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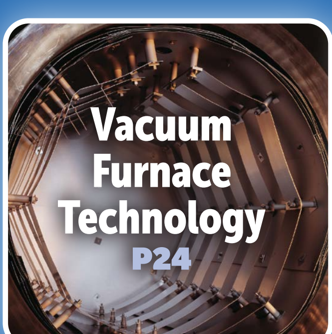
VOLUME 5 • NO. 8 DECEMBER 2022

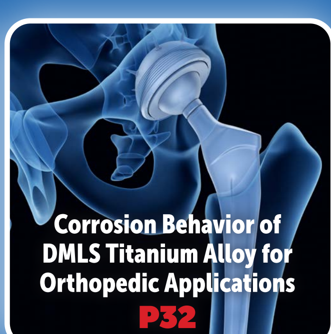
Heat Treat Today

Technology, Tips & News for Manufacturers with In-House Heat Treat

Annual Medical and Energy Heat Treat Issue

In this Issue





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Energy Smart Cooling

Start Counting Your Savings

Air cooled heat exchanger

Evaporative cooling tower with outdoor mechanical room

Chiller (mechanical refrigeration)

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.

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"We believe people are happier and make better decisions when they are well informed."

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The Lord's loving kindnesses indeed never ceases,
For His compassions never fail.
They are new every morning;
Great is Your faithfulness.
Holy Bible, Lamentations 3:22-23

VOLUME 5 • NO. 8

DECEMBER 2022

Columns

P8 COMBUSTION CORNER

Improving Your Use of Radiant Tubes, Part 2

Last month, we introduced the importance of radiant tubes in the heat treat industry. We explored the "why" of radiant tubes and skimmed the surface, exploring materials, sizing, shapes, longevity, and installation — all topics we'll deep dive into in future posts. This month, let's explore what typically occurs inside a radiant tube.

By John Clarke, Technical Director, Helios Electric Corporation

P10 The Role of Heat Treat in Binder Jetting AM for Metals

Additive manufacturing (AM) at a commercial scale began about 30 years ago and has expanded well beyond its original scope. As AM becomes increasing prominent across different industries, heat treaters need to know how to handle AM parts in their shops. Learn about the history of binder jetting AM, the alloys used in this technology that require post-heat heat treatment, and what heat treaters should expect for the future.

By Animesh Bose, Vice President of Special Projects, Desktop Metal

P36 CYBERSECURITY DESK

Cybersecurity Best Practices: Dos and Don'ts

Cybercrime is hands-down one of the quickest growing crimes around the globe and it continues to impact organizations from all industries. This article will give you a better understanding of some general cybersecurity best practices for all businesses, and a few tips for what you should and shouldn't do.

By Joe Coleman, Cybersecurity Officer, Bluestreak Consulting™

P44 News From Abroad

In this issue, we look to our European and international information partners to discover global heat treat events, technology trends, and equipment contracts in Europe and the world.

heat processing | Furnaces INTERNATIONAL

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The latest in equipment, personnel, company updates, and kudos from around the industry.

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P46 MTI Member Company Profile
Get to know an insurance company willing to work with heat treaters.

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P14 2023 Executive Forecasts

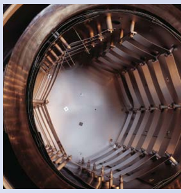
The new year is barreling toward us at a pretty fast clip. What will 2023 offer to the heat treat industry? Will you need to think outside the box to maintain a competitive edge? Discover what leading executives from key companies in the North American heat treat industry have to share about their company's plans and views as they look ahead to 2023.

P20 Harnessing the Sun: A Heat Treat Case Study with General Atomics

Imagine this: A huge lab facility nestled in the south of France. . . teams of scientists and technicians striving to bring carbon-free energy solutions to the world. . . "replicating the high-energy fusion reaction that powers the sun and stars." To complete the project, what heat treat solution is needed? Read to find out.

By Rafal Walczak, Product Manager, SECO/VACUUM

P24 Vacuum Furnace Technology



Vacuum furnaces are used for multiple processes including brazing, aging, and solution heat treating for countless materials. Typically, they are utilized to ensure a lack of oxidation/contamination during heat treatment. Learn about the origins, theory, and main parts of vacuum technology and how it is used in both aerospace and automotive industries.

By Jason Schulze, Director of Technical Services Special Process – Metallurgy, Conrad Kacsik Instrument Systems, Inc.

P28 Heat Treating: The Best Medicine

When it comes to medical implant and device heat treating, what heat treat processing options are available to manufacturers that will benefit patients? What should we know about the heat treating processes that make metal parts functional as knees, hips, and elbows? Find out in this expert analysis.

By Heat Treat Today Editorial Team

P32 Corrosion Behavior of DMLS Titanium Alloy for Orthopedic Applications

In this article, explore the importance of alternative advanced manufacturing processes and the effects of post-process heat treating of DMLS titanium alloy parts. In a recent study, a team at Worcester Polytechnic Institute (WPI) evaluated the effects of these processes. Read along to see what they found.

By Richard D. Sisson Jr., YangZi Xu, and Jianyu Liang, Department of Mechanical and Materials Engineering Worcester Polytechnic Institute

P37 Endings . . . People We Lost

Beginnings and endings often come together. As we prepare to begin a new year next month, we want to pause to remember a few lives that came to an end. Although the following are by no means the only important endings, Heat Treat Today would like to honor the memory of a few individuals who left their mark in the heat treating world.

P38 Fueling the Future: Heat Treat Kids

Heat Treat Today is taking a moment to spotlight the joyful beginnings of growing future leaders – Heat Treat Kids! With the happy grins, we're also grilling them on their heat treat knowledge. We asked the ones who could talk the following questions: What does your heat-treating parent/grandparent do for work? What is a furnace? How hot do they get? What do YOU want to be when you grow up? This one will surely make you smile.

By Ellen Porter

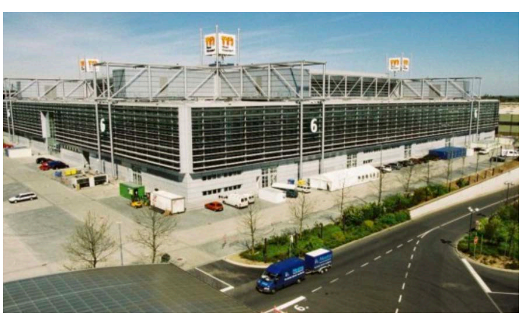
Doug Glenn, Publisher
Heat Treat Today

Letter from the Publisher

Beaver, Pennsylvania & Dusseldorf, Germany

It's roughly noon on November 8, 2022, and I'm sitting outside Starbucks in downtown Beaver, Pennsylvania, about 40 minutes from downtown Pittsburgh, enjoying an unseasonably mid-70s, pure blue sky day. I live another 40 minutes away near New Castle, PA, but I'm here in Beaver to see the newest Glenn grandchild and stopped at Starbucks to buy a triple-shot decaf espresso – the mid-afternoon drink of choice for my wife — which the barista's have affectionately dubbed "Why Bother." (Think about it . . . three shots of DECAF espresso. Why bother?)

There's plenty of human activity here in downtown Beaver. People walking and talking. Many conversations and warm greetings — handholding, smiling, kids with parents, cars passing, movement and activity everywhere.



This moment in Beaver reminds me of the Altstadt in Dusseldorf, Germany in June of any given year. Aldstadt, which means "old town," is the hub of activity in the evening after each of the five days of Thermprocess, the world's largest heat treating trade show held every four years at the Messe (fairgrounds) in Dusseldorf, Germany. In fact, walking and eating dinner in the Aldstadt is one of the highlights of participating in Thermprocess.

If you've never heard of Thermprocess and you're involved in the heat treating industry, you need to know about it. It is one of four co-located metals trade shows held in mid-June every four years in Dusseldorf. It is an event to behold, and one highly recommended by the author of this column. In addition to Thermprocess, there is GIFA (a foundry event), NEWCAST (a casting event), and METEC (a metallurgical event). All-in-all, over 70,000 visitors and over 2,000 exhibitors flood the Messe every four years.

In 2023, Thermprocess is being held from June 12-16, and I would like to personally invite you to join me in Dusseldorf. As the largest heat treat event in the Western world (and arguably, the ENTIRE world), Thermprocess offers North American participants an opportunity to expand their view of what is happening in the heat treating/thermal processing world. And a broader perspective is exactly what we need. For those of you who have ever attended one of the larger manufacturing events here in North America, IMTS for example, Thermprocess and her three sister shows are MUCH bigger and better.

The Messe, where the event is located, is easily twice to three times the size of McCormick Place in Chicago, where IMTS is located. It would easily take you 20 minutes to walk from one end of the Messe to the other. During the full week it is open, the Messe is packed with metals-related exhibits and activities. It is not humanly possible to see all that is available to be seen.

Heat Treat Today is encouraging North American heat treat suppliers who market internationally to exhibit. We are putting together a group of like-minded North American exhibitors to join us. Assuming we get enough companies to join us, we will exhibit close to one another and share resources to make it more affordable for all concerned. We'll share things like food & beverage, interpreters (if needed), and meeting rooms. By the way, unlike many North American shows, it is not unusual for people to actually strike deals and sign contracts at Thermprocess.

If you're not a heat treat industry supplier, we encourage you, as a consumer of heat treat products, services, or supplies, to attend the event. The technology that you will see will be eye-opening.

Please let us know if we can be helpful getting you to Dusseldorf in June 2023 **HTT**

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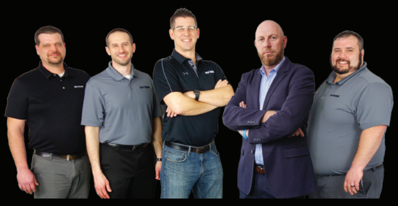

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Karen Gantzer, Senior Editor/ Associate Publisher
Heat Treat Today

Message from the Editor

Passing the Baton

Transitions. How appropriate as we look at 2023 approaching without hesitation. We have no choice but to welcome this new year, preferably with joy and perhaps a child-like anticipation of the new adventures to come.

One of the transitions taking place now, albeit an intentionally slow and steady one, is the move of all the print responsibilities at **Heat Treat Today** from my plate to Bethany Leone's as she continues to assume the managing editor role.

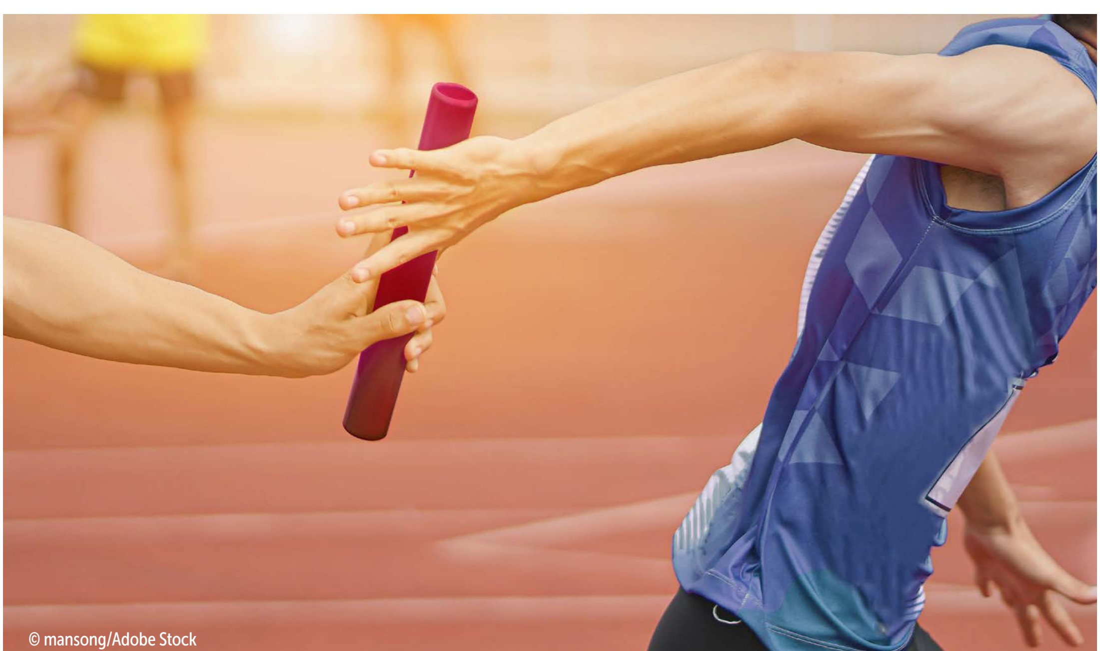
I've been leading the editorial team for the past several years as we've expanded to eight annual print magazines. I have loved helping to produce them each quarter, and honestly, it's been difficult passing the baton of this responsibility. Not because I don't think Bethany can do it — I know she will do a phenomenal job in leading the team. I'm seeing it now and am so stoked!

No, it's because I kind of see the magazine as my "baby." It's hard to give it up! Can anyone relate? When you work on a project and see it grow, how exciting and rewarding. To build our team and watch them pivot when necessary and contribute creative and thoughtful ideas to help better serve has truly been energizing and exciting. I think it's because I love experiencing the process and seeing that magazine in print.

However, the time has come for Bethany to receive the complete baton hand off. (If you ever ran on a relay team and practiced those hand offs, do you remember running with your hand outstretched behind you and adjusting your speed so that you could achieve the perfect transition of the baton from your teammate's hand to yours without dropping the baton?!) Bethany has her hand in perfect position to receive the baton and I'm looking forward to passing it to her smoothly and completely so that she can run with confidence and vigor.

I'm not leaving **Heat Treat Today**, just transitioning into new responsibilities — that of associate publisher and senior editor. I'll still be able to be part of the print publication from 20,000 feet, just not up close and personal (for which Bethany will be incredibly thankful ☺)! I'm looking forward to working on special projects and learning other facets of the publishing world.

So, in February 2023's **Air and Atmosphere Heat Treat** magazine, you'll see Bethany's picture on this page and enjoy her column in each issue, and you'll know then that hand off went down without a hitch! HTT



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General:	System 1 rear handler

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Controls:	SSI controls

U3788 Wisconsin Oven Gas-Fired Batch Oven

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Heating:	Natural gas, 1.0 MM BTU
Controls:	Control panel mounted on oven
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Type::	Charge Car – DE/DP
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John Clarke, *Technical Director,*
Helios Electric Corporation

Improving Your Use of Radiant Tubes, Part 2

Last month, we introduced the importance of radiant tubes in the heat treat industry. We explored the "why" of radiant tubes and skimmed the surface, exploring materials, sizing, shapes, longevity, and installation — all topics we'll deep dive into in future posts. This month, let's explore what typically occurs inside a radiant tube.

