 70-80% (for tempering such materials, this figure can approach 90%). Induction hardening also does not involve the diffusion of chemicals into components. For this reason, induction is often considered a "cleaner" hardening method relative to thermo-chemical alternatives such as carburizing and nitriding.

Induction Power-Supply Innovation

The development of HF transistor power supplies in the 1950s and 1960s dramatically and positively altered the future of induction heat treatment. The introduction of simultaneous dual-frequency power supplies in the late 1990s and early 2000s provided a significant improvement in induction hardening capability, particularly with respect to hardening small-to-medium gears. Very recently, after nearly two decades of relatively minor advancements in induction power supplies, a revolutionary technology – an inverter capable of practically instantaneous, in-operation frequency modulation – was introduced.

In an induction heating process, the frequency of the applied electromagnetic field (i.e., the frequency of alternating current passing through the induction coil) influences the depth in which thermal energy is generated in the heated component. The depth in which the majority (approximately 86%) of induced heat generation occurs in a body conducting alternating current is often called the skin depth. Skin depth (δ) is a function of the body's electrical resistivity (ρ) and magnetic permeability (μ) and the frequency (F) of the applied magnetic field. It can be approximated by:

$$\delta = \sqrt{\frac{\rho}{\pi \mu F}}$$

Practically speaking, this means that the selection and manipulation of frequency is the only means of controlling the depth in which heat generation occurs in an induction

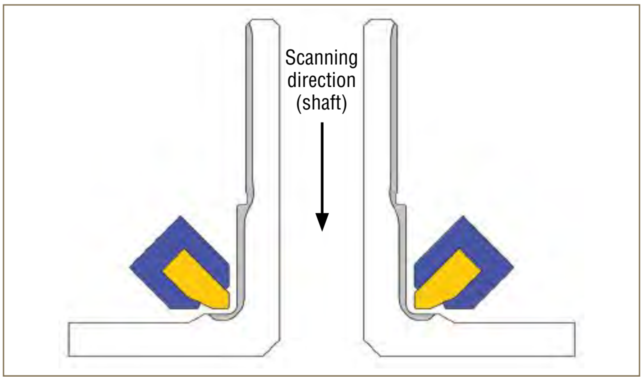


Fig. 1. Scanning process for hardening a medium-carbon steel (SAE 4140) shaft

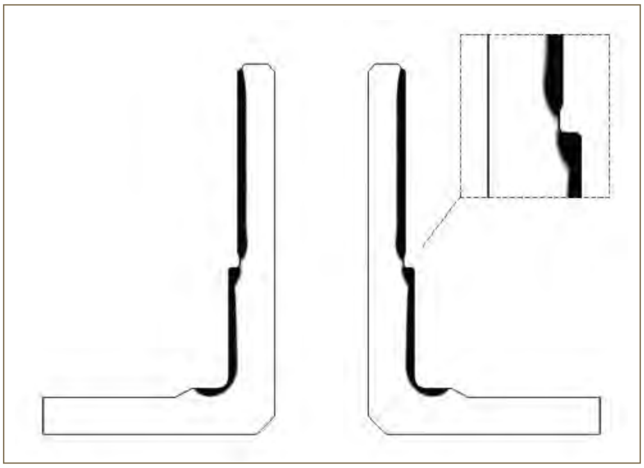


Fig. 2. The process provides good results along the majority of the hardened length of the component, but there are problems in the diameter transition area.

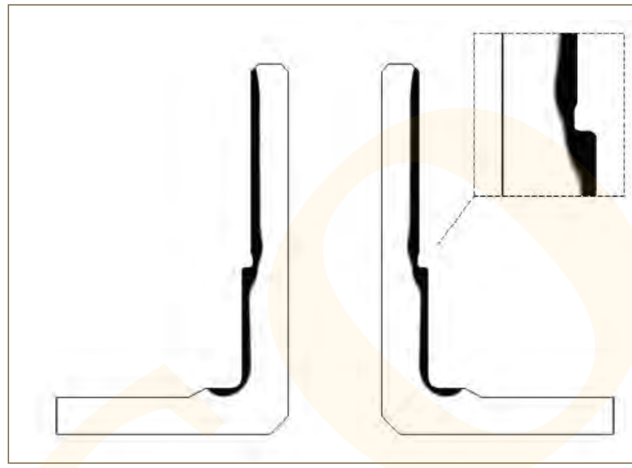


Fig. 3. Increasing the temperature in the internal corner without doing so in the external corner is achievable by altering frequency when heating the diameter transition area.

heated component. Accordingly, the ability to measurably and deliberately change frequency during a heat-treatment process, a characteristic unique to Inductoheat's IFP™ (Independent Frequency & Power) inverter, represents a massive heat-treatment opportunity.

Case Study: Scan Hardening

Scan hardening is a proven application of variable-frequency power supplies. The ability to change frequency is the ideal solution for accommodating variations in geometry and hardening requirements along the length of scan-hardened components.

The process outlined in Figure 1, a scanning process for hardening a medium-carbon steel (SAE 4140) shaft, provides a convenient case study. This shaft, representative of many modern automotive components, is hollow, features a flanged end and includes an appreciable change in diameter. The diameters above and below the transition are approximately 45 mm and 50 mm respectively.

This 5-mm-diameter change, which is large relative to the required case depth, creates inherent electromagnetic and thermal challenges. In the internal corner of the diameter transition, it is inherently difficult to induce sufficient heat generation to overcome the conduction of heat into the relatively large surrounding mass. The presence of a 0.5-mm undercut, which effectively increases the localized coupling between the coil and component, provides an additional obstacle. Meanwhile, the external corner can easily be overheated because it protrudes outward into the path of the magnetic flux lines looping around the single-turn coil.

If a single frequency were selected for hardening this component, 30 kHz would be a likely choice given the effective case-depth target of approximately 2 mm. As shown in Figure 2, this process provides good results along the majority of the hardened length of the component, but there are problems in the diameter transition area.

Due to insufficient austenitization (i.e., heating), very little martensite formation is projected in the undercut. Increasing coil power and/or effective heating time in this region may seem like logical corrective actions. However, this would further increase the peak temperature in the adjacent external corner. Given that this temperature is already on the order of 1060°C (1940°F), further temperature increase could produce undesirable (and potentially unacceptable) localized grain coarsening.

Increasing the temperature in the internal corner without doing so in the external corner is a seemingly paradoxical task given that these features are separated by just 3 mm. As shown in Figure 3, however, this is achievable by altering frequency when heating the diameter transition area (i.e., when the coil is directly adjacent to this feature).

A reduction in the inverter output frequency from 30 kHz to 10 kHz, which increases the skin depth in the component by a magnitude of about 1.7, simultaneously alleviates the electromagnetic proximity challenge in the internal corner and reduces the risk of overheating the external corner. This variable-frequency process provides a significant increase in case depth in the undercut while reducing the peak temperature in the adjacent shoulder by almost 40°C.

This case study, while relatively simple, illustrates one of the quality advantages afforded by variable-frequency scan-hardening systems. If this component featured substantially different case-depth requirements along its length, the ability to modulate frequency would have additional benefits. Furthermore, while outside the scope of this article, IFP technology also offers quality and flexibility advantages in various other applications including horizontal continuous hardening, spin hardening (of gears and sprockets) and tempering/stress relieving.

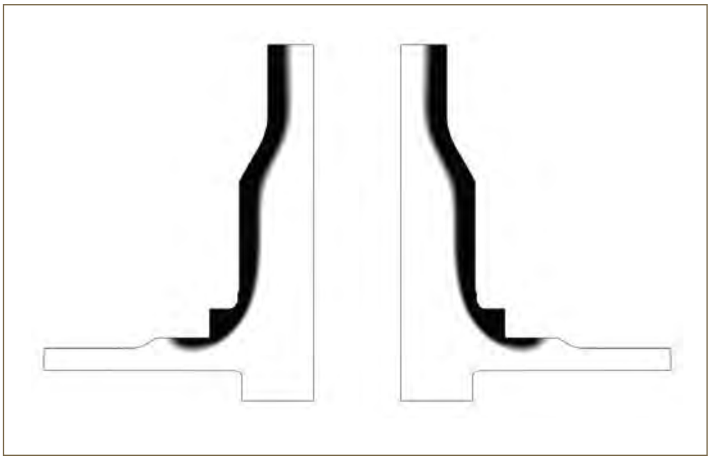


Fig. 4. In a single-shot hardening process, the entire region of the component is heated using an induction coil that induces both circumferential and longitudinal current flow.

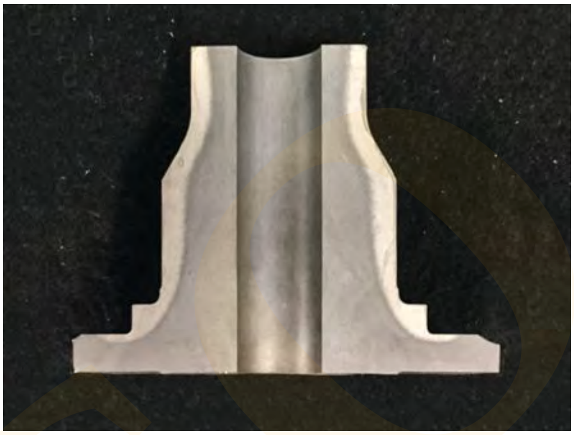


Fig. 5. Continuous improvements in software functionality and the increasing affordability of computational resources are reshaping the practical feasibility of conducting complex, resource-intensive simulations.

Integration of Simulation into Equipment, Process Design

Incorporating computer simulation into the design of induction heat-treatment systems can provide improved product quality, reduced engineering time and manufacturing costs, and faster process development. These advantages, however, can be easily negated by the amount of time required to create a representative model and compute numerical results.

In certain applications, particularly those that require 3-D simulation, the amount of time required to obtain useful information from simulations is simply impractical. Fortunately, the increasing capabilities of simulation software and decreasing cost of computer hardware are diminishing this barrier.

Case Study: Single-Shot Hardening

In a single-shot hardening process, the entire region of the component that is to be hardened is heated using an induction coil that induces both circumferential and longitudinal current flow (Fig. 4). Rotation of the part during heating and quenching promotes circumferentially uniform hardening results. The ability to simulate single-shot hardening processes reliably and in a reasonable amount of time offers manufacturers and users of induction heat-treatment equipment substantial value because:

- Single-shot hardening is a very common induction heat-treatment process.
- The design of single-shot coils is much less intuitive than that of most other induction hardening coils.
- Hardening results are predominantly determined by the geometry of the coil, as opposed to process parameters (unlike scan hardening).
- Coil fabrication costs can be considerable, especially taking into account the iterative modifications often associated with trial-and-error design.
- Single-shot coils are often subjected to very high power densities and can therefore be prone to premature failure.

Unfortunately, the physical characteristics of single-shot hardening processes necessitate 3-D electromagnetic-thermal simulation, and the amount of time required to set up 3-D finite-element models and compute accurate solutions has historically been quite prohibitive. For this reason, the simulation of single-shot hardening processes is still quite rare in industry.

As illustrated in Figure 5, however, this reality is changing. Continuous improvements in software functionality and the increasing affordability of computational resources are reshaping the practical feasibility of conducting these complex, resource-intensive simulations. Both manufacturers and users of induction heat-treatment equipment are reaping the rewards.

For more information: Contact Collin A. Russell, software modeling design engineer, Inductoheat Inc. – An Inductotherm Group Company, 32251 N. Avis Dr., Madison Heights, MI 48071; tel: 248-629-5024; e-mail: crussell@inductoheat.com; web: www.inductoheat.com

THE PRODUCT ROUNDUP

The Product Roundup is a showcase of some of the best products and technologies the thermal-processing industry has to offer. *Industrial Heating* has rounded up these advanced, energy-efficient and cost-effective items in one special section for easy reference.

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 heating from a distance with high efficiency. Mid-frequency induction heaters are good for heating, melting and surface heating mid-sized parts. Low-frequency induction heaters are designed for heating large-sized parts. **www.acrossinternational.com**

Ajax TOCCO Magnethermic

Ajax TOCCO Magnethermic designs and manufactures custom induction heating systems for all metal industries. Heat-treating systems include: tooth by tooth gear scanners, vertical and horizontal scanners, lift and rotates, single shot and unique applications. Metallurgical, technical and product experts develop systems and processes for each customer and part. Hardened areas are precisely controlled in case depth, width, location and hardness. Distortion is reduced by precise heating and quenching. **www.ajaxtocco.com**

Applied Test Systems

Applied Test Systems (ATS) has been a leading manufacturer of process heating and materials testing equipment since 1965. Customers looking for a unique lab furnace or industrial oven can depend on over 50 years of reliability, backed by our expertly trained team of service and repair technicians. We offer an extensive range of customizable options and accessories, including but not limited to: load train ports, thermocouples and connectors, mounting accessories and temperature control systems. **www.atspa.com**

Dry Coolers Inc.