The radiant tube burner combines fuel and an oxidizer (commonly air) in the presence of a source of ignition. Radiant tube burners differ from burners that are fired into an open furnace. They function to distribute heat as uniformly as possible within the interior of the tube to maximize its temperature and heat transfer uniformity. In some applications, a low rate of heat transfer is acceptable (for example, in the holding zone of a continuous furnace). In that same furnace, a much higher heat transfer rate may be required in the front of the furnace. In all cases, higher heat transfer rates result in higher internal tube temperatures. In most cases, the higher the temperature, the greater the stress on the material.

Within the radiant tube in the visual flame region, the energy is transferred to the inner surface of the tube by convection and radiation. The rate of convective transfer has much to do with the mixing characteristics of the burner in question. Once combustion is complete, the heated products of combustion — CO_2, O_2, H_2O, and N_2 — continue to flow through the radiant tube. They impart heat to the interior surface of the radiant tube through convections and — in the case of the CO_2 and H_2 — radiation. The non-polar gases (O_2 and N_2) are effectively transparent to radiation: neither absorbing nor radiating heat. This transparency poses a problem for the performance of radiant tubes because the combustion process is ideally complete some distance before the end of the radiant tube.

There are a few ways to make use of the heat stored in the O_2 and N_2. One way is to stir the mixtures to ensure these gases meet the inside walls of the tube and can convectively transfer their energy. Another way is to insert a "core buster" or other device into the exit end of the radiant tube. This device must be able to withstand the peak temperature of the products of combustion at this point, so it is typically constructed of some ceramic material or a composite of ceramics. As the heated gases pass over this "core buster," the resistance forces higher flows around the perimeter of the tube, increasing convective transfer. The "core buster" also is convectively heated and can then radiate heat to the inner surface of the tube and, finally, the "core buster" increases mixing of the gases to ensure all remaining hydrocarbons and carbon monoxide are brought into contact with oxygen to complete the oxidation process.

The transfer of heat to the inner surface is dependent on the effective surface area. A tube with a nominal inside diameter of four inches may have a much greater effective surface area due to roughness, which resemble very small peaks and valleys. Anyone who has attempted to walk around a small Caribbean island can attest — it takes a lot longer than you would think by looking at the map and really scares your shipmates when they cannot find you. Cast and composite radiant tubes can be fabricated to increase this effective internal surface area. Tubing can also be equipped with internal fins. No matter what the construction, ultimately it does no good to transfer heat to the interior of the radiant tube if the tube cannot transfer the same quantity of heat through the exterior to the furnace and work being heated.

Which mode of control is better? High/Low, proportional, or pulsed? Any method can achieve a uniform tube heat release given the correct burner-radiant tube combination. The important thing is that the vigor of the mixing is matched to the length and roughness of the radiant tube. Burner X may be perfectly suited to a short radiant tube but lead to non-uniform heating as the tube length is extended. On the other hand, Burner Y, with a relatively lazy flame, may work perfectly on long tubes with lower heat transfer demands but be unsuitable for short tubes where high heat transfer rates are desired.

In the coming months, we will examine many of these areas in greater detail, and this author can make use of his experience of many failures to inform the readers of what not to do. Then, by extension, we'll learn how to get more from the furnaces by thinking systematically about their radiant tubes, burners, and controls. HTT

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The Role of Heat Treat in Binder Jetting AM for Metals

By Animesh Bose, Vice President of Special Projects, Desktop Metal

Binder Jetting of Metals: Origins

Additive manufacturing (AM) at a commercial scale began about 30 years ago and has expanded well beyond its original scope. At the beginning, rapid prototyping (RP) was the name for the burgeoning technology; it emerged in the 1990s to bridge the gap between the need for quickly produced prototypes for manufacturers, not just plastic replicas. Rapid tooling (RT) of metal tooling parts joined RP R&D at this time as the research frontier for materials engineers. The current name for these technologies stands at "additive manufacturing," or AM, though the popular terminology is simply "3D printing."

Polymers

Developments in polymer AM also advanced rapidly with both extrusion-based technology as well as through advancements in Digital Light Processing of photopolymers. Stratasys Ltd., an American-Israeli manufacturer of 3D printers, software, and materials for polymer additive manufacturing as well as 3D-printed parts on-demand, began using a material extrusion-based process with their FFF (fused filament fabrication) technology to print parts, patented in 1989. This worked by feeding coils of polymeric materials though a printer, which would extrude the material through a small, heated chamber where the material would pass through a small orifice to extrude — or print — in a three-dimensional design. This method allowed for very fine, hair-like material to print in a precise X ,Y, and Z motion, building layer by layer. Vat polymerization was another polymer AM technology that gained traction and involved photopolymer processing. Both technologies are currently used for polymeric materials. Interestingly, both processes have been adapted and are being used for metal 3D printing.

Metal AM

In 1993, an MIT engineering professor named Emanuel "Ely" M. Sachs — a man who could be considered the father of metal binder jetting technique — along with his colleagues from MIT patented the process of laying fluent, porous materials in layers between 50- to 100-micron thickness to form 3D parts. They were able to do this by spraying an organic binder on each layer of material where they wanted to increase the height of the part to produce a bonded layer in the selected area. This layering is repeated several times before the unbonded powder is removed immediately or after further processing.

One of the biggest advancements in metal AM happened in 2014 when GE Aviation combined multiple parts into one huge, complex design using a laser-based additive manufacturing method called direct metal laser melting. The end result was an airplane fuel nozzle made of 20 parts for the LEAP™ engine. All of AM came into the limelight, and direct metal laser melting — a melt-based technology — just took off.

But there were limitations to this laser process, the main one being cost and special powder requirements to layer and melt to form the part. The process was also technologically intensive and not fast enough for high volume production (as would be necessary for automotive or consumer good-type application).

Binder Jetting Technology

Binder jetting that had been developing in the early-2000s started to gain traction as a non-melt-based process for high volume mass production. Instead of melting the powder material, a binder is used to adhere the powder metal layers where needed. This method of printing results in a more uniform final part microstructure compared to the melt-based processes. ExOne, a binder jet 3D printing company, pursued the binder jetting technology using a license from MIT. In 2015, Desktop Metal was formed, and they focused on high volume mass production by binderjet using their Single Pass Jetting (SPJ™) technology. As binderjet gained traction, other companies entered the market (HP, GE, and Digital Metal). Desktop Metal recently acquired ExOne and efforts at developing standards for the technology are in full swing.

Heat Treating of AM Metals

Stainless Steels

There are two popular types of stainless steel for AM. The first is 17-4 PH, a precipitation-hardened stainless steel, which I like to call an "all purpose" stainless steel. When heat treated, one can achieve varying levels of strength, hardness, and elongation; and since it's stainless steel it has a reasonable corrosion resistance. The aging treatments are already well-established — for example, H900, H1100, etc. The other popular grade is 316L, a non-heat treatable grade used in the food industry among others. Now, most stainless steels have chromium and nickel in decent amounts, so companies have developed a grade which is called "nickel-free stainless steel" for applications where people might be allergic to nickel. This class of alloy is also heat treatable. There are many more stainless steel grades that are being developed by the binderjet process.

Continued on page 35

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Heat Treat Today News Chatter

Business briefs from around the industry

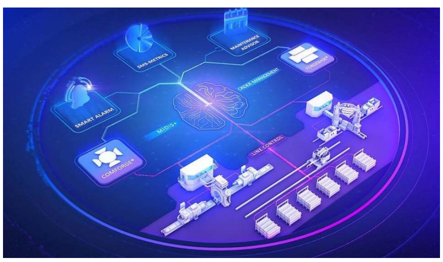
A Few Dozen Quick Heat Treat News Items To Keep You Current

*Heat Treat Today is pleased to highlight the announcements of heat treat-related growth and achievement throughout the industry by sharing them in **News Chatter**, where we feature representatives, transactions, moves, and kudos from aerospace, automotive, medical, energy, and other sectors of manufacturing. Here are just a few of the news items that appeared in the Heat Treat Daily during the past few months as well as "new" news items.*

Subscribe to the Heat Treat Daily e-newsletter at heattreattoday.com/subscribe and receive 1–2 news items from around the heat treat industry 5 days a week. Submit your news items to editor@heattreattoday.com.

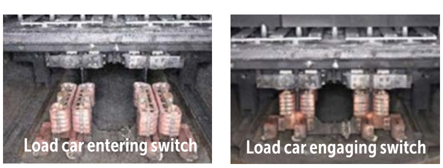
EQUIPMENT CHATTER

› American titanium producer **Perryman Company**, in Houston, PA, has placed an order for the supply of two forging machines from **SMS group**: a high-speed open-die forging press in the pull-down design and a hydraulic radial forging machine with two forging manipulators as well as the order and production control system for the entire forging line.



New SMS group forging machines with digitization tools and technology packages for Perryman Company

› **Solar Atmospheres** in Souderton, PA, has had an automatic disconnect switch installed into a production car bottom vacuum furnace. The switch, from **Solar Manufacturing**, saves time by eliminating the manual maneuver of disconnecting and then reconnecting the power terminal bars at each end of the car bottom during each production run.



Switch for Solar Atmospheres

› **General Atomics** has heat treated the seventh and final module for a large superconducting magnet for **ITER**, a multi-national science experiment, with a vacuum furnace from **SECO/VACUUM**.

› **RIDGID® TOOLS** received twin furnace systems from **DELTA H®**. These systems will heat parts from ambient to 975°F, soak for two hours, cool to 120°F, soak two hours, and then repeat.

Twin furnaces for RIDGID® TOOLS

› **P.W.P.T. POSTEOR Sp. z o. o.** in Poland turns to **NITREX** as it converts to in-house heat treating capabilities rather than outsourcing its nitriding for stainless steel power generation parts.

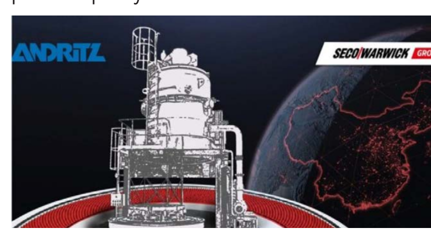
› Global commodities group, **Anglo American**, and **thyssenkrupp Steel** have signed a memorandum of understanding to collaborate on developing new pathways for the decarbonization of steelmaking. The collaboration will focus on joint research to accelerate the development of high-quality input stock for lower carbon steel production, using both conventional blast furnace and direct reduction iron.

Collaborative R&D between Anglo American and thyssenkrupp Steel for greener steelmaking technologies

› **SECO/WARWICK** delivered additional CAB lines to **SUZHOU RETEK** in China.

Two CAB lines for SUZHOU RETEK

› The **Andritz Group**, a manufacturer of complete lines for cold-rolled strip production and processing, has ordered a **SECO/WARWICK** vertical vacuum furnace. The furnace for gas quenching processes will help produce consistent product quality.



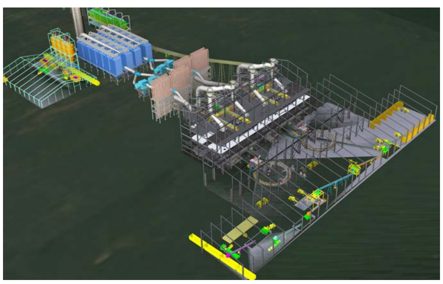
› **MTC Powder Solutions** received a hot isostatic press (HIP) from **Quintus Technologies** that will extend the onsite size parameters of the Powder Metallurgy Near-Net Shape (PM-NNS) HIP components for the oil and gas, chemical, nuclear, and power generation industries.

Quintus Technologies HIP System

› **ArcelorMittal Dofasco** chooses **Tenova** for the supply of a hydrogen-ready 2,500,000 tons/year ENERGIRON® direct reduction system, to be located in Hamilton, Canada. This system will be incorporated in the decarbonization plan through a direct reduced iron (DRI) program.

ArcelorMittal Dofasco to be supplied by Tenova with direct reduction system

› **Tenova** was contracted by **Sinova Global** to supply the basic engineering of a new silicon metal plant in Tennessee. The site will be North America's most modern and efficient silicon metal plant, a greenfield development for Sinova Global.



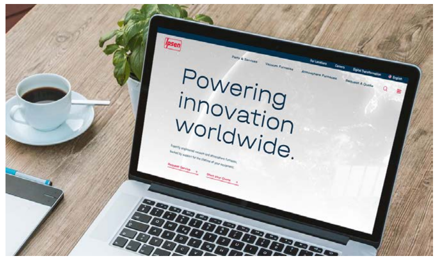
Sinova Silicon Metal Plant from Tenova

PERSONNEL AND COMPANY CHATTER

› **Bryan Stern** has joined **Gasbarre** as the product development manager for **Gasbarre Thermal Processing Systems**. Bryan's experience, knowledge, and forward-thinking will allow him to support existing clients and advance the company's growing footprint in the vacuum furnace market.

Bryan Stern, Product Development Manager, Gasbarre Thermal Processing Systems

› **Ipsen** recently launched a new website with the goal of providing a better user experience for customers worldwide. IpsenGlobal.com now incorporates all Ipsen locations, products, and services under one domain.



New website: IpsenGlobal.com

› **Furnaces North America 2022**, the premier trade show and technical conference in the North American heat treating industry, attracted over 1,200 attendees from around the world. The show is produced by the **Metal Treating Institute** in partnership with its media partner, **Heat Treat Today**.

Many exhibitors and attendees at FNA 2022

KUDOS CHATTER

› Representatives from **TAV VACUUM FURNACES** gave a speech during the first day of the 27th IFHTSE Congress & European Conference on Heat Treatment 2022. The talk was about the heat treatment of titanium alloys, specifically, "Vacuum heat treatment of Ti6Al4V alloy produced via SLM additive manufacturing."

› **RETECH**, a **SECO/WARWICK Group** company, was acknowledged as "The Most Innovative Metallurgical Equipment Specialist in 2022 for the USA" by Acquisition International Magazine. Additionally, **Earl Good**, its managing director, has been honored by The Corporate Magazine in the "Top 20 Most Dynamic Business Leaders of 2022."

RETECH company and managing director receive honors

› **Nitrex Metal, Inc.** announced that it was selected for the "American Dream" series airing on **Bloomberg** and **Amazon Prime**. The series explores the entrepreneurial stories of men and women who founded and built incredible companies from the ground up.

Nitrex Metal, Inc. part of "American Dream" TV series

› **Jim Oakes**, president of **Super Systems, Inc.**, has been awarded the first ever **Furnaces North America** (FNA) Industry Award at the trade show's opening night kickoff reception.

Industry Award to Jim Oakes, president of Super Systems, Inc.