PAC Series Process Chillers

Omni-Chill™ PAC series are complete with pump, tank and controls. Designed for induction processes, these nonferrous units feature high reliability in industrial environments. Oversized condenser and air filters, easy access for maintenance, small footprint and easy installation make our PAC chillers the right choice. **www.drycoolers.com**

G-M Enterprises

Vacuum Furnaces

G-M presents our unique vacuum-furnace technologies designed for low maintenance and high performance. Patented 2-point element support, high-velocity venturi gas-cooling nozzles, true convection heating and cooling with gas exchange in/out of the hot zone, power feed-throughs and 20-bar furnace with advanced computerized control systems. **www.gmenterprises.com**

Induction Tooling Inc.

Induction Tooling Inc. is ISO/IEC accredited for mechanical testing. Since our core business for 42 years has been the design, fabrication and repair of heat-treat inductors and associated tooling, it made sense to integrate our induction and metallurgical laboratories. The induction laboratory is a valuable extension of our services, allowing us the ability to not only design and fabricate high-quality inductors but also characterize them on-site. The metallurgical laboratory will record process parameters for production and formally validate the results in a format that can be submitted directly to the end customer. **www.inductiontooling.com**

L&L Special Furnace Co. Inc.

L&L Model XLE furnaces are highly uniform and controllable electric box furnaces widely adaptable to many applications, including hardening, neutral hardening, solution heat treating, stress relieving, annealing, aging, precipitation hardening and tempering. Brazing, calcining, drying, melting and sintering are some of the other applications XLE furnaces are used for. Although "standard" configurations are made, each furnace is normally fitted with standard and special options to suit specific needs. These include vertical doors, fans, special hearths, racks, baskets, quenching systems, program controls and recorders. **www.llfurnace.com**

North American Cronite

North American 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

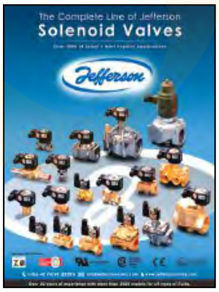
Ipsen

Ipsen's Engineering Team has the experience and resources to design and manufacture innovative, highly technical atmosphere and vacuum solutions that allow you to perform virtually any specialized job. When it comes to advanced engineering, Ipsen works consultatively with the customer to understand their needs, as well as parts and process requirements. Then their team of engineers develops a strategy and tests the product designs early in the process to ensure they provide the best solution.
go.IpsenUSA.com/Advanced-Engineering

Jefferson Solenoid Valves

Solenoid Valves

Jefferson Solenoid Valves offers over 3,000 different valves for applications such as boilers, burners, cooling towers and many others. We also offer a diverse range of liquids and gases such as water, air, steam, oils, oxygen, liquid nitrogen, corrosive fluids and many others. Our products have approvals in accordance with UL 429, UL Hazardous Locations, CSA and is ISO 9001 certified.
www.jeffersonvalves.com



LECO

LECO's AMH55 automatic hardness testing system applies our exclusive Cornerstone® brand software to a variety of hardness testing platforms for superior performance and maximum productivity. Providing a number of versatile automatic features within a touchscreen interface, the AMH55 gives users simultaneous automatic alignment and parfocality of optics, intuitive fly-out menus and an optional Advanced Analysis Module with color contour mapping. **www.leco.com**

Protection Controls Inc.

Combustion Safeguards

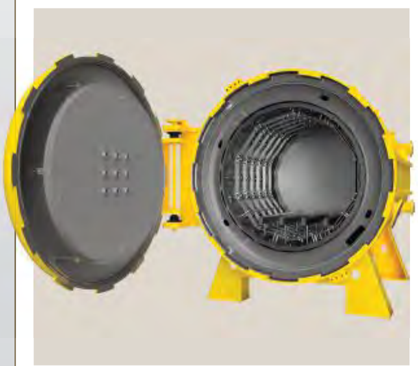
Protection Controls Inc. offers a comprehensive Service Manual covering all Protectofier combustion safeguard units. It provides important and valuable information on installation, service, guides, testing and troubleshooting as well as specifications, features and application on Protection Controls' single and multi-burner units.
www.protectioncontrolsinc.com

SECO/VACUUM Technologies

The CaseMaster Evolution (CMe) integral quench vacuum furnace from SECO/VACUUM is designed with state-of-the-art construction and options for two or three chambers to provide maximum productivity flexibility in heat treating to perform continuous batch processing. With dozens of CME oil quench vacuum furnaces installed, SECO/VACUUM is currently at the forefront of the international vacuum heat-treating market. **www.secovacusa.com**

Solar Manufacturing

Solar Manufacturing introduces an innovative, more thermally efficient hot-zone design utilizing a new graphite insulation board called HEFVAC™. The high density and superior strength of HEFVAC foil-faced board improves thermal efficiency (conductive losses), requires less hardware and reduces moisture absorption. Our unique beveled Z-edge forms tight joints between insulation boards to stop radiation losses.
www.solarmfg.com



Ultraflex Power Technologies

The Ultraheat SM series is an ultra-compact, 5-kW induction heating system capable of delivering full power in the 30-200 kHz frequency range. This series includes a variable ratio output isolation transformer for load matching of a wide range of loads and coils. Other features include: 5 programs with 9 programmable parameters; interface board with digital I/O and analog power control; temperature control with K thermocouple input; and serial interface (RS-232 or RS-485).
www.ultraflexpower.com

Wisconsin Oven

Standard Draw Batch Oven

The draw batch oven features heavy-duty construction, which includes a plate-steel outer shell, a reinforced steel plate oven front, a lined inner shell and exterior structural reinforcements as required. There are 40 standard draw batch oven models offered in 10 standard sizes and four temperature ranges. Standard maximum continuous temperature ratings are 800°F, 1000°F, 1250°F and 1400°F. Applications include tempering, solution treating, aging, annealing, normalizing and stress relieving.
www.wisoven.com

Induction Heaters

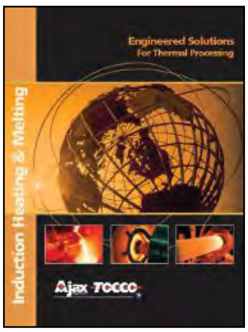
Across International

Founded and based in New Jersey, Across International supplies laboratory equipment in the areas of heat treatment and material processing for universities, research facilities and labs. We have more than 20 years of industrial manufacturing experience with induction heaters, drying ovens, ball mills, lab furnaces and pellet presses.
www.acrossinternational.com

Induction Tooling Facility

Induction Tooling, Inc.

Induction Tooling, Inc. is the world's premier induction tooling facility celebrating over 40 successful years. We specialize in the design, build and repair of selective hardening inductors. Our quick-change designs have become the standard in the industry.
www.inductiontooling.com



Induction Heating Systems

Ajax TOCCO Magnethermic Corporation

Ajax TOCCO Magnethermic Corporation is a world leader in the induction heating, melting and forging industries. Our proven applications include brazing, annealing, hardening, tempering, seam annealing, shrink fitting, curing, forging and melting.
www.ajaxtocco.com

PdMetrics® – The Power of Possibilities

Ipsen

Imagine a tool that allows you to anticipate disruption. A tool that gives you the power to optimize equipment performance and production efficiency. A tool that connects your team to critical information they need to make your business more agile, more competitive. That's the power of Ipsen's PdMetrics® software platform for predictive maintenance. www.IpsenUSA.com/PdMetrics

Materials Testing Equipment

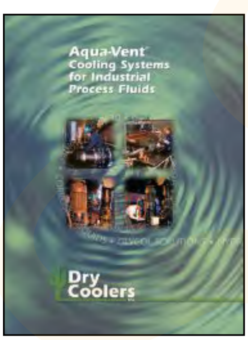
Applied Test Systems

This brochure gives an overview of ATS' extensive line of affordable yet uncompromising materials testing equipment. ATS is large enough to offer an extensive line of standard products. However, it is and always will be flexible enough to custom-tailor any systems for a specific application.
www.atspa.com

Transformers and Reactors

Jackson Transformer Company

Specialists in developing, designing and manufacturing transformers and reactors for the induction heating industry since 1955. Jackson is your one source for all your transformer needs. From 5 VA to 15,000 KVA. From DC to over 1.5 Mhz. Air or water cooled. Open or encapsulated. Jackson transformers are made to your requirements with features designed for – and with – our customers.
www.jacksontransformer.com



Process Cooling Systems

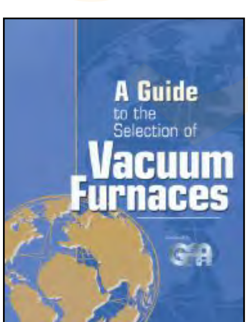
Dry Coolers Inc.

Informative six-page brochure describes closed loop water systems including air-cooled heat exchangers, evaporative cooling towers and mechanical refrigeration chillers. Contains information on complete systems with pumping stations, electrical control panels and optional equipment. Request Aqua-Vent bulletin AV-105.
800-525-8173
www.drycoolers.com

Furnaces & Ovens

L&L Special Furnace Co. Inc.

L&L Special Furnace Co. Inc. designs and builds high-temperature furnaces, ovens, kilns, quench tanks and heat-treating systems. We specialize in batch production furnaces and ovens, particularly applications requiring high uniformity and controlled atmosphere. L&L sells and services equipment worldwide.
www.llfurnace.com



Vacuum Furnace Selection Guide

G-M Enterprises

An (8) eight-page, full-color handout for prospective furnace buyers. The handout is a checklist of considerations when purchasing a new vacuum furnace. Please call for our "Guide to the Selection of Vacuum Furnaces."
Phone: 951-340-4646
www.gmenterprises.com

Combustion Safeguards

Protection Controls Inc.

This comprehensive Service Manual covers all PROTECTOFIER combustion safeguard units. It provides important and valuable information on installation, service guides, testing and troubleshooting as well as specifications, features and application on Protection Controls' single and multi-burner units. For a free copy, fax 847-674-7009.
www.protectioncontrolsinc.com

Vacuum Furnaces

SECO/Vacuum Technologies

A new brochure from SECO/Vacuum Technologies (SVT) describes the company's mission to serve the North American vacuum heat-treatment, brazing, sintering and metallurgy markets with vacuum furnace technologies and support close to home. Innovative technologies, advanced engineering and a unique Value Incentive Program distinguish SECO/Vacuum as an industry leader. www.SecoVacUSA.com

Vacuum Furnaces

Solar Manufacturing

Solar Manufacturing designs and fabricates a full range of vacuum furnaces for heat treating, brazing, carburizing, nitriding and sintering. Energy-efficient hot-zone designs, advanced SolarVac controls and improved quench technologies provide maximum performance.
www.solarmfg.com

Induction Heating Systems

Ultraflex Power Technologies

Ultraflex Power Technologies has been manufacturing induction heating equipment since 2008. We offer the most advanced and innovative digitally controlled technology in the industry. Our high-quality products, global technical support and cutting-edge simulation tools ensure Ultraflex customers get the most out of their induction systems.
www.ultraflexpower.com

Drop-Bottom Furnaces

Wisconsin Oven

Wisconsin Oven manufactures drop-bottom furnaces, quench tanks, age ovens and related equipment for solution treatment of aluminum extrusions, sheet metal, castings and other parts. We serve the automotive, aerospace and other industries. Our equipment is designed to the most stringent specifications.
Contact: 262-642-3938
www.wisoven.com

Lit/Web Showcases

Industrial Heating

Every month, *Industrial Heating* provides a way for you to get your literature or CD into the hands of the entire industry. Qualifying advertisers get a FREE literature showcase! Paid showcases are always available for $750/month for a full-color brochure cover reproduction. Max. 50 words. Contact Kathy Pisano: kathy@industrialheating.com

Thermal Processing Products

Refractory Repair

Plibrico

Redi-Shapes precast shapes are designed to help steel and aluminum makers significantly reduce the time and labor costs required to repair furnace refractory linings. They can be tailor-made to the exact

specifications of a furnace, in any size or configuration, from 10- to 15,000-pound engineered refractories. Custom-firing optimizes shape properties for specific application challenges, such as abrasion, erosion, thermal shock or metal penetration. Redi-Shapes also eliminate the need to tear out major positions of the refractory lining adjacent to the damaged zone. www.plibrico.com

Metals Monitoring System

AMETEK Surface Vision

The SmartAdvisor Edge for Metals cross-section monitoring system enables both trimmed material edges in a metal processing line to be continuously monitored to detect anomalies, such as cut-to-break ratios and burrs. This is critical for quality-control purposes and to avoid any issues in the subsequent processing line. Specifically designed for the metals industry, the system magnifies, captures, stores and presents high- resolution images of the edges, while the line is running at full production speed, as a continuous smooth video stream for monitoring. The edge images are processed and stabilized for analysis so that an operator can see subtle changes in the cut edge, including cut- to-break ratios and eccentricities in knife runout. The system is also able to pause and scroll back through the images at any time. www.ameteksurfacevision.com

Ultrahigh Temperature Adhesive

Aremco Products

Ceramabond 670 is a single part, water-dispersible, aluminum-oxide-based adhesive and coating system that offers exceptional mechanical and electrical properties up to 3000˚F (1650˚C). It is ideal for use with ceramics as well as non-ceramic substrates such as steel and stainless

steel. Applied easily using a brush, syringe or pneumatic dispenser, it dries rapidly at room temperature and cures in 2-4 hours at 200˚F. Additional uses for Ceramabond 670 include the assembly and electrical isolation of high-temperature sensors, instrumentation and resistive heating elements. www.aremco.com

Safety Robot

Weld Mold Company

The WMC SafetyRobot telerobotic welding system allows operators to perform remote floodwelding in a temperature-controlled environment. As a result, operators are protected from heat, smoke, fumes and radiation. The complete system package includes robot and controls with proprietary software; welding power source with associated equipment for running .035-inch-diameter to 3/16-inch-diameter wires; an operator station and office complete with AC and heat and lighting; dual monitors, PC, cameras and video capabilities; all interconnecting cables; and safety caging. www.weldmold.com

Safety Air Gun

Exair Corp.