› At the recent 2022 MTI fall meeting held in Indianapolis, IN, the **Metal Treating Institute** recognized **Roy Adkins**, director of Corporate Quality, with the MTI Award of Industry Merit. This award is given in recognition of current and ongoing commitment to the betterment of the commercial heat treating industry with one or more significant accomplishments.

Roy Adkins (center) with past MTI Presidents, Jim Oakes (left) and Don Hendry (right)

› **Hubbard-Hall** has been awarded the Top Workplaces 2022 honor by **Hearst Media Services** in Connecticut. The award is based solely on employee feedback gathered through a third-party survey that is administered by employee engagement technology partner **Energage LLC**.

› **Pelican Wire Calibration Laboratory** received "ISO/IEC 17025:2017" accreditation from **ANSI National Accreditation Board**.

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2023 Executive Forecasts

The new year is barreling toward us at a pretty fast clip. What will 2023 offer to the heat treat industry? Will supply chain issues be resolved? Will you be able to secure trained workers and retain them? Will you need to think outside the box to maintain a competitive edge?

In the following section, leading executives from key companies in the North American heat treat industry share their company's plans and views as they look ahead to 2023.

Tom Schultz, Sales Manager,
L&L Special Furnace Co, Inc.

L&L Special FURNACE CO, INC

website: llfurnace.com

telephone: (610) 459-9216

What Will 2023 Bring?

As the dust continues to settle on the COVID landscape, manufacturers find themselves in an envious yet delicately balanced situation. L&L Special Furnace Co, Inc., along with our friendly competitors, has enjoyed two full good years of business and we are all hoping that what we see is a recovery from the COVID pandemic.

This increase in production is not born out of the needs of increased capacity necessarily but is an effort to keep individual businesses open and functioning during a very trying time. It goes without saying that the myriad difficulties of the past two years have presented both opportunities and setbacks.

Although most businesses suffered, many had to weather the storm by whatever means necessary. Although captive heat treaters are coming back on line, it is proving much slower than originally anticipated. Many employees have moved on or are part of the "Great Resignation." This alone is making getting heat treated parts from suppliers much harder and takes much longer.

As a result we have many customers that need to continue thermal processing to keep things moving in their particular production facility. L&L is ready to help our customers with this ongoing problem. Being ready to react is going to be a key goal in 2023 along with proper spacing of large production jobs.

Manufacturers need suppliers to be as responsive as possible. Delays in the supply chain only complicate this matter which lead to longer deliveries and constant sourcing headaches, which usually entail a higher cost, and this impacts a manufacturer's profit margins and delivery schedules.

L&L plans to stock some smaller tool room equipment along with a complete dual chamber heat treat package for companies that want to take control of their heat treat in house.

L&L looks forward optimistically to another good year in 2023, with aerospace, military, and power generation fields that will continue to see steady growth. The conflict in Ukraine certainly bears watching as it could upset supply chains in general and the global alloy market in particular. The alloy market is key in respect to the CMC field in which L&L has a heavy presence and sees continued growth and expansion.

If you have a thermal application, L&L Special Furnace Co, Inc. is here to help you with your process and provide the knowledgeable and key insight you need to make an investment in thermal processing equipment.

Save the Date:
June 12-16, 2023

THERMPROCESS 2023

the world's largest thermal processing & heat treating event held every four years

DÜSSELDORF GERMANY

Invitation from the publisher

Dear Industry Supplier:

I'd like to invite you to join me in Dusseldorf, Germany for the world's largest and most impressive heat treating trade show in the world – Thermprocess 2023 – June 12-16. This event is held every four years. I've had the pleasure and privilege of attending nearly every event since 1999 and have never been disappointed.

If you're a supplier to the industry and do business in Europe, Asia, Africa, Latin or South America, this event is a don't miss, never-forget event that will be well worth your time.

Please set aside June 12-16 on your calendar and contact me if you're interested in joining me as an exhibitor (or visitor) at Thermprocess. Heat Treat Today is setting up a North American Group Participation. As a group, the show organizer, Messe Düsseldorf, can assist us with booking our booths and providing additional exhibitor support services to ensure a smooth and worry-free exhibiting experience.

Please let me know ASAP if you are interested in exhibiting at this quadrennial event. Trust me, it will be an event you will not quickly forget.

Let me know if you have any questions.

Sincerely,

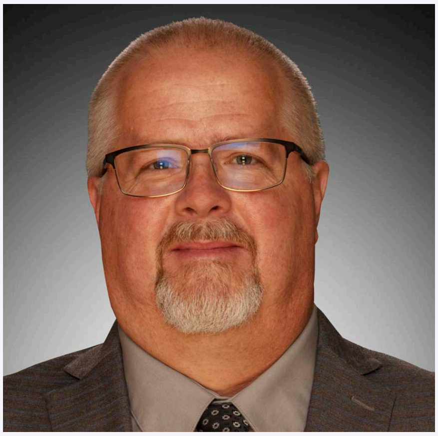
Doug Glenn

Doug Glenn
Publisher/Founder/Owner
Heat Treat Today

CONTACT

doug@heattreattoday.com

724-923-8089



Tracy Dougherty, Vice-President of Sales, AFC-Holcroft

website: afc-holcroft.com

telephone: (248) 624-8191

AFC-Holcroft Goes Green

As we approach 2023, we at AFC-Holcroft are doing so with a corporate commitment to offer our customers green solutions to reduce their carbon footprint. In fact, we are in the final stages of completing both phase 1 and 2 of our facility remodel and expansion with energy-saving design features which greatly reduce our own carbon footprint.

Many of our customers are requiring a multifaceted approach to becoming carbon neutral, with some setting more aggressive goals than others. This has led to our internal engineering groups exploring many additional options to assist in this effort. These options really need to expand beyond simply converting from gas to electric heating, since this can often have a negative short-term impact on one's carbon footprint depending on the source of electricity.

We've seen tremendous growth for both batch and continuous salt quench furnaces for austempering and marquenching. In addition to being a more environmentally friendly option, there are added benefits by reducing distortion, thus minimizing or eliminating secondary operations. This has even greater importance on many of the higher RPM gears we are seeing for the EV market. We expect this growth to continue into 2023 and beyond.

David Wolff, Regional Sales Manager, Nel Hydrogen

website: nelhydrogen.com

telephone: (203) 949-8697

Future-proofing Hydrogen Supply

Nel is the world's largest manufacturer of water electrolysis equipment, with the widest product range. Nel Hydrogen has built hydrogen generation equipment since 1927 and is expanding our capacity and range to make massive volumes of hydrogen available. Producing more and larger systems with breakthrough CAPEX and OPEX efficiency builds on Nel's decades of experience and fielded systems.

Hydrogen has served industrial needs for chemical, metallurgy, and high-tech manufacturing applications, valued for its unique properties. But hydrogen demand by industry exceeds the capability of traditional hydrogen deliverers. Many aspects of the traditional hydrogen supply chain are incapable of meeting higher levels of hydrogen demand. Industrial hydrogen users are at risk.

Now hydrogen is gaining entirely new uses for electrochemical energy storage (essentially stored electricity) and as the basis for green chemistry. These new markets may be hundreds of times larger than all traditional hydrogen markets together.

Nel Hydrogen is committed to meeting the hydrogen needs of thermal processing, while investing to meet the huge new needs for hydrogen for energy storage and green chemistry. Nel innovations in hydrogen generation will create unprecedented new levels of cost-effectiveness, reliability, and ease-of-use for hydrogen generators of all sizes. Generated hydrogen will gradually displace supply-chain hindered delivered hydrogen.

Cliff Orcutt, Vice President, American Isostatic Presses, Inc.

AMERICAN ISOSTATIC PRESSES, INC.

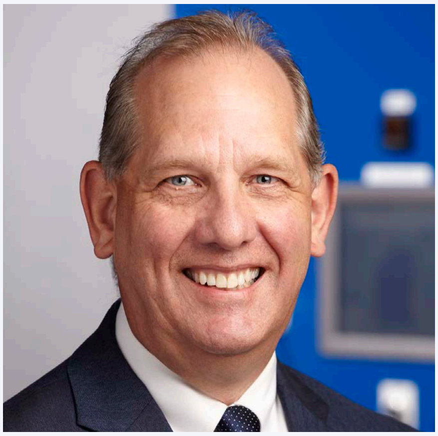
website: aiphip.com
telephone: (614) 497-3148

AIP Installs a Rapid Cool System to Its AM R&D Hot Isostatic Pressing Center

American Isostatic Presses, Inc. (AIP) in Columbus, Ohio, introduced a state-of-the-art rapid cooling system to assist in developing the continuously growing additive manufacturing sector. The current system can quench parts at up 200°C per minute. The hot zone of the HIP system is 10" diameter by 18" long and can process parts up to 1250°C. In addition to a rapid cooling HIP system, our research facility is equipped with HIP systems that can process parts to 60KSI and 2000°C and a CIP/WIP system capable of going to 85000 psi.

The new system is designed for materials that can benefit from rapid cooling to produce favorable microstructures. It can result in maintaining fine-grained microstructures, precipitation of carbides and oxides at grain boundaries, and improving high-temperature strength and creep resistance. In addition, rapid cooling can eliminate the need for additional heat treatments such as quenching and solution heat treatment. AIP, however, takes a balanced approach for industrial/production operations as sometimes, with some heat treatments, it is more cost-effective to do separately. AIP is not only a toll HIP provider but also an industry expert in process development to give your product a competitive advantage. Our rapid cool system lets customers choose if this route works best for their materials.

Our HIP processing capacity has increased with our new facility expansion in Ohio and unit expansions at our sister companies Isostatic Pressing Services (IPS) in Oregon, and Isostatic Toll Services (ITS), in Mississippi and Spain. As a result, our companies have increased availability and reduced production run turnaround times. We continue our dedication to the industry and our customers by maintaining ITAR compliance and certifications in ISO and NADCAP. Contact us today to be added to our 2023 schedule!



Bob Fincken, Vice President Sales, Super Systems, Inc.

website: supersystems.com

telephone: (513) 772-0060

Optimistic Vision for Super Systems, Inc.

Super Systems, Inc. (SSi) has had a solid 2022 and we are approaching 2023 with an optimistic vision.

There is a steady need for products and services that SSI supplies the industry. Our customers are looking for hardware and software solutions that eliminate mistakes and rework. The Load Entry 3 software module that works within our SuperDATA Pro suite has been a key point in our offering.

This software not only provides the traditional charting and data acquisition, but also adds the extra benefits of tracking furnace usage, work order creation, tracking, and report generation. We look forward to the addition of a Pyrometry module that provides detailed accounting for all AMS2750G requirements. This is a seamless transition for us because the assets are already a part of the SuperDATA Pro system. Hooks for third party software have been integrated for customers using web-based or PC-based Manufacturing Execution Systems (MES) or Quality Management Systems (QMS) solutions.

Businesses look to us to provide solutions using technology that is reliable and easy to use. We have our standard offering for hardware devices like our Gold Probe, dew point analyzers, CO, CO2, CH4, and H2 analyzers that will be needed for anyone trying to troubleshoot, automate, or improve their process.

Our eFlo high pressure and low pressure flow meter offerings continue to grow at a rapid pace, again due to the technology offered and the precision control that older flowmeters cannot meet.

With manpower concerns among all our customers, our goal is to offer products that will eliminate traditional needs that a person might need to perform with automation. We look forward to another productive year in 2023.

Peter Zawistowski, Managing Director, SECO/VACUUM Technologies

We support your success.

website: secovacusa.com

telephone: (814) 332-8520

Lower Carbon Footprint and Net-Zero Initiatives

From our perspective at SECO/VACUUM, we expect manufacturers with in-house heat treating to continue to embrace clean electric vacuum furnace technologies versus gas atmosphere furnaces for a variety of reasons.

First, forward-thinking companies are looking to comply with lower carbon footprint and Net-Zero initiatives being deployed by governments worldwide, so new carburizing plants are moving increasingly from atmosphere to low pressure carburizing (LPC), and quenching systems are migrating from oil to gas. This trend will gain momentum as efforts to reduce emissions from atmosphere technologies increase.

Second, and as a consequence of Net-Zero initiatives already taking hold in Europe, American companies supplying products for global European firms will need to comply with regulations even if those components are not made in Europe. Ultimately, we see similar initiatives resulting in regulations throughout North America, so the sooner U.S. manufacturers get on board, the better positioned they will be to participate in all markets.

Finally, we are also seeing increasing interest in automation in manufacturing — and in heat treatment in particular — to improve consistency and reduce reliance on skilled labor. Single-piece flow vacuum carburizing and gas quenching systems take a machined part and heat treat and quench it one at a time with unequalled uniformity while virtually eliminating post-heat treatment distortion remediation. We think this is a big part of the future of heat treating in the modern plant.

Trevor Jones, CEO, Solar Manufacturing

SOLAR MANUFACTURING

website: solarmfg.com

telephone: (267) 384-5040

The Brightest Solutions Through Ingenuity

The 20th anniversary of Solar Manufacturing was celebrated in 2022, and it came with steady growth that we expect to continue into 2023. With an unknown business and political climate next year, Solar Manufacturing is fortunate to be entering the upcoming year with a healthy backlog of orders to weather any potential economic storm that may lie ahead. Additionally, strong quotation activity levels seem to indicate customers are optimistic to expand after the pandemic ramifications continue to ease.

We foresee extended supply chains and inflationary costs carrying into next year, though, at lower levels than experienced in recent years. Environmental policies will continue to subsidize and enforce technologies with a lower carbon footprint such as the EV industry.

Solar Manufacturing is also excited about our newly designed vacuum oil quench furnace, NEO, which is a safer, cleaner, and more environmentally friendly method to oil quench materials as compared to atmosphere integral oil quench furnaces. We will also be rolling out a vacuum debind and sinter furnace in 2023 for the metal injection molding and additive manufacturing industries. This furnace is designed to efficiently collect organic binders remaining from the manufacturing process. Finally, we expect more onshoring of manufacturing back to the United States, which we welcome as our furnaces are also proudly made in the USA.

Harnessing the Sun: A Heat Treat Case Study with General Atomics

By Rafal Walczak, Product Manager, SECO/VACUUM

Imagine this: A huge lab facility nestled in the south of France. . . teams of scientists and technicians striving to bring carbon-free energy solutions to the world. . . "replicating the high-energy fusion reaction that powers the sun and stars." To complete the project, what heat treat solution is needed? Read to find out.

Introduction

For this case study, we will discuss how SECO/VACUUM built a highly specialized custom heat treating furnace used in the construction of the central component of a large, multinational science experiment.