The Soft Grip Super Air Scraper is a safety air gun designed to help remove debris found within industrial facilities. The design uses a scraping blade to aid the powerful compressed airflow removal of debris. It can remove grease, lubricant, paint and difficult-to-sweep metal chips or flakes. It is available with extensions from 2 inches up to 72 inches long to aid in cleaning tabletops, inside machines or other remote surfaces. www.exair.com

Inspection Cages

Bricking Solutions

Safety inspection cages and personal protection tunnels are designed for heightened worker safety. Cages and tunnels provide workers a sheltered area to repair and inspect a kiln, keeping them safe from the debris that commonly falls as coatings shrink and expand. Made of T6-6061 aircraft aluminum, the cages are lightweight (140 pounds) – as much as 50% lighter than the steel alternative. Personal protection tunnels provide masons safe passage in and out of the kiln. Made with aluminum sides and a steel mesh cover, tunnels are designed to

withstand impacts of up to 250 pounds and can handle drops from up to 18 inches. www.brickingsolutions.com

Refractory Paddle Mixer

Blastcrete Equipment

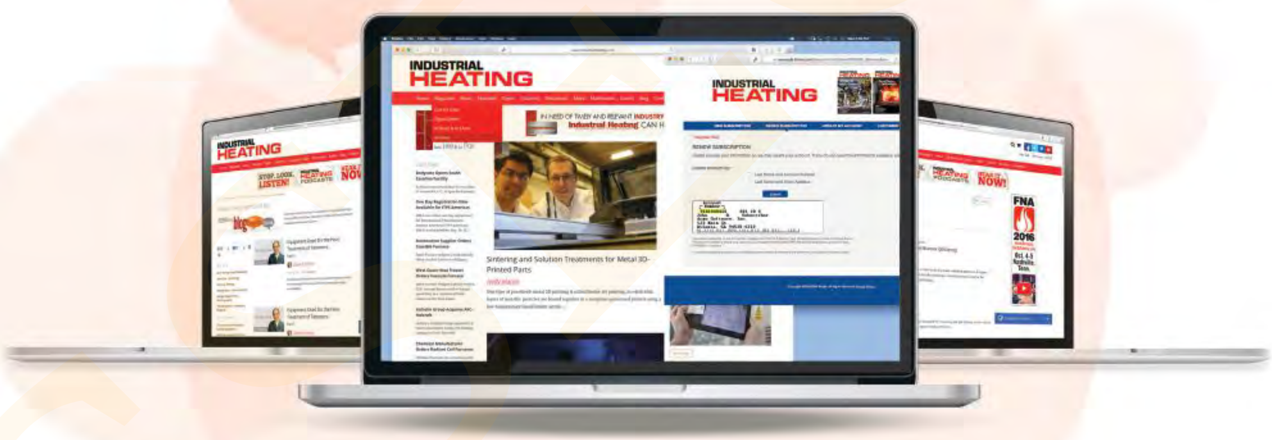
A refractory paddle mixer delivers fast mix times while working with mixtures that include aggregates up to 0.5 inches thick.

The hydraulic machine mixes as much as 500 pounds of refractory castable in 1.5 to 2 minutes and performs well in form-and-pour jobs and other applications involving precast shapes, mortars and grouts. Its oversized, heavy-duty, chain-and-sprocket drive system provides years of reliable use under harsh conditions. The mixer also features a pair of easily accessible levers to control the hydraulic dump and operate the system in both forward and reverse. www.blastcrete.com

Compact Temperature Calibrator

Ametek Sensor, Test & Calibration

The JOFRA CTC-1205 compact temperature calibrator is ideal for the metals industry, waste incineration and oil-and-gas production. It offers a temperature range of 212-2201°F (100-1205°C), accuracy of ±0.2°C (± 0.36°F) and stability to ± 0.1°C (± 0.18°F) for the total temperature range. The calibrator includes silent mode operation, which provides an improved working climate in laboratory areas, and faster cooling times (down to 45 minutes). CTC-1205 features an intuitive easy-to-use interface, and functions such as automatic switch test and auto stepping are available with special one-key-one-function buttons. www.ametekcalibration.com



INDUSTRIAL HEATING

offers high-impact packages so you can find the most qualified job candidates!

Contact Becky McClelland at: 412-306-4355 or becky@industrialheating.com

2018 Print Rates: $150 per column inch for 1x frequency; $140 for 3x; $125 for 6x; $120 for 12x

- **Print ad PLUS online posting:** Add $49.00
- **Print ad, Online Ad PLUS IH Daily News Brief Eblast:** Add $75.00

Web ONLY! Need Maximum Exposure Right Away? Online Ad Posting, IH Daily Newsbrief and Listing: $250.00

EQUIPMENT FOR SALE

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*

NEW WISCONSIN

WISCONSIN GAS FIRED BATCH OVEN, 6' x 6' x 6', 1,250°F, 10,000 lbs, 1.2 MBTUH complete with vertical rising door, insulated floor with tracks for load cart, cart included and controls.

NEW SHERWOOD

Sherwood Gas Fired Mesh Belt Furnace, 5'W x 10'H x 30'L (Heated), 500°F, 500,000 BTUH c/w controls.

NEW VACUUM INDUSTRIES (CENTORR)

Vacuum Industries (Centorr) VII Metallurgical Vacuum System, 6"W x 5"H x 15"L, 2,400°F, 460V/3 PHASE/60 CY/55 AMPS/38 KVA c/w controls, pumps etc

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.

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.

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 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.

SALT BATH TRANSFORMER

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

SALT BATH TRANSFORMER

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 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.

AFC - HOLCROFT

(2) INTEGRAL QUENCH FURNACES, 36"W x 30"H x 48"L, 1,800°F Max, Recuperated with Top Cool, Rear Handler, Oil Heaters (54kW), Re-Circ. Fan, Control System.