The Experiment

ITER (standing for International Thermonuclear Experimental Reactor and meaning "the way" in Latin) is the largest high-energy science experiment ever conducted. At a giant lab facility in southern France, 35 countries, hundreds of vendors, and thousands of scientists and technicians are collaborating on a device to demonstrate the feasibility of clean, safe, carbon-free energy production by replicating the high-energy fusion reaction that powers the sun and stars. There are no solid materials that can touch, much less contain, such a high-energy reaction without immediately vaporizing. Instead, this super-hot cloud of plasma must be contained by a special configuration of magnets called a tokamak, which can trap charged particles in a toroidal or donut-shape cloud. This tokamak has 10 times more plasma containment volume than any other tokamak ever built.

The term "tokamak" comes to us from a Russian acronym that stands for "toroidal chamber with magnetic coils" (тороидальная камера с магнитными катушками).

Figure 1. ITER Laboratory at the Cadarache research center in southern France

Photo source: ITER Organization

The Magnet

General Atomics' Magnet Technologies Center near San Diego, CA was contracted to build the ITER tokamak's large central magnet, the most powerful superconducting magnet ever built, strong enough to lift an aircraft carrier. Other magnets in the tokamak serve to contain the plasma. The central solenoid is an oscillating magnet responsible for inducing current in the plasma cloud similar to how an induction stove heats a pan, except it is heating the plasma to 15 times the temperature of the surface of the sun. Far too large to be constructed and transported in one piece, the 12-meter-tall, 4-meter-wide coil of wires must be built in six 2-meter-tall modules to be joined once they are all on site at the lab. A seventh module will be built as a spare.

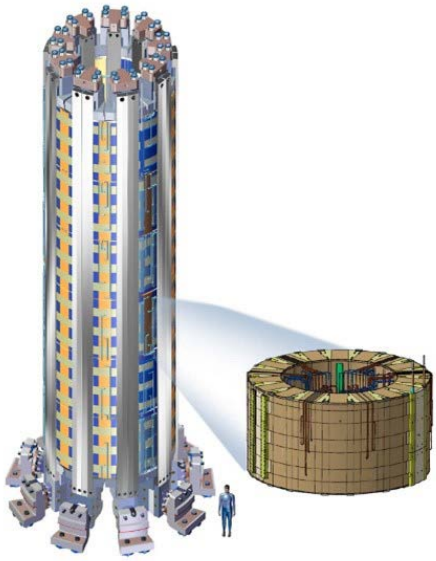


Figure 2. ITER central solenoid and one isolated solenoid module

Photo source: General Atomics ITER Manufacturing

Kenneth Khumthong, technical lead for final testing and fabrication certification for ITER Central Solenoid at General Atomics, described the tests on each module of the magnet, saying, "We run a battery of tests on each and every module, subjecting them to voltages as high as 30,000 volts and powering them with as much current as 40,000 amps. This is done to ensure that every module meets all of ITER's specifications prior to shipping them out to France."

Embrittlement vs. Field Strength Tradeoff

Other superconducting electromagnets in the ITER tokamak will be made using coils of relatively durable niobium-titanium alloy. Past experiments have demonstrated that magnetic fields greater than 12 tesla disrupt the superconducting properties of Nb_3Ti. The ITER central solenoid, however, must sustain magnetic field strengths above 13 tesla. For this reason, the central solenoid coils must instead use niobium-tin as its superconducting wire, which more reliably maintains superconducting properties in such high magnetic fields but is also more brittle and too fragile to bend after reaction to Nb_3Sn. In order to accommodate for the brittle wire, General Atomics had to first coil the wire and jacket into their final shape *before* heat treating the metals into their superconducting, albeit brittle, alloy Nb_3Sn.

The Wire

- Niobium-tin wire strands react to become Nb_3Sn.
- Copper strands serve as traditional conductors to safely dissipate stored energy when the superconductivity experiences a disruption. The copper strands do not react with the niobium-tin.
- A central spiral maintains a hollow channel to circulate liquid helium to chill the Nb_3Sn wires to 4°K, below their superconducting temperature of 12°K.
- Creating such strong magnetic fields inside a coil of wire will also tear apart the coil of wire itself if that wire is not supported inside a high strength jacket. The ITER central solenoid wire bundle is about 38.5mm in diameter, housed inside a 50 x 50mm stainless steel jacket.
- Total maximum current in the superconductor wire is 48,000 amps.

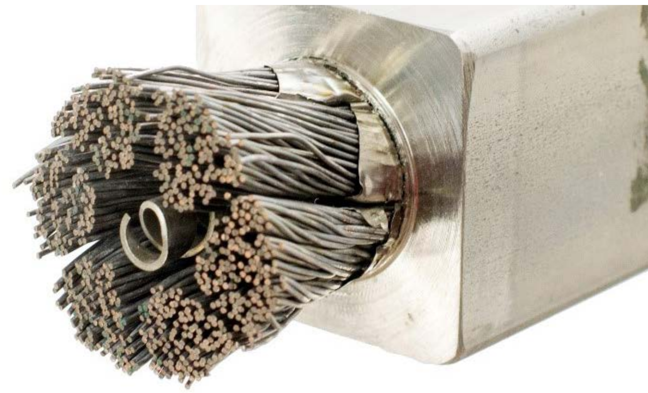


Figure 3. A dissection of the central solenoid conductor strands, central spiral, and structural jacket

Photo source: ITER Organization

- Worldwide niobium production increased six-fold for several years just to meet the niobium demands of the ITER project.

Figure 4. Technicians ensure proper placement before lowering heat treat furnace

Photo source: General Atomics ITER Manufacturing

The Heat Treating Furnace

In order to convert the niobium-tin metal conductors into superconductors, each of these 4 meter by 2 meter 110 ton solenoid sections must be heat treated for five weeks, exceeding 1200°F (650°C) at its peak. The heat treatment serves to alloy the niobium and tin together into Nb_3Sn, which becomes a superconductor when chilled with liquid helium to 4°Kelvin. No such heat treating furnaces existed, so General Atomics turned to SECO/VACUUM to build a custom heat treating furnace large enough to fit these solenoids and packed with all the technology needed to meet the strict quality control standards of this monumental experiment.

Five inch wide metal band heaters ring around the walls of the furnace with nearly 900kW of heating power. Covering 50% of the walls, they provide a very uniform heat. This is brought about by the following seven steps.

The Heat Treating Sequence

In addition to alloying the niobium-tin wires, the furnace also serves to remove the stresses in the stainless steel jacket housing the superconducting wire and to bake off any residual contaminants prior to reaching reaction temperature.

1. Complete a quality control test: Vacuum seal the untreated solenoid coil in the room temperature furnace and charge the inside of the conductor jacket with 30 bar high pressure helium to test for leaks after forming and welding.
   a. Monitor furnace atmosphere with ultra-high sensitivity mass-spectrometer helium detectors.
2. Purge with argon gas while slowly ramping up heat.
   a. This drives off hydrocarbons and oxygen before the system reaches reaction temperatures.
   b. Monitor furnace atmosphere with gas chromatograph to find impurities from residual oils and lubricants leftover from manufacturing process.
   c. Monitor and control argon circulation and exchange with mass flow sensors and circulation blowers that penetrate the furnace lid with ferrofluidic feedthrough seals around the blower motor shafts.
3. Maintain at 1058°F (570°C) for about 10 days. Confirm stabilized temperature and pure atmosphere.
4. Proceed to 1202°F (650°C) for four days. This is the actual reaction phase that achieves the primary objective of converting the niobium-tin into the superconducting alloy Nb_3Sn.
5. Very slowly and uniformly ramp back down to room temperature to avoid additional stresses in the coil.
6. Complete another quality control test: Evacuate the argon and once again vacuum seal the solenoid coil in the room temperature furnace and recharge with 30 bar high pressure helium to test for leaks after heat treating. Monitor atmosphere for the presence of helium, which would indicate a leak in the coil.
7. Only then is it ready for the post-heat treating stages of wrapping with insulation and encasing in epoxy resin for rigidity.

Options, Upgrades, Special Features

There was no room for error. SECO/VACUUM collaborated with the engineers at General Atomics to create a heat treat furnace that can assure temperature variation within the coil never varies by more than 18°F (10°C) anywhere in the furnace at any time in the five-week cycle and achieves near-perfect repeatability for all seven modules.

They accomplished this with quadruple-redundant control thermocouples and feeding temperature data from 150 points in the coil into the control computers. To shield against impurities, the furnace is first evacuated to a vacuum pressure of 0.001 Torr, and then purged with pure argon

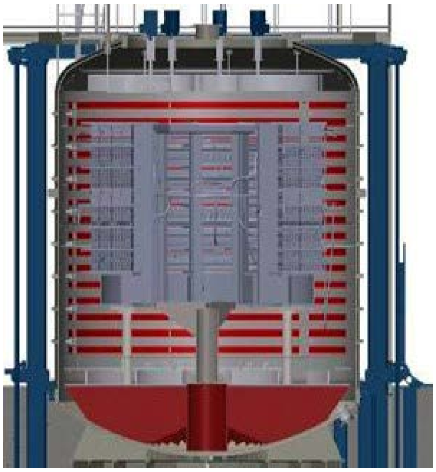


Figure 5. Cutaway illustration showing the furnace construction

Photo source: SECO/VACUUM

to drive out any residual oxygen or hydrocarbons that could contaminate the purity of the superconductor. Monitoring the argon atmosphere for impurities are redundant mass spectrometers. The argon is circulated by seven convection fans to heat the solenoid assembly evenly. Each of these fans must be driven through ferrofluidic feedthrough seals, which allow the rotating shafts to operate through the furnace walls without compromising the vacuum seal of the furnace. **HTT**

About the Author:

Rafal Walczak is the product manager at SECO/VACUUM. Rafal joined SECO/WARWICK Group as a service engineer in the Vacuum Furnaces Division soon after graduation from Technical University of Zielona Góra in Poland in 2002. Since 2008, he has been involved in vacuum furnace sales in Europe and the USA. The combination of his technical background and field service experience help him provide outstanding support to his SECO/VACUUM customers.

For more information

Contact Rafal at ***Rafal.Walczak@SecoVacUSA.com***

General Atomics first began discussing this project with Rafał Walczak, the product manager at SECO/VACUUM, in early 2010. Both teams spent over two years on conceptual discussions, preliminary designs, and process simulations before SECO was even awarded the contract. Once SECO was on board, it took another two years of design, fabrication, and installation before the furnace could be put into operation. SECO/VACUUM built it to handle a lifetime of use without error so they could be sure that it would work flawlessly for the seven cycles that it actually had to run.

The SECO/VISORY Heat Treat Advisory Council is a team of SECO/VACUUM heat treat experts and consultants with diverse thermal experience and process knowledge who are available to help companies solve their specific heat treat equipment challenges.

Vacuum Furnace Technology

By Jason Schulze, Director of Technical Services Special Process – Metallurgy, Conrad Kacsik Instrument Systems, Inc.

Vacuum furnaces are widely used in the aerospace and automotive industries. These furnaces are used for multiple processes including brazing, aging, and solution heat treating for countless materials. Typically, vacuum furnaces are utilized to ensure a lack of oxidation/contamination during heat treatment. This article will talk about the origins, theory, and main parts of vacuum technology and how it is used in both aerospace and automotive industries.

A Brief History

Vacuum furnaces began to be used in the 1930s for annealing and melting titanium sponge materials. Early vacuum furnaces were hot wall vacuum furnaces, not cold wall vacuum furnaces like we use today. Additionally, most early vacuum furnaces did not utilize diffusion pumps.

Vacuum Heat Treat Theory

Vacuum technology includes vacuum pumping systems which enable the vessel to be pulled down to different stages through the process. Degrees of vacuum level are expressed opposite of pressure levels: high vacuum means low pressure. In common usage, the levels shown below in Figure 1 correspond to the recommendations of the American Vacuum Society Standards Committee.

Low Vacuum:	Atmosphere to 10 torr
Medium Vacuum:	100 torr to 10^{-2} torr
High Vacuum:	10^{-3} torr to 10^{-5} torr
Very High Vacuum:	10^{-6} torr to 10^{-8} torr
Ultra High Vacuum:	10^{-9} torr and below

Figure 1. Vacuum levels corresponding to the recommendations of the American Vacuum Society Standards Committee

Vacuum level will modify vapor pressure in a given material. The vapor pressure of a material is that pressure exerted at a given temperature when a material is in equilibrium with its own vapor. Vapor pressure is a function of both the material and the temperature. Chromium, at 760 torr, has a vapor pressure of ~4,031°F. At 10 ¯ 5, the vapor pressure is ~2,201°F. This may cause potential process challenges when processing certain materials in the furnace. As an example, consider a 4-point temperature uniformity survey processed at 1000°F, 1500°F, 1800°F, and 2250°F. This type of TUS will typically take 6-8 hours and, as the furnace heats up through the test temperatures, vacuum readings will most likely increase to a greater vacuum level. If expendable Type K thermocouples are used, there is a fair chance that, at high readings, you may begin to have test thermocouple failure due to vapor pressure.

Vacuum Furnace Pumping System

Vacuum heat treating is designed to eliminate contact between the product being heat treated and oxidizing elements. This is achieved through the elimination of an atmosphere as the vacuum pumps engage and pulls a vacuum on the vessel. Vacuum furnaces have several stages to the pumping system that must work in sequence to achieve the desired vacuum level. In this section we will examine those states as well as potential troubleshooting methods to identify when one or more of those stages contributes to failure in the system.

Vacuum furnaces have several stages to the pumping system that must work in sequence to achieve the desired vacuum level. Each pump within the system has the capability to pull different vacuum levels. These pumps work in conjunction with each other (see Figure 2).

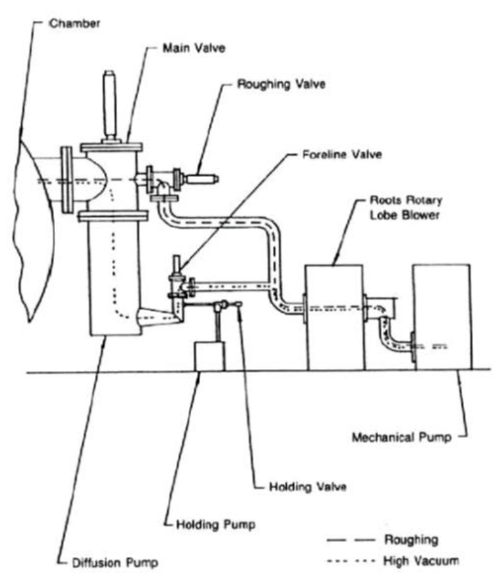


Figure 2. Vacuum pumps work in conjunction with one another

The mechanical pump is the initial stage of vacuum. This pump may pull from 105 to 10. At pressures below 20 torr the efficiency of a mechanical pump begins to decline. This is when the booster pump is initiated.

The booster pump has two double-lobe impellers mounted on parallel shafts which rotate in opposite directions (see Figure 3).

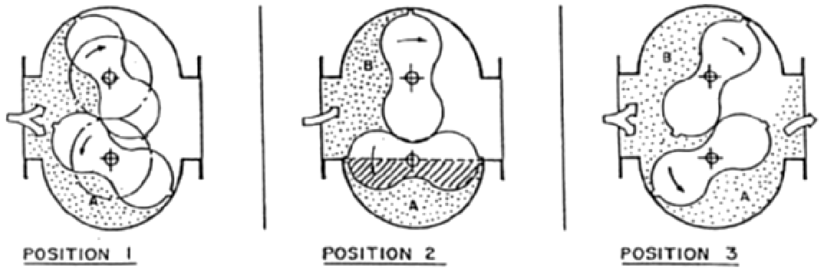


Figure 3. Booster pump positions

The diffusion pump (Figure 4) is activated into the pumping system between 10 and 1 microns. The diffusion pump allows the system to pump down to high vacuum and lower. The diffusion pump has no moving parts.

The pump works based on the vaporization of the oil, condensation as it falls, and the trapping and extraction of gas molecules through the pumping system.

The holding pump (Image 1) creates greater pressure within the fore-line to ensure that, when the crossover valve between the mechanical and diffusion pump is activated, the oil within the diffusion pump will not escape into the vessel.

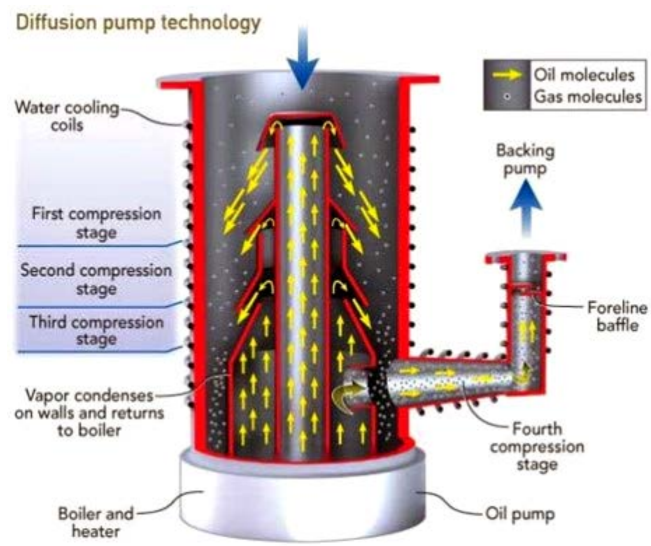


Figure 4. Diffusion Pump

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Image 1. Holding Pump

Vacuum Furnace Hot Zone Design

The hot zone within a vacuum furnace is where the heating takes place. The hot zone is simply an insulated chamber that is suspended away from the inner cold wall. Vacuum itself is a good insulator so the space between the cold wall and hot zone ensures the flow of heat from the inside to the outside of the furnace can be reduced. There are two types of vacuum furnace hot zones used: insulated (Image 2) and radiation style (Image 3).

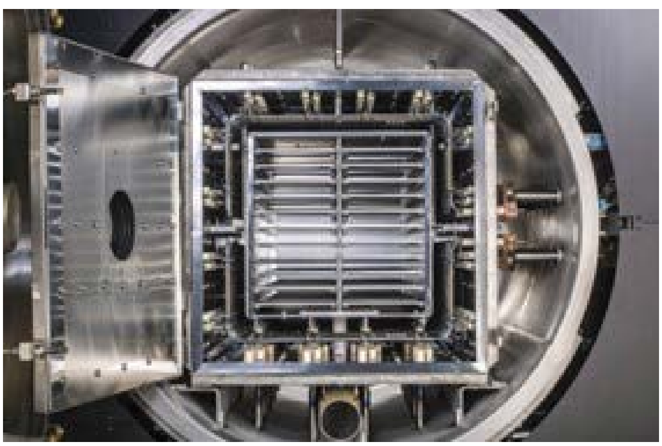

Image 2. Insulated

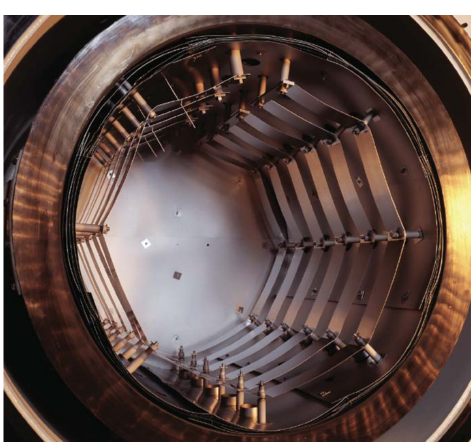

Image 3. Radiation

The two most common heat shielding materials are molybdenum and graphite. Both have advantages and disadvantages. Below is a comparison (Tables 1 and 2).

Molybdenum	
Advantage	Disadvantage
*Strong at high temp. *Cleaner process *Higher vacuum	*Brittle at low temp *Cost

Table 1.

Graphite	
Advantage	Disadvantage
*Cost *Repair Easily	*Absorption of contaminants

Table 2.

Vacuum Furnace Quenching System

Quenching is defined as the rapid cooling of a metal to obtain desired properties. Different alloys may require different quenching rates to achieve the properties required. Vacuum furnaces use inert gas to quench when quenching is required. As the gas passes over the load, it absorbs the heat which then exits the chamber and travels through quenching piping which cools the gas. The cooled gas is then drawn back into the chamber to repeat the process (see Figure 5).

Vacuum Furnace Trouble Shooting

On page 27, in Table 3 are some helpful suggestions with regard to problems processors may have.

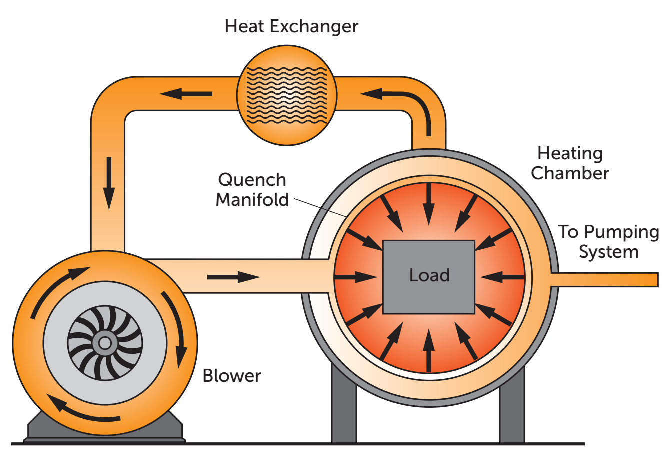

Figure 5. Diagram of gas quenching

Probable Cause	Suggested Remedy
Leak in the system	**Detect leaks using a helium leak detector.**
Diffusion pump oil contamination	**Replace/Clean diffusion oil.**
Low heat input to diffusion pump	**Check voltage and amperage of heating element. Check wires – use high temp wires and lugs. Water in quick cool coil. Excessive or too low cold water flow.**
High Fore line pressure	**Check for leaks – poor mechanical pump performance.**
Low oil level	**Check and add oil.**
Oil/System contamination	**Perform a burn out. Use better cleaning prior to processing.**
Malfunctioning pump assembly, improperly located jets or damaged jets	**Check and correct jets.**

Probable Cause	Suggested Remedy
Contaminated Oil	Change Oil.
Worn out Pump	Check pump blank off pressure (pressure when roughing valve is open).
Inaccurate Vacuum Gauges	Replace gauge or tube. Check main O-ring. Check threaded joints of the vacuum fitting.

Table 3.

Summary

Vacuum furnaces are an essential piece of equipment when materials need to be kept free of contamination. However, there are times when this equipment may not be necessary, and is therefore considered cost prohibitive, although this is something each processor must research. This article is meant to merely touch on vacuum technology and its uses. For additional and more in-depth information regarding vacuum furnaces, I recommend a technical book called *Steel Heat Treatment*, edited by George E. Totten. **HTT**

About the Author:

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As a metallurgical engineer with over 20 years in aerospace, he assists potential and existing Nadcap suppliers in conformance as well as metallurgical consulting. He is contracted by eQuaLearn to teach multiple PRI courses, including pyrometry, RCCA, and Checklists Review for heat treat.

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Heat Treating: The Best Medicine

By Heat Treat Today Editorial Team

Heat treating solutions are important for more than keeping an airplane flying in the sky or a bridge suspended above the water. These two examples are high profile, but what about the heat treating solutions that do not zoom through the air or mark the skyline above rivers? In the medical industry, heat treating solutions are often unseen unless something goes wrong. When it comes to medical implant and device heat treating, what options are available to manufacturers that will benefit patients? What should we know about the heat treating processes that make metal parts functional as knees, hips, and elbows? Find out in this expert analysis.

Introduction

Dan McCurdy, former president at Bodycote, Automotive and General Industrial Heat Treatment for North America and Asia, knows full well just how much time, energy, and pain the right medical heat treating practice and alloy composition can save a patient. Dan's wife suffered from complications due to a nickel allergy in a traditionally thermally-processed ASTM F75 knee implant. She dealt with constant inflammation, swelling, and pain. Physical therapy and a second procedure did nothing to ease the discomfort. The best medicine for Dan's wife? A specially heat treated medical implant.*

** To read more of Dan's story, see page 30*

To understand the stories behind final medical products, **Heat Treat Today** asked Quintus Technologies and ECM USA, Inc. to share two different approaches on medical implant and device heat treatment. These two companies at the forefront of the medical heat treating industry shared about hot isostatic pressing (HIP) with additive manufacturing, and vacuum heat treating. Read their answers to our questions and learn how, when it comes to implantable medical devices, heat treating can be the best medicine.

How do you ensure your equipment maintains the precise specifications required in the medical industry? What specifically is necessary to maintain compliance when it comes to medical implants?

Quintus Technologies

Chad Beamer, Applications Engineer, Quintus Technologies

Quintus Technologies has observed a trend in bringing Nadcap to the medical industry. Historically the medical industry has focused on the standards and regulations for the quality management system of their approved supplier, but a consistent transition to technical aspects of critical processes (including HIPing) is becoming the norm.

Quintus Technologies' background is one of delivering HIP equipment in line with Nadcap and AMS2750 specifications. The medical industry requires best-in-class temperature uniformity and accuracy; systems designed with production driven flexibility (such as thermocouple quick-connectors for T/C sensor installation to minimize downtime); HIP furnaces equipped with uniform rapid cooling (URC®) for optimized cycle productivity; active involvement in standards committees; and working directly with the industry.

Requirements are increasing in terms of productivity and the introduction of more complex surface requirements. It is crucial to work closely with the industry to reduce oxidation of orthopedic implants during the HIP and heat treatment processes.

Steering of the HIP cycle is key, along with in-HIP heat treatments to achieve the desired microstructure for the application, which is a standard offering for High Pressure Heat Treatment™ (HPHT™) equipment.

ECM USA, Inc.

Dennis Beauchesne, General Manager, ECM USA, Inc.

Some of the features that are most important are leak rate at deep vacuum along with a chamber and furnace design that does not contribute to any contamination. In our systems, these features, along with others, are of the utmost importance when supplying equipment for the medical implant market.

What are the top 3–5 key requirements or compliance/quality issues needed to heat treat medical implants?

Quintus Technologies

There are several industry standards that have been released to establish key requirements for the HIP process that are often leveraged for medical applications demanding performance and reliability. For example, Nadcap has released AC 7102/6 which details the audit criteria for HIP. This document was developed with significant input from the industry and the government to define operational requirements for quality assurance. It offers a checklist for the HIP processing of metal products and includes requirements for:

- managing the equipment per pyrometry standard AMS2750
- qualifying technical instructions and personnel training
- handling product during the loading and unloading operations
- complying with gas purity requirements of the pressure medium
- controlling temperature, including uniformity and accuracy evaluations and management

These aspects are critical to ensure product quality meeting medical customer requirements and expectations. Recent additions beyond conventional requirements highlighted above include high speed cooling in the HIP process (>200 K/min) for some materials which is important for metallurgical results.

ECM USA, Inc.

Key requirements include thermal performance (both uniformity and ramp control); real-time vacuum and gas management; traceability and production lot follow up through human machine interface (HMI); quality procedures for all sensor calibrations; and remote access for control and troubleshooting.

Can you share an example of how your equipment could be used to heat treat a medical implant/device from start to finish?

Quintus Technologies

Many medical implants — whether fabricated using conventional processing techniques such as casting, or more novel approaches such as additive manufacturing — require HIP to eliminate process related material defects. Defects include shrinkage porosity for castings and lack-of-fusion and keyhole defects for fusion based additive manufacturing techniques. These defects can have a negative impact on product quality, impacting performance and reliability. Once HIP has been applied to a material, post processing is often not complete, with additional thermal treatments required to achieve the optimum microstructure leading to the desired material properties and performance. Such thermal treatments are material and process dependent, but could include a stress relief, solution anneal, rapid cooling or quenching, and aging and are often applied in separate heat treat equipment.

Quintus Technologies has introduced HIP systems providing capabilities beyond conventional densification. Decades' worth of work in equipment design, system functionality, and control now offers an opportunity to perform HIP and heat treatment in a combined cycle, referred to as HPHT. Combined HIP and heat treatment for castings and AM implants can mitigate the risk of thermally induced porosity, as well as grain growth, which can offer advantages for mechanical and chemical properties in implants. This methodology provides a more sustainable processing route with improved productivity and energy efficiency. A joint HIP and heat treatment offers significant advantages with lead time, and this improvement in lead time couples well with the demands placed on the personalized medical implants. It also offers opportunities to further optimize microstructures for improvement in material properties coupled with ease of manufacturability. HPHT and modern HIP equipment may allow for a higher performing material system, which produces an implant with improved reliability and life.