SURFACE COMBUSTION

(2) INTEGRAL QUENCH FURNACES, 30"W x 30"H x 48"L, 1,750°F, 1,000,000 BTUH, Trident Tubes, Endo/Natural Gas/Ammonia, SSI Atmosphere Controllers, SSI Gold Probes, Oil Filters And SBS Coolers. System Comes Complete with a Gas Fired Temper, Washer and Charge Car.

SURFACE COMBUSTION

INTEGRAL QUENCH FURNACE, 10,000 lb. payload, 87" W x 87" L x 36" H, 1,850°F, 4,600,000 BTUH, 12,500 Gallons, 6 Agitators, Eclipse Burners, 3 Rear Handlers & Controls with PLC.

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.

HOLCROFT

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

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

Park Thermal International (1996) Corp.

Since 1938

62 Todd Road, Georgetown, ON L7G 4R7

Tel: (905) 877-5254 • Fax: (905) 877-6205 • Toll Free: (877) 834-HEAT (4328)

Email: jmistry@parkthermal.com • Website: www.parkthermal.com

FOR SALE

PHOENIX INDUCTION CORPORATION

Qualified Induction Specialists with over 90 years of combined experience, providing on site:

- Troubleshooting "down" equipment
- Quality preventative maintenance
- Acid flushing, thermal imaging & analysis
- Large inventory of OEM parts, as well as other manufacturers, AJAX*, AIH*, Bone Frontier*, IEH*, and Robotron*
- 24/7/365 days a year emergency phone support

Call: 248-486-8760
sales@phoenixinduction.com
www.phoenixinduction.com

*Registered trademarks of their respective companies

EQUIPMENT FOR SALE

Mowry Enterprises, Inc.

New ★ Used ★ Rebuilt ★ Solutions

★ FOR SALE ★

Ipsen H4848 6 Bar: 30 x 36 x 48, new graphite hot zone, Internal quench

Abar HR 34-60 : 24 h x 24 w x 60 d, 2 Bar Graphite hot zone, high vac port

Surface 20 22 36 2 bar, High vacuum, Graphite hot zone,

Heat Source 2 Bar, 1800˚C, 20 w x 10 h x 30 dep, Graphite, with debind, new PLC touch screen controls

Abar HR 26 2 Bar: 2400˚F, 18" x 24" x 36" graphite hot zone, High vacuum, 2 bar Pressure Quench

C.I. Hayes 24 x 24 x 36 Vacuum Temper: 1450˚F

Borel 18 x 24 x 36 Hydrogen Retort Furnace: 1832˚F

TM 12 x 12 x 20: graphite hot zone, high vacuum, internal quench, 5 psig positive quench

www.mowryenterprises.com
email: grm@mowryenterprises.com
Phone: 978-808-8634 Fax: 508-845-4769

To Advertise Call: 412-306-4355

Check out the latest Used Equipment Listings on Facebook and Twitter – #IHUsedEquip

INDUSTRIAL HEATING
ONLINE 24/7

- Industrial Heating's Buyers Guide
- Aftermarket Services Directory
- Commercial Heat Treat Capabilities Directory
- Materials Characterization & Testing Directory

www.industrialheating.com/directories

FOR SALE

CARBURIZE FASTER?
IT ONLY SEEMS IMPOSSIBLE

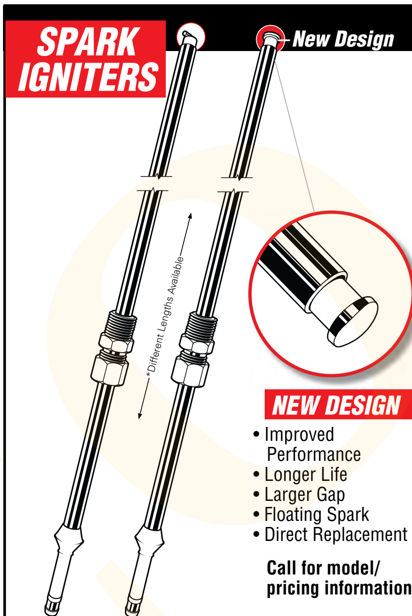
- With 1.5%C & -2˚F dew point
- CH_4 is always under control
- Easily drive any residual carbon
- Into the next load of parts.
- (No burn off – No waste)
- R.O.I. – 6 months.
- Future savings are all profit.

HEAVY CARBON CO. ENDOCARB
700 lb. gear carburized 18% faster

HEAVY CARBON CO., LLC
Please send questions & specks to:
George Barbour
heavycarbon@frontiernet.net
Online at www.heavycarbon.com

FOR SALE

SPARK IGNITERS



NEW DESIGN
- Improved Performance
- Longer Life
- Larger Gap
- Floating Spark
- Direct Replacement

Call for model/ pricing information

*We offer both designs

THE DUFFY COMPANY
283 East Hellen Road • Palatine, IL 60067
Tel: 847.202.0000 • Fax: 847.202.0004
www.duffycompany.com

FOR SALE

FOR SALE
Surface Rotary Hearth Furnace
- Gas Fired – 1750˚F
- Radiant Tube (Atmosphere)
- Alloy Hearth
- 24" Depth
- Door Opening 28"W x 9"H
- Digital Controls
- Excellent Condition

THE W.H. KAY COMPANY
Cleveland, OH
Ph: 440-519-3800
Email: sales@whkay.com

FOR SALE

High Temperature Adhesive & Sealant

Moist Creamy Putty
Just Apply and Let Dry
Bonds Most Materials
Resists Chemicals, Electricity, Molten Metals and Abrasion

2300˚F

COTRONICS CORP.
www.cotronics.com
sales@cotronics.com • 718-788-5533

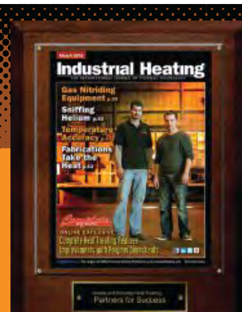
FOR SALE

R & G Services, Inc.
101 Bissell Street, Joliet, IL 60432

Heat Treating Equipment
New & Used
Service • Installation • Rebuilds
Nickel Catalyst Cubes
IN STOCK

Phone: (815) 727-3300
Fax: (815) 727-3335
Please visit our website for a complete list of available furnaces, ovens & generators
www.randgservices.com
Email: weston@randgservices.com

INDUSTRIAL HEATING
Contact Becky McClelland at 412-306-4355 or becky@industrialheating.com for REPRINT PLAQUES



Place Your IH Classified Ad Today In Print, or Online! Contact Becky McClelland at 412-306-4355

HEAT TREAT EQUIPMENT

42056 Michigan Avenue. Canton, MI 48188
Phone: 734-331-3939 • Fax: 734-331-3915
E-mail: john@heattreatequip.com

Batch

C0052 Surface Combustion Temper Furnace (30"W x 48"L x 30"H, 1200°F, gas-fired)
C0068 Despatch Aluminum Aging Box Furnace (60"W x 72"D x 66"H, 395°F, electric)
U3624 Lindberg Nitrogen Temper Furnace (24"W x 36"D x 18"H, 1350°F, gas-fired)
V1010 Dow Batch Temper Furnace (30"W x 48"L x 20"H, 1250°F, gas-fired)
V1024 PIFCO Batch Temper Furnace, Skid Hearth (36"W x 48"L x 30"H, 1200°F, electric)
V1068 Surface Combustion Oil Quench Furnace (30"W x 30"D x 48"H, 1950°F, gas-fired)
V1095 Surface Combustion Temper Furnace (30"W x 48"D x 30"H, 1250°F, gas-fired)
V1096 Surface Combustion Temper Furnace (30"W x 48"D x 30"H, 1400°F, gas-fired)
V1106 Dow Batch Normalizer Furnace (45"W x 84"D x 32"H, 1800°F, gas-fired)

Batch High-Temp Furnaces

U3556 Pacific Industrial Batch High-Temp Furnace (24"W x 36"L x 18"H, 2800°F, electric)
U3637 Pacific Scientific Batch Temper Furnace (30"W x 48"D x 24"H, 1600°F, gas-fired)
U3643 Surface Combustion Temper Furnace (30"W x 48"D x 42"H, 1400°F, electric, 81kw)
V1013 Thermolyne High-Temp Batch Furnace (10"W x 14"L x 9"H, 2000°F, electric)
V1067 Seco Warwick High-Temp Batch Furnace (24"W x 36"D x 24"H, 2000°F, electric)
V1130 Onspec Slot Forge Furnace (72"W x 96"D x 48"H, 2400°F, gas-fired)

Batch Oil Quench Furnaces

C0086 Huber Car Bottom Furnace (10'4"W x 12'8"D x 8'H, 1800°F, gas-fired)

Drop Bottom Furnaces

C0069 Enviro-Pak Drop Bottom Furnace (48"W x 48"D x 48"H, 1200°F, electric)
U3543 Despatch AL Quench Drop Bottom Furnace (48"W x 72"L x 48"H, 1200°F, electric)

Internal Quench Furnaces

C0064 Lucifer IQ Furnace (18"W x 24"D x 18"H, 1900°F, electric)
U3569 Surface Combustion IQ Furnace (24"W x 36"D x 18"H, 1750°F, gas-fired)
U3606 Dow/AFC IQ Furnace (30"W x 48"L x 24"H, 1850°F, gas-fired)
V1046 Surface Combustion IQ Furnace (87"W x 87"L x 36"H, 1850°F, gas-fired)
V1082 Holcroft IQ Furnace with Top Cool (36"W x 48"D x 30"H, 1850°F, gas-fired)
V1093 Surface Combustion Allcase IQ Furnace (30"W x 48"L x 30"H, 1850°F, gas-fired)
V1111 Surface Combustion IQ Furnace (30"W x 48"D x 30"H, 1850°F, gas-fired)

Mesh Belt Brazing Furnaces

C0102JL Becker MB Brazing Furnace w/Exo & Dryer (30"W x 24'5"heated L x 10"H, 2050°F, electric)
U3529 CI Hayes Mesh Belt Brazing Furnace (18"W x 6"H x 8' heating, 2100°F, electric)
U3592 JL Becker Mesh Belt Brazing Furnace (12"W x 6"H, 2100°F, electric)
V1035 Seco Warwick Mesh Belt Brazing Furnace (18"W x 12"H x 8'heated, 2100°F, electric)

Mesh Belt Tempering Furnaces

C0044 CGS Moore Mesh Belt Curing Oven (22"W x 20'L x 10"H, 500°F, gas-fired)
C0073 Heat Machine Mesh Belt Tempering Furnace (24"W x 10'L x 4"H, 1000°F, gas-fired)
C0075 Industrial Heating Mesh Belt Tempering Furnace (24"W x 22'L x 10"H, 950°F, gas-fired)
C0080 Surface Combustion Mesh Belt Temper Furnace (18"W x 11"H, 13' long, 1000°F, gas-fired)
C0081 Park Thermal Mesh Belt Temper Furnace (17.5"W x 7"H, 15'8" long, 900°F, gas-fired)
C0083 Eltropuls Plasma Furnace System (56"Dia x 80"D, 1022°F, electric)
C0090 Hengli Mesh Belt Sealing Furnace - Atmosphere (6"W x 3.5"H, 2100°F, electric)
U3638 American Gas Furnace MB Temper Furnace (31"W x 5"H, 17' heated length, 1200°F, gas-fired)
V1022 Surface Combustion Mesh Belt Tempering Furnace (42"W x 12"H x 36'L, 1350°F, gas-fired)

Pit Furnaces

V1088 Leeds & Northrup Pit Furnace (24"ID x 30"D, 750°F, electric)

Pusher Furnaces

U3648 Ipsen P-12 Pusher Furnace (30"W x 30"L x 30"H, 1650°F,gas-fired)

Roller Hearth & Rotary Furnaces

U3550 PIFCO Powered Roller Hearth Temper Furnace (21"W x 120"L x 18"H, 1000°F, electric)
V1009 Ipsen Continuous Temper Roller Hearth Furnace (24"W x 120"L x 18"H, 1350°F, electric)
V1091 Finn & Dreffein Rotary Hearth Furnace (13'3"ID x 5'3"ID x 4'W x 2'8"H, 2275°F, electric)

Salt Pot Furnaces

C0136 Park Thermal Salt Pot Furnace (16" dia x 30" deep, 1650°F-1750°F, elect)

Steam Tempering Furnace

U3616 Degussa Durferrit Steam Tempering Furnace (24"Dia x 48"D, 1200°F, electric)

Tip Up Furnaces

C0043 Industrial Furnace Tip-Up Furnace (8'W x 22'4"D x 6'H, 1800°F, gas-fired)

Vacuum Furnaces

C0013 CI Hayes Oil Quench Vacuum Furnace (24"W x 36"D x 18"H, 2400°F, electric)
C0027 Pacific Scientific Vacuum Temper Furnace (24"W x 36"D x 24"H, 1450°F, electric)
C0111 Lindberg Vacuum Furnace (15"W x 24"L x 12"H, 2400°F, electric)
C0137 Surface Combustion 2-Bar Vacuum Furnace (48"W x 60"D x 48"H, 2400°F, elect)
U3612 AVS Vacuum Annealing Furnace 2-Bar (18"W x 24"D x 12"H, 2400°F, electric)
V1004 CI Hayes Vacuum Furnace, Oil Quench (18"W x 30"L x 12"H, 2400°F, electric)
V1131 Abar Vacuum Furnace (24"W x 60"D x 24"H, 2250°F, electric)
V1135 Abar Vacuum Furn Vert Bottom Load 2 Bar (72"Dia x72"Deep, 2400°F, electric)
V1136 Surface Combustion Vacuum Furnace, 2-Bar (26"W x 36"L x 22"H, 2400°F, electric)
V1138 Ipsen Vacuum Furnace, 5-Bar (24"W x 36"L x 14"H, 2400°F, electric)
V1143 Surface Combustion Vacuum 2-Bar Furnace (48"W x 60"D x 48"H, 2400°F, elect)