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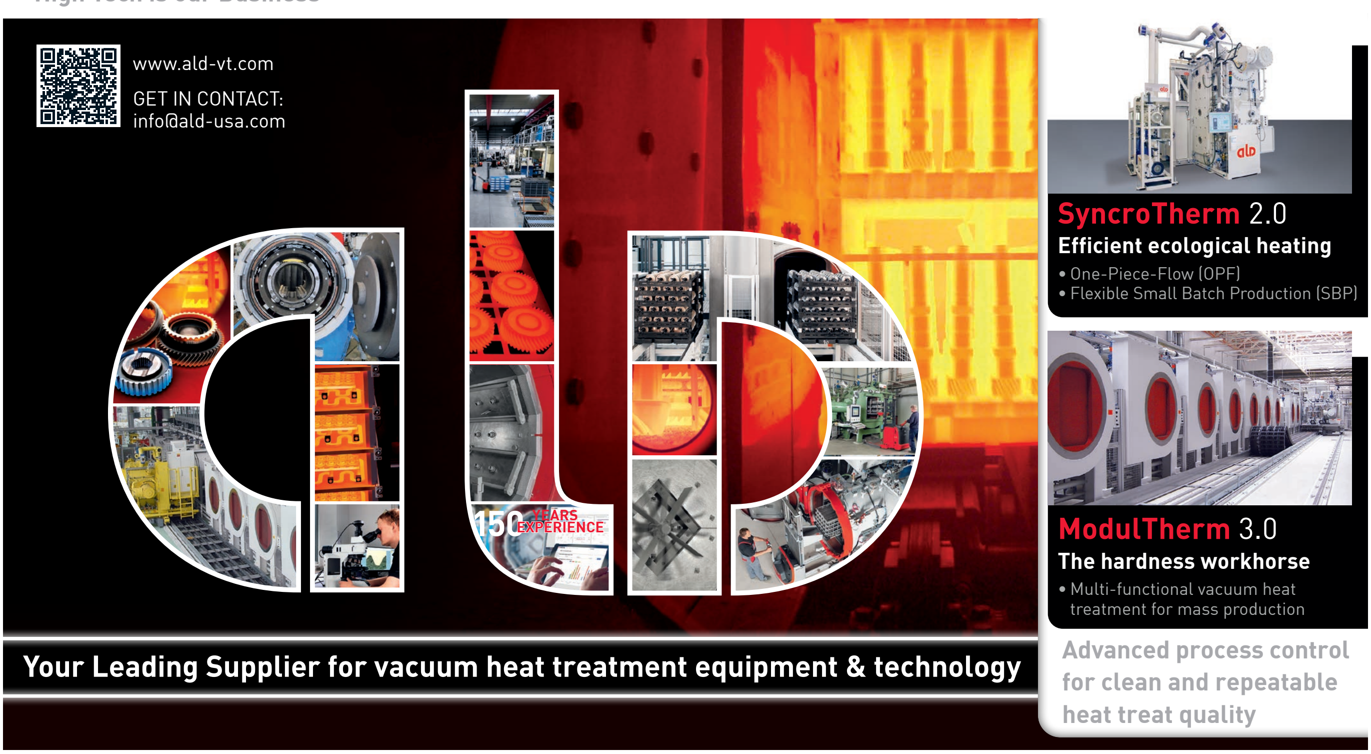

Within the medical industry, fine grain AM microstructure, repeatability, and low porosity are key concerns. There are many reported benefits by applying the combined HPHT route such as reduced number of process steps, reduced cycle time and lead time, and improved process and quality control. Other advantages include spending less time at elevated temperatures helping to preserve the fine grain AM microstructure by minimizing grain growth. Tight control and steering of the cooling rates during the different steps of the HPHT cycle ensures repeatability of the properties. Manufacturability can be improved through HPHT as this approach reduces the cooling or quench severity during cooling segments which can often lead to part distortion or cracking. Improved functionality and control go hand-in-hand with the high quality and reliability demanded in the medical industry.

ECM USA, Inc.

We have several customers making titanium alloy prothesis for various applications: shoulders, hips. Our furnaces are used for post printing processes, such as stress relieving and solution annealing.

Given concerns of metal poisoning, do you know of any changes in alloy composition of medical devices over the last decade?

Quintus Technologies

There are some metals that are becoming more common for implants, including tantalum, magnesium, CP Titanium, etc., and there have been major steps in improving ceramic materials to compete with metals for many applications.

ECM USA, Inc.

As a vacuum furnace equipment supplier, we are not deeply involved in the entire process of material selection. In the early stages of 3D printing joint replacements, from 2013 to 2014, we saw cobalt being part of some alloys. Lately it seems, indeed, that there is a trend in removing that element from the finished parts. HTT

Hot Isostatic Press QIH 60 offering Quintus Technologies' most advanced Uniform Rapid Cooling (URC®) furnace technology with temperature control and accuracy

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For more information

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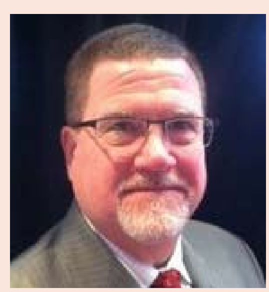
The effects of metal poisoning and metal allergies post-surgery can be devastating. In the narrative below, Dan McCurdy shares the story of his wife's struggle with an allergic reaction to a knee implant, and the heat treating solution that proved to be the best medicine for her.

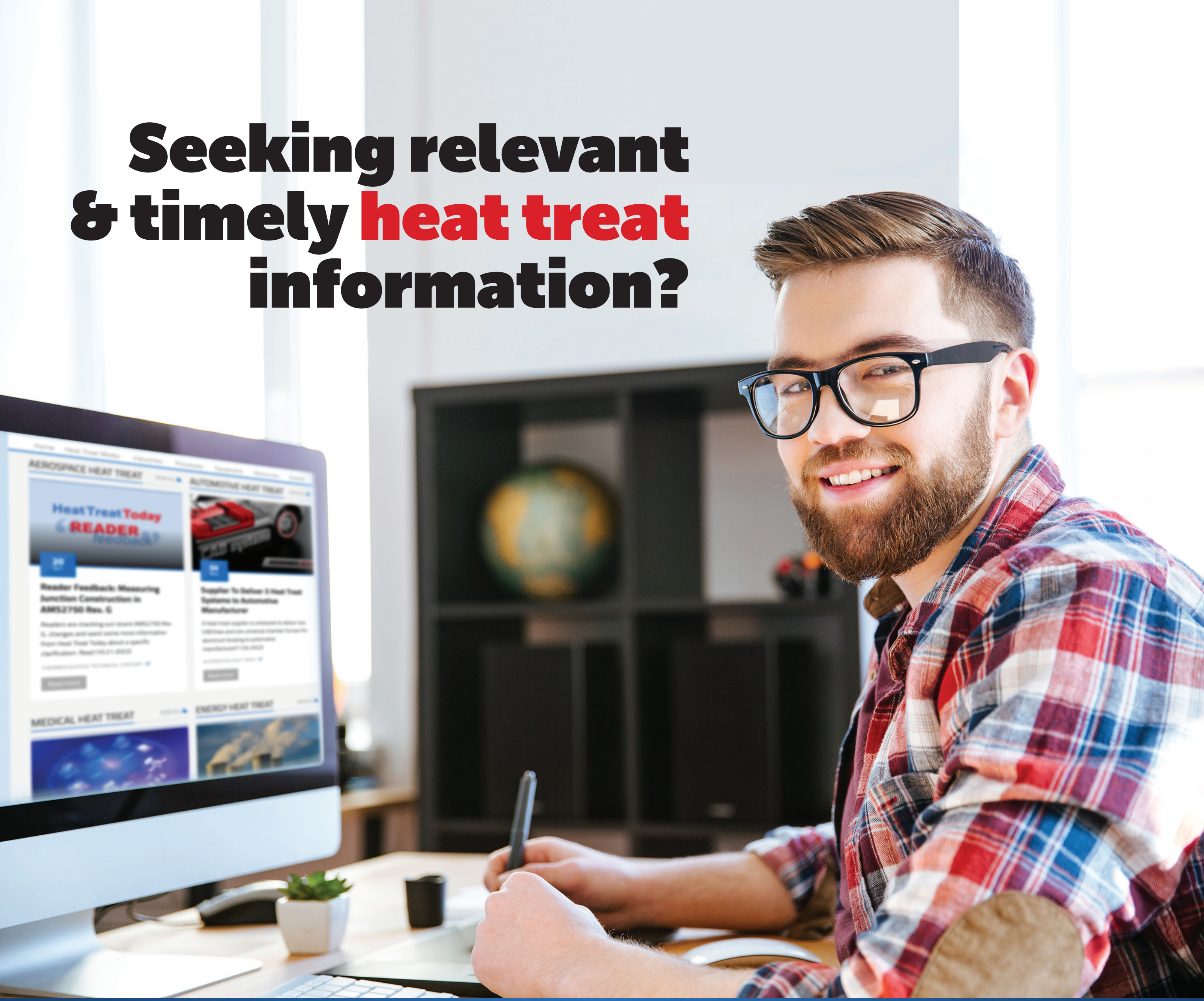
My wife, an avid runner up and down the hills of Cincinnati, was diagnosed with osteoarthritis in both knees at the age of 53. Her orthopedist suggested a knee replacement for the most degraded one. The replacement was a well-known brand, made from investment-cast ASTM F75 (nominally a Co-Cr-Mo alloy) with full FDA-approval. After a successful surgery and diligent physical therapy, her recovery plateaued, and she experienced chronic inflammation, swelling, and pain.

A blood test, designed to detect allergies to materials used in orthopedic implants, showed a reaction to nickel that was nearly off the charts. We were surprised, as she had previously tested negative for nickel allergies through skin patch testing. The ASTM F75 specification allows for up to 0.5% bulk nickel as a tramp element in implantable devices; however, depending on foundry practices, the concentration of tramp alloys at any point on the surface of a casting can vary significantly. Titanium implants may be the solution to this, but FDA-approved titanium alloys can still contain up to 0.1% Ni.



Dan McCurdy, former president, Bodycote, Automotive and General Industrial Heat Treatment for North America and Asia

The solution for my wife, as it turned out, was a different material, originally developed for the nuclear industry, along with an innovative heat treatment process. Created with an alloy of zirconium and niobium (with a maximum nickel content of 0.0035%), her new knee was heat treated at a high temperature in an oxidizing environment, which converts the soft zirconium surface into hard ceramic zirconia, increasing hardness and wear resistance. With this specially heat treated implant in place, my wife is back to nearly 10K steps a day.



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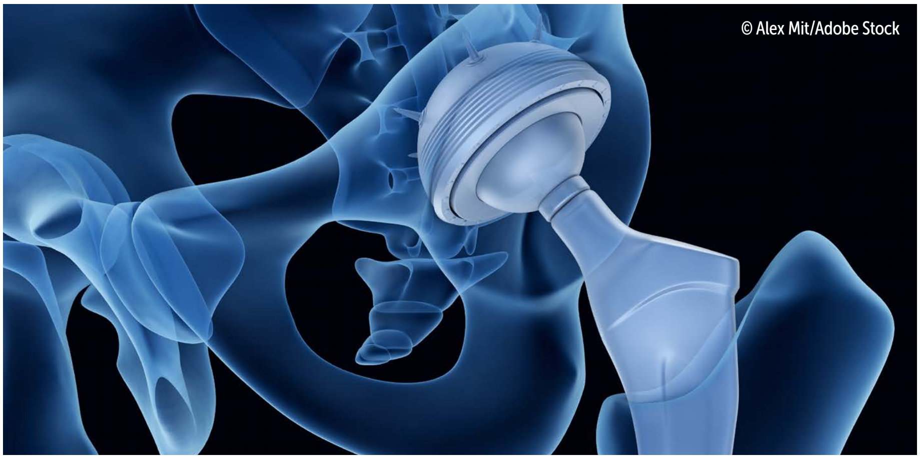


Corrosion Behavior of DMLS Titanium Alloy for Orthopedic Applications

By Richard D. Sisson Jr., YangZi Xu, and Jianyu Liang, Department of Mechanical and Materials Engineering, Worcester Polytechnic Institute

In this article, explore the importance of alternative advanced manufacturing processes and the effects of post-process heat treating of DMLS titanium alloy parts. In a recent study, a team at Worcester Polytechnic Institute (WPI) evaluated the effects of these processes. Read along to see what they found.

According to Markets and Markets reports, the metal implants and medical alloys market[1] will reach $17.64 billion by 2024, at a CAGR of 9.4%, with titanium metal implants and medical alloys accounting for the largest share of the market. Since it was first reported in the 1940s that titanium had excellent compatibility with human bones, titanium has been used in a wide range of biomedical applications, including arthroplasty and bone replacement, prostheses, craniofacial, maxillofacial, and dental implants, as well as surgical instruments and healthcare goods.[2, 3]

Although Ti-6Al-4V alloy was originally developed for aerospace applications, its many attractive properties — such as high strength-to-weight ratio, satisfactory biocompatibility, and good corrosion resistance — resulted in it being one of the most widely used biomedical alloys.[4] However, Ti-6Al-4V alloy is very difficult to machine. Traditional Ti-6Al-4V manufacturing processes include casting, wrought (forging/milling from ingots), and powder metallurgy (P/M), with wrought products accounting for 70% of the titanium and titanium alloy market.[5]

In recent decades, additive manufacturing (AM) processes have been rigorously developed as an alternative advanced manufacturing process for Ti-6Al-4V, especially in personalized biomedical applications. Alternate processes, including powder-bed fusion (PBF), directed energy deposition (DED), and sheet lamination (SL) have been applied in AM processing of titanium and its alloys.[6] Direct metal laser sintering (DMLS), a PBF technology, was the first commercial rapid prototyping method to produce metal parts in a single process and is one of the most widely used AM technologies to manufacture Ti-6Al-4V parts.[7] However, even with the protective oxide film (mainly TiO2), titanium alloys still suffer from pitting and crevice corrosion. Localized breakdown of the protective film leads to the formation of pits. These pits can grow and propagate into macroscopic cracks, which lead to catastrophic failure in orthopedic applications.[8, 9]

It was reported that post-heat treatment of Ti-6Al-4V parts fabricated by AM techniques could improve its mechanical properties, especially increasing ductility and fatigue strength. However, the changes in corrosion behavior with various post-heat treatments of Ti-6Al-4V parts fabricated by AM techniques have not been fully understood. In a recent study, a team at Worcester Polytechnic Institute (WPI) evaluated the effects of various post-process heat-treatments (including solution treatment and aging, annealing, stress relief, and hot isostatic pressing (HIP)), on the corrosion behavior of Ti-6Al-4V parts manufactured by DMLS. The researchers then proposed a desirable post-treatment procedure that can obtain a good combination of mechanical properties and corrosion behavior of as-printed parts in a simulated body environment.[10, 11, 12]

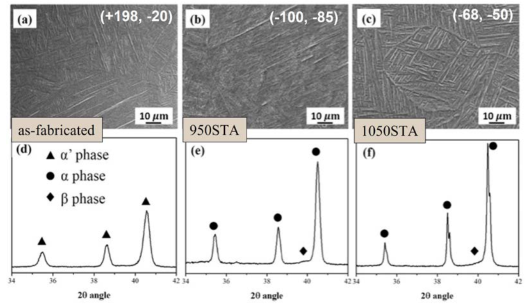
Ti-6Al-4V dumbbell-shaped tensile testing bars were fabricated by DMLS, according to ASTM standards. The microstructure, phase fraction, porosity, and residual stress of as-printed parts were examined and compared to those of the commercial Grade 5 alloy. It was found that the as-printed samples, mainly composed of acicular α' martensite phase with a small amount of nano-scaled β precipitates, dispersed in the α' matrix due to rapid cooling during laser processing, whereas the Grade 5 alloy has an $\alpha + \beta$ two phase with an equiaxed microstructure. The β phase fractions in the as-printed and Grade 5 alloy were 1.6% and 20%, respectively, based on the results of x-ray diffraction refinement. Furthermore, porosity and defects due to lack of fusion or entrapped gas were observed in the DMLS samples. The rapid cooling rate also resulted in residual tensile stress in the as-printed parts.

The microstructure and phase changes due to different heat-treatment processes were examined and compared to those of the commercial Grade 5 alloy. The corrosion behavior of the heat-treated DMLS parts was studied in simulated body fluid by well-established electrochemical methods.

Transformation from α' to α phase, coarsening of the α lath microstructure, and the development of β phase were observed in samples after heat treatments. The greatest fraction of β phase was obtained in the high-temperature annealed sample. Enhanced corrosion resistance was found in all heat-treated samples. The reasons for improved corrosion resistance after heat treatments include: 1) a passive layer that was developed on the sample surface after heat-treatments; 2) increased β phase fraction and size after heat treatments that led to the reduction of the corrosion susceptible sites. Furthermore, only a single passive layer has been observed in the as-printed sample, whereas double passive layers have been observed in samples after heat treatments at temperature higher than 550°C. However, this second layer, which was largely composed of Al_2O_3 and V_2O_5, had very low corrosion resistance compared to that of the primary passive layer that was primarily TiO_2.

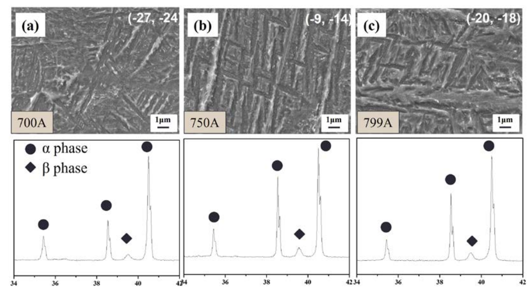
It was also found that the surface roughness had an exponential effect on the corrosion current density and calculated corrosion rate. A rough surface led to a higher corrosion rate, but a rough surface is known to enhance osteointegration. Therefore, surface roughness needs to be adjusted, based on specific applications.

The effect of porosity was analyzed by using a crevice corrosion test. After a one-month immersion in Ringer's solution at body temperature, pits were found on the Ti-6Al-4V sample surface near the pores in the as-printed samples, which was due to the formation of localized O_2 concentration cells near the pore. Porosity in the as-printed parts was confirmed to impair crevice corrosion resistance. To reduce porosity, HIP was applied at three different temperatures. Based on polarization tests and electrochemical impedance spectroscopy tests, different degrees of reduction in porosity and corrosion-current density were observed in samples after HIP; this reduction was most significant after high-temperature HIP at 799°C (1470°F).



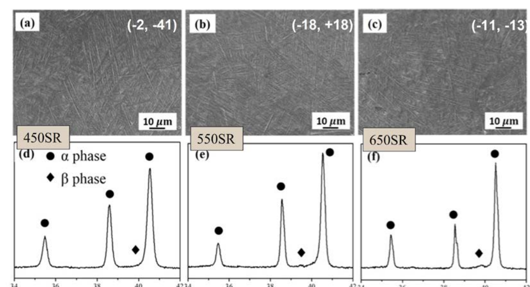
Microstructure: coarsening of the α lath, and grain boundary can be observed

Phase identification: narrowing of α characteristic peaks (reduced microstrain, increased grain size) and evolution of β phase



Microstructure: no significant change in the α lath thickness

Phase identification: narrowing of α characteristic peaks (reduced microstrain), evolution of β phase



Microstructure: coarsening of the α lath thickness, more spherical β precipitates.

Phase identification: narrowed α characteristic peaks (reduced compressive residual stress)

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In summary, it was found that high temperature heat-treatment enhanced the corrosion resistance of DMLS Ti-6Al-4V parts. HIP was effective in reducing porosity and improving corrosion resistance. HIP below the annealing temperature (799°C, 1470°F) was recommended as a post-treatment for DMLS-printed Ti-6Al-4V, to achieve a good corrosion resistance. HTT

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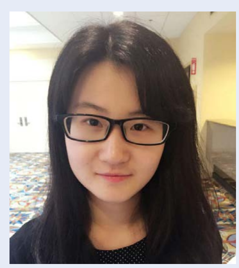
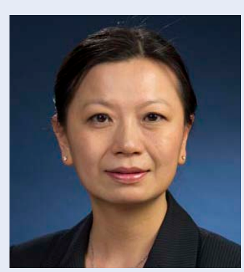
Professor Richard Sisson is a key heat treat researcher and lecturer at Worchester Polytechnic Institute. His main research interest is the application of diffusion and thermodynamics to the solution of materials problems. Currently, he is working on modeling the surface treatment of steels and the post-processing of AM ceramics and metals. His research endeavors have resulted in over 300 publications and over 300 technical presentations.



Dr. Yangzi Xu is currently working at Intel Corporation as a Yield & Module Process Engineer. She received her PhD at Worcester Polytechnic Institute (WPI) and focuses her research on understanding the mechanical and electrochemical properties of AM Ti alloys with different types of heat treatments, and their corrosion performance in biofluid for potential orthopedic applications. Her background includes research in polymer and food science and engineering.



Professor Jianyu Liang is a Professor of Mechanical and Materials Engineering at Worchester Polytechnic Institute, with affiliated appointments in the departments of Civil and Environmental Engineering, Chemical Engineering, and Fire Protection Engineering. Her research work on nanomaterials, AM, agile manufacturing, machine learning for materials science and manufacturing engineering, and sustainability has been funded by NSF, NASA, DoD, ED, and industry. Her work has resulted in over 300 research papers and technical presentations. As an educator, Liang strives to equip students with the confidence, enthusiasm, knowledge, and skills to allow them to enjoy learning throughout their lives.

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Continued from page 10

Low Alloy Steels

Many low alloy steels are used in AM. For example, 4140 and 4340 have various, small amounts of alloying elements. These low alloy steels also need to be heat treated.

Tool Steels

Again, most tool steels are heat treatable. One of the most popular grades is H13; it is a tool steel that is heat treatable and can achieve fairly high hardness. It's used for dies and other types of tooling.

Then, there is a category of tool steels known as A2 and D2; those are steels in which the strength can be changed through heat treatment.

Metal Alloys with Binder Jetting

There are also non-steel alloys that are used in binder jetting and require heat treatment. One example is nickel-based alloys, which fall in the broad category of super alloys. With some of these alloys, a heat treater would solutionize the part by taking it to a high temperature (950–1000°C), hold it for 60 minutes, and then quench in water, high pressure gas, or (in some instances) in air. The part then undergoes an aging treatment for several hours, depending on part thickness.

Additionally, there is a class of copper alloys with small amounts of zirconium and chromium that is heat treatable. These alloys have lower thermal and electrical conductivity compared to pure copper but have an advantage of higher strength and hardness over pure copper, which is very soft and malleable. For example, in applications that require additional strength and hardness compared to copper, the copper-zirconium-chromium-based alloys may be appropriate since their strength and hardness can be increased by heat treatment.

This is just an introduction to the many alloys that have been used in binder jetting that need heat treatment.

Future of Binder Jet and Heat Treat

While heat treaters know about AM in the medical and aerospace industries, AM will likely gain more traction in the automotive industry. Presently, these are relatively small parts, but you will begin to see larger components coming from AM; one of the things to be aware of is that AM can create organic shapes, including all kinds of twisted and complex metal geometries. To ensure that these organic shapes do not distort or droop, larger parts must be well-supported. The development of a software known as Live Sinter™ by Desktop Metal offers the possibility of negatively distorting a complex shaped part (in the green state) so that after sintering, the part shrinks and distorts to eventually provide the desired complex shape at the end. This allows for the possibility of sintering parts either with minimal or without any support structures.

Heat treaters can also anticipate high volume AM production. This is one of the major focuses for binder jet engineers — to reduce costs for most automotive parts — as it will make AM very appealing to this cost-conscious industry.

Finally, optimizing sintering processes and related equipment for AM parts will result in meeting the production demands of the industry, and this will lead to AM parts being seen in heat treat shops more regularly. It would not be a stretch to consider (since there are heat treatments where gas atmosphere quenching at high pressures is possible), that the complete heat treatment cycle may be performed in the same furnace. HTT

About the Author:
Animesh Bose is the Vice President of Research & Development at Desktop Metal, where he is responsible for building out the company's palette of materials that can be used to print quality parts. He has been involved in the area of powder metallurgy and particulate materials (PM) for more than thirty years.

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Cybersecurity Best Practices: Dos and Don'ts

Joe Coleman
Cybersecurity Officer
Bluestreak Consulting™

Introduction

Cybercrime is hands-down one of the quickest growing crimes around the globe and it continues to impact organizations from all industries. Being protected from cyber-attacks is becoming more and more challenging. While cyber criminals are constantly looking for ways to take advantage of your security vulnerabilities, it's very difficult for most organizations to keep up with them.

This fourth article in the series will give you a better understanding of some general cybersecurity best practices for all businesses, and a few tips for what you should and shouldn't do.

What Are the Risks of Having Poor Cybersecurity?

It's difficult to remain 100% protected 100% of the time, but the risks from failing to have proper cybersecurity are hefty. The risks include: malware that can delete your entire system; the selling of your data or your customers' data; an attacker hacking your system and altering files; an attacker using your computer to attack others; or an attacker stealing your credit card information and making unauthorized purchases.

12 Best Practices To Reduce the Chance of Cyberattacks

Follow these cybersecurity best practices to minimize the risks of cyberattacks and improve your cybersecurity:

1. **Use complex passwords**: Use at least 12 to 16 characters, including letters (upper and lower case), numbers, and special characters. Remember to change your passwords frequently.
2. **Keep software up to date, including antivirus and antimalware**: Install software patches as soon as they become available. Also, be sure to enable automatic virus definition updates to ensure maximum protection against the latest threats.
3. **Utilize a firewall**: Firewalls may be able to prevent some types of attacks by blocking malicious code before it can infect your computer. Enable and properly configure the firewall as specified.
4. **Enable Multi-Factor Authentication (MFA) or 2-Factor Authentication (2FA)**: This gives you an additional layer of protection that helps to verify that you are an authorized user.
5. **Be suspicious of unexpected emails**: Phishing emails are currently one of the biggest risks to a user. The goal of a phishing email is to gain information about you, steal money from you, or install malware on your device (if you click on something in the email).
6. **Use VPNs to ensure connections are private**: To have a more secure and private network connection, use a VPN (virtual private network). Your connection will be encrypted, and your private information protected.
7. **Look for HTTPS on websites (instead of just HTTP)**: On websites that do not use HTTPS, there's no guarantee that the information between you and the site's servers is secure.
8. **Scan external storage devices**: External storage devices have the same risk as internal storage devices. Always scan external storage devices for malware before accessing them.
9. **Train your employees**: If your cybersecurity program has any chance of working, make sure your employees are well trained and always using security best practices. It only takes one mistake. Educate your staff to be aware and on the lookout for different types of malicious social engineering (including a simple phone call asking for a username and/or password).
10. **Backup your important data**: Critical data can be lost with security attacks. Make sure you backup your important data frequently to the cloud or local storage device (preferably multiple devices).
11. **Don't use public networks**: Avoid public networks or use a VPN to connect. All of your information is vulnerable on public networks at hotels, coffee shops, airports, and other similar locations.
12. **Use secure file-sharing to encrypt data**: When sharing sensitive or confidential information, always use a secure file-sharing solution. If emails are intercepted, unauthorized users will have access to your data.

Improve Your Cybersecurity Weaknesses

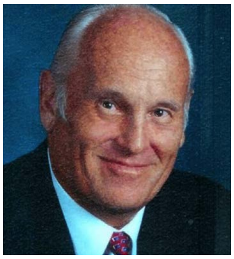
NIST SP 800-171 is an excellent best practice, even if you are not in the DoD downstream or military-related supply chain, to ensure your data and your customer's data is always secure.

My fifth article in this Cybersecurity Desk series will be: "Performing Your Basic & Your Final NIST 800-171 Assessments."

Scan to download a list of cybersecurity acronyms.

Endings . . . People We Lost

Beginnings and endings often come together. As we prepare to begin a new year next month, we want to pause to remember a few lives that came to an end. Although the following are by no means the only important endings, **Heat Treat Today** *would like to honor the memory of the following individuals who left their mark in the heat treating world.*



Klaus Hemsath
Surface Combustion

(1935–2022)

Klaus Hemsath and his family emigrated from Germany in 1967 to begin work at Surface Combustion. To this day, Klaus has over 60 patents to his name in the United States. Among his many accomplishments in the heat treating industry, Klaus founded Indugas, Inc. and wrote several books on climate change. Klaus will be greatly missed by his son, Mark Hemsath (Nitrex), as well as all others in the heat treating industry who knew him.

William "Bill" Cleary
Surface Combustion

(1960–2022)

Bill Cleary joined Surface Combustion directly after graduating college and remained with the company through the next 36 years. Working as a mechanical engineer and later as senior sales engineer, Bill was a constant presence at Surface Combustion — always the first person to help and listen.

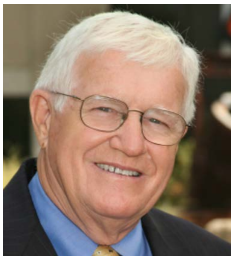
(source: MTI)

David Soderberg
County Heat Treat

(1951–2022)

With over 45 years of experience in metallurgy, Dave Soderberg had a vast knowledge of nitriding, aluminum solution aging, stress relieving, and other heat treating processes. His expertise especially honed in on aerospace heat treating, where he was appointed the designated supplier quality representative by GE Aerospace Engineering Group. Dave was a skilled metallurgist, able to develop heat treatments according to custom specifications.

(source: telegram.com/obituaries)



Jon K. Tabor
Allied Mineral Products

(1933–2022)

After a 65-year career in refractories, Jon Tabor joined Allied Mineral Products in 1970 and helped to build it to the multi-national corporation it is today. Some of John's accomplishments at Allied were transforming it into an employee-owned company and establishing a manufacturing presence in several countries, including China, South Africa, the Netherlands, and Brazil.

Roger Joseph Fabian
Lindberg & Bodycote

(1940–2022)

Roger Fabian received his B.S. in metallurgical engineering in 1962 and his MBA in 1980 from Rensselaer Polytechnic Institute. He began his career with Lindberg Corporation in 1962 as a plant manager at Lindberg's Boston Division, and in 1964 transferred to the Berlin Division, where he was named chief metallurgist and quality control manager. He was promoted to division manager at Berlin in 1979 and named vice president of Lindberg Heat Treating Company in 1992. When Lindberg was purchased by Bodycote Thermal Processing in 2001, Roger was named Eastern Region sales manager and finally retired in 2010 after 48 years.

Roger had many professional accomplishments, including president of ASM International, president of the ASM Heat Treating Society (an affiliate society of ASM International), and was a long-time member of both societies. He also served as a president for the Metal Treating Institute (MTI), and as chairman of the ASM Technical Programming Board. He was instrumental in the development of the Center for Heat Treating Excellence (CHTE) at Worcester Polytechnical Institute and served as director-at-large and industrial liaison. He was known to be always a gentleman and a friend.

(source: dignitymemorial.com)

Fueling the Future: Heat Treat KIDS

By Ellen Porter

*Heat Treat Today is taking a moment to spotlight the joyful beginnings of growing future leaders – **Heat Treat Kids**! With the happy grins, we're also grilling them on their heat treat knowledge. We asked the ones who could talk the following questions: What does your heat-treating parent/grandparent do for work? What is a furnace? How hot do they get? What do YOU want to be when you grow up?*

*Some of them really know their stuff! Who knows, we may even see them at **Heat Treat Boot Camp** in 2045.*

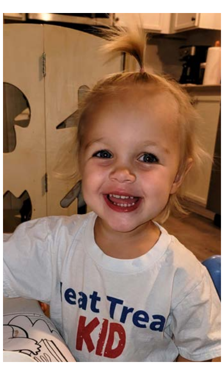
Keegan (6 yrs) and Koleson (3 yrs) Beltz

Heat Treat Grandkids of Ron Beltz, Bluestreak

What does your grandpa do for work?
He just works; and tells people where the stuff is.

What is a furnace and how hot do they get?
I think it's part of a house. Maybe 50; or like 5 degrees.

What do YOU want to be when you grow up?
An artichoke (he meant architect).



Ronnie Catherine Merrill (2 yrs)

Heat Treat Kid of Ellen Conway Merrill, DELTA H Technologies

Maeve Elizabeth Coleman (3.5 months)

Heat Treat Grandkid of Joe Coleman, Bluestreak

Caroline (10 yrs) and Findley (4 yrs) Hilger

Heat Treat Kids of Philip Hilger, Aalberts surface technologies

What does your dad do for work?
Caroline: My dad uses ovens to make supplies. He is also the one who handles the hand sanitizer, napkins, and that kind of stuff.

Findley: He calls phones. He works on the computer.

What is a furnace?
Caroline: An oven is something that gets hot. It helps people get hot when they are cold. It can get up to 200 degrees.

Findley: An oven is a cover. It gets really hot.

What do YOU want to be when you grow up?
Caroline: I want to be a teacher.

Findley: I want to be a ninja turtle.

Londyn E. Hamling (2 yrs)

Heat Treat Kid of Philip Hamling, ZIRCAR Ceramics, Inc.

Heat Treat Kids of Casey O'Neill, RoMan Manufacturing

Marlee and Jaycee O'Neil (14 yrs)

Josiah O'Neil (6 yrs)

Clara and Fiona O'Neil (8 yrs) and (3 yrs)

What does your dad do for work?
Marlee: He sells stuff.

Jaycee: Sales Manager.

Josiah: Work for the family.

Clara: Pays bills.

Fiona: I don't know.

What is a furnace? How hot does it get?
Marlee: It heats stuff, and I don't know.

Jaycee: It gets really hot.

Josiah/Clara/Fiona: I don't know, I don't know.

What do YOU want to be when you grow up?
Marlee: An art teacher or a forensic investigator.

Jaycee: A lawyer or a hairdresser or an artist.

Josiah: A policeman.

Clara: A chef.

Fiona: A police.

The Heat Treat KIDS of Heat Treat Today

Ben Bootsma (2 yrs)

Heat Treat Kid of Alyssa and Joe Bootsma

Nora Porter (1 yr) and Jackson (5 yrs)

Heat Treat Kids of Ellen and David Porter and Heat Treat Grandkids of Doug and Mary Glenn

Jackson says, "Ovens are like volcanos and are hot like fire! OUCH! SSHHH DON'T TOUCH IT!"

Wilder Porter (1 yr)

Heat Treat Kid of Lauren and John Porter

Eden Glenn (11 yrs)

Declan Glenn (8 yrs)

Silas Glenn (6 yrs)

Abel Glenn (3 yrs)

Heat Treat Kids of Brandon and Samantha Glenn

Eden says, "My dad designs the newsletter and website. A furnace cooks big pieces of metal. I want to be a photographer when I grow up."

Declan says, "He types on a computer."

Silas says, "He types in stuff. A furnace is a giant oven. They get SUPER hot! I want to be an animal rescuer in the jungle."

Abel says, ". . . A furnace spins. It gets REALLY hot! I want to be a Phillies baseball player."

Need a shirt or have a **Heat Treat Kid** photo to submit? Email Ellen Porter at *htt@heattreattoday.com.*

All photos of the kids were shared by their parents or guardians with permission for use in **Heat Treat Today**.

Children are a heritage from the LORD, offspring a reward from Him. – Holy Bible, Psalm 127:3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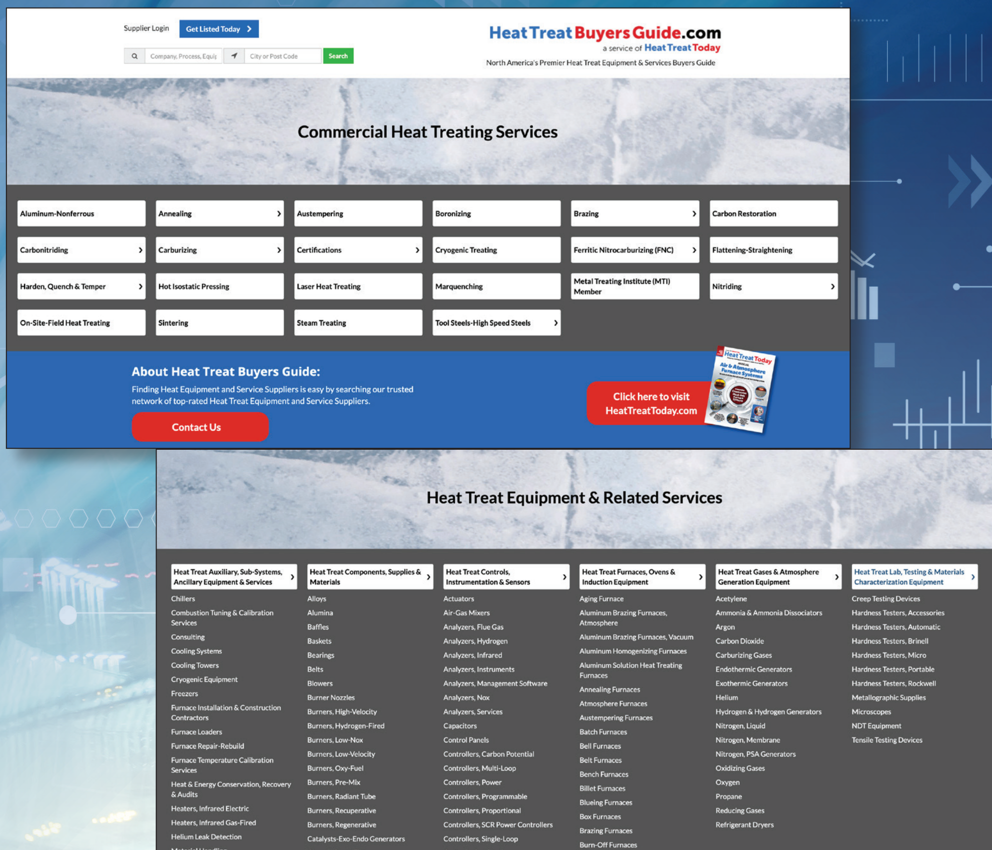

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HT BG

Heat Treat Shop

Heat Treat Today believes that people are happier and make better decisions when they are well informed. To get a sense of what options the market has for you, check out some of the heat treat components, parts, services, and supplies listed below. These products have been featured in our monthly e-newsletter called **Heat Treat Shop**, where manufacturers with in-house heat treat departments — especially in the aerospace, automotive, medical, and energy sectors as well as general manufacturing — can easily share this information.

Want to see your product listed here? Contact Doug Glenn at **doug@heattreattoday.com**.

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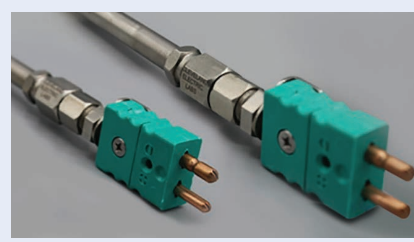

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News from Abroad

Heat Treat Today *is partnering with two international publications:* **heat processing***, a Vulkan-Verlag GmbH publication that serves mostly the European and Asian heat treat markets, and* **Furnaces International***, a Quartz Business Media publication that primarily serves the English-speaking globe. Through these partnerships, we are sharing the latest news, tech tips, and cutting-edge articles that will serve our audience — manufacturers with in-house heat treat.*

In this issue, we look at updates on industry events around the globe such as electric furnaces in Finland and new technology to accommodate additive manufacturing advances.

Electrode Regulation System Gets an Upgrade

"After the decision taken by Stahl Gerlafingen to upgrade its Electrode Regulation System as part of its secondary steelmaking process, AMI supplied the DigitARC® PX3 ERS which was delivered in May 2022, with all onsite commissioning work finished in mid-2022."

Read More: *"AMI Automation supplies steel producer with DigitARC® PX3 ERS"* at furnaces-international.com

Reducing CO_2 Emissions with Electric Furnace in Finland

"Fiskars Group will replace the Iittala factory's existing, natural gas-powered furnaces with electricity-powered furnaces. The investment will reduce the factory's CO_2 emissions by approximately 10,000 tons a year (74%) and decrease nitrogen oxide and fine particle emissions."

Read More: *"Iittala to receive €10 million electric furnace investment"* at furnaces-international.com

Integrated Steel Making Facility for Bangladesh

"Bashundhara Multisteel Industries Limited, the Steel Division of Bashundhara Group, one of the largest business conglomerates in Bangladesh, signed a contract with SMS group to install an integrated facility to produce more than two million tons of hot rolled coils annually with the goal of filling the gap in demand for flat products in Bangladesh. The plant will be located at Bangabandhu Sheikh Mujib Shilpa Nagar (BSMSN), Mirsharai, Chattogram. In the future, this plant can be expanded to produce four million tons annually."

Read More: *"Bashundhara Multisteel and SMS group sign contract for integrated CSP® plant"* at heat-processing.com

From right to left: Mr. Safwan Sobhan, Vice Chairman Bashundhara Group shaking hands with Mr. Burkhard Dahmen, Chairman of the Managing Board & CEO, SMS group. BMSIL & SMS Group team members during contract signing at Dhaka. (Source: SMS group)

New Tech Accelerates Material Deposition and Alloys in AM Advancements

"At Formnext, ponticon GmbH will introduce its new pE3D system for Dynamic Material Deposition (DMD), a process developed for additive manufacturing, coating and repairing complex-shaped metallic workpieces. The new system combines high process speed with utmost precision and high flexibility in terms of the choice of alloying elements. With the [DMD] process developed by ponticon, alloys of any elemental compositions can be deposited on metallic and ceramic components."

Dr.-Ing. Tobias Stittgen (right) and Thomas Horr, the two Managing Directors of ponticon GmbH, are standing next to a pE3D system. (Source: ponticon)

Read More: *"High-precision laser cladding with short process times"* at heat-processing.com

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- 3000 CFH Endo, Electric, 1950°F, Gasbarre, Water Cooled
- 3000 CFH Endo, AFC, 1950°F, Gas - 2 Available
- 5600 CFH Endo, Gas Fired, 1950°F, Rogers Engineering

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- 30"W x 30"H x 48"L, 1750°F, Electric, Surface Combustion
- 10'6"W x 6'H x 35'L, Gas Fired, 1650°F, Drever, Atmosphere
- 36"W x 36"H x 72"L, Surface Combustion, 1750°F, Gas Fired
- 48"W x 48"H x 96"L, L & L Special Furnace, 2200°F, Gas Fired
- 15"W x 12"H x 18"L, Lindberg Sinterall, 2100°F, H2 Atmos.
- 30"W x 30"H x 48"L, Surface Combustion, 1450°F, Gas
- 36"W x 30"H x 48"L, Surface Combustion, 1250°F, Gas

BELT OVENS

- 18"W x 5"H x 10'L, 500°F, Electric, Despatch
- 30"W x 15"H x 10'L, Grieve, 400°F, Electric
- 18"W x 23"H x 12'L, Jensen, 550°F, Gas Fired

INTEGRAL QUENCH FURNACES

- 36"W x 36"H x 48"L, Surface, Electric, 1750°F Combustion
- 24"W x 18"H x 48"L, 1850°F, Gas Fired, Ipsen T-8, 2 Zones
- 30"W x 20"H x 48"L, Gas Fired, 1750°F, Surface Combustion
- 36"W x 36"H x 48"L, Surface, Gas, 1750°F
- 36"W x 36"H x 48"L, AFC, Gas, 1750°F
- 30"W x 30"H x 48"L, Surface/J.L. Becker, 1750°F, Top-Cool, Gas Fired
- 24"W x 18"H x 36"L, Ipsen T-4, 1850°F, Gas Fired

ROLLER HEARTH FURNACES

- 60"W x 13"H x 40'L, Electric, 1600°F, Atmosphere, Wellman

ROTARY HEARTH FURNACES

- 50" Dia, 18"W x 9H Door, Electric, 1600°F

INDUCTION HEATING/MELTING

- 125 kW, 3 kHz, 300 Lb. VIM Melter
- 200 kW, 3 kHz Pillar w/Scanner
- 100 kW, 30-50 kHz Inducto-Heat
- 150 kW, 30 kHz, Inducto-Heat
- 100 kW, 10 kHz Inducto-Heat
- 300 kW, 3/10 kHz Inducto-Heat BSP5
- 100 kW, 3/10 kHz Inducto-Heat BSP
- 150 kW, 3/10 kHz Tocco Inductron II
- 100 kW