Endothermic Gas Generators

U3594 AFC-Holcroft Gas Generator (3,000 CFH Endo, gas)
U3635 Lindberg Hydryzing Gas Generator (6000 CFH Endo, gas)
U3647 Lindberg Gas Generator (3000 CFH Endo, 2050°F, gas)
V1075 Lindberg Gas Generator (3,000 CFH Endo, gas)

Exothermic Gas Generators

C0103 JL Becker Exothermic Generator (8,000 CFH Exo, 2050°F, gas)
U3652 Surface Combustion Gas Generator (10,000 CFH Exo, gas)
V1036 Seco Warwick Gas Generator (3,000 CFH Exo, gas)

Material Handling - Conveyors

U3565 Conveyor - Roller (48"W x 20'L)

Ovens - Cabinet

U020 Blue-M Oven/Ref (20"W x 20"H x 18"D), (-4°F/400°F)
U3625 Lindberg Atmosphere Oven (38"W x 38"D x 38"H, 850°F, electric)
U3629 Cabinet Oven (30"W x 30"D x 36"H, 750°F, electric)
U3642 Blue-M Oven/Ref, 20"W x 18"D x 20"H, (-4°F/400°F)

Ovens - Walk-In

C0039 Gehnrich Walk-In Oven (72"W x 96"L x 72"H, 400°F, electric)
C0108 Park Thermal Walk-In Oven (90"W x 144"D x 72"H, 850°F, gas-fired)

Freezers

V1129 Webber Freezer (-120°F, electric)

Blowers

U018 Twin City Blower (20 HP, RBA-SW, Class 22)

Charge Cars

U3621 Dow Charge Car, DEDP (66"W x 60"D x 54"H)
V1085 Holcroft Charge Car (DE/DP, 36"W x 48"D)

Scissors Lifts & Holding Tables

V1086 Holcroft Scissors Lift & (2) Holding Tables

Heat Exchanger Systems

U030 Graham Systems Heat Exchanger - Plate
V1104 SBS Heat Exchanger - Air Cooled

Holding & Cooling Stations

V1113 Surface Combustion Forced Cool Station (30"W x 48"D x 30"H)
Many other holding stations - ask for details

Water Cooling Systems

U3404 JL Becker Cooling Tower with Tank: Tower: (51"W x 36"D x 64"H, Tank: 72"W x 84"D x 66"H)
U3595 JL Becker 2-Tank Water Cooling System, 2 Dayton 1HP Motors
U3646 HydroThrift, Duplex Pump Base, Water Cooling System
V1038 Bell & Gossett Shell & Tube Heat Exchanger with Tank

Washers

C0134 Surface Combustion Washer (60"W 60"D 40"H, 180°F, gas-fired)
V1084 Holcroft Spray/Dunk Washer (36"W x 48"D x 30"H, 190°F, gas-fired)
V1101 Surface Combustion Spray Washer (36"W x 48"D x 30"H, 180°F, electric, 58kw)

Transformers

Extensive inventory of all types of transformers for any and all applications

Baskets & Boxes

Extensive inventory of heat treat baskets and boxes Heat Treat Lines

Heat Treat Lines

V1137 T-6 Annealing & Aging Furnace Line

HEAT TREAT EQUIPMENT

For miscellaneous parts inventory and complete equipment listings use this QR-Code to go directly to our listings, or visit www.heattreatequip.com

INDEX OF ADVERTISERS IN THIS ISSUE

Advertiser	Page	Phone	Website
Across International LLC	7	888-988-0899	www.acrossinternational.com
Ajax TOCCO Magnethermic Corp.	43	800-547-1527	www.ajaxtocco.com
Applied Test Systems	41	800-299-6408	www.atspa.com
Dry Coolers Inc.	Inside Front Cover	800-525-8173	www.drycoolers.com
G-M Enterprises	Back Cover	951-340-4646	www.gmenterprises.com
Induction Tooling Inc.	13	440-237-0711	www.inductiontooling.com
Ipsen Inc.	3	800-727-7626	www.ipsenusa.com
Jackson Transformer Co.	39	813-879-5811	www.jacksontransformer.com
Jefferson Solenoid Valves USA, Inc.	21	866-42-VALVE	www.jeffersonvalves.com
L & L Special Furnace Co., Inc.	22	910-459-9216	www.llfurnace.com
LECO Corp.	27	800-292-6141	www.leco.com
METAL Treating Institute	Inside Back Cover	904-249-0448	www.furnacesnorthamerica.com
North American Cronite	20	440-353-6594	www.safe-cronite.us
Protection Controls Inc.	22, 41	847-674-7676	www.protectioncontrolsinc.com
SECO/Vacuum Technologies LLC	15	814-332-8400	www.SecoVacUSA.com
Solar Manufacturing	9	267-384-5040	www.solarmfg.com
Thermocouple Technology, LLC	23	800-784-3783	www.tteconline.com
Ultraflex Power Technologies	23	631-467-6814	www.ultraflexpower.com
Wisconsin Oven Corp.	19	262-642-3938	www.wisoven.com

G-M Model HVF 401-XSFQ (20-BAR)

"State-of-the-art" Vacuum Furnace commissioned at one of the Leading US Commercial Heat Treat Plants.

Having a free work area of 36"W x 36"H x 60"L and a 8,000 lbs. gross loading capacity, Equipped with externally mounted 600 HP motor with Allen-Bradley Variable Frequency Drive (VFD) to provide controlled cooling with externally mounted 14,000,000 BTUs/hour primary heat exchanger and a 300,000 BTUs/Hr. post cooler to provide maximum quenching capabilities for various types of loads and large cross-sections. Furnace controls equipped with Honeywell HC900 and Wonderware Computer Control.

Contact G-M ENTERPRISES for

Furnaces that REALLY work

Vacuum Furnaces - Atmosphere Furnaces - Replacement Parts - Hot Zones

Locations: East Coast, Midwest & West Coast

www.gmenterprises.com • phone (951) 340-4646 • fax: (951) 340-9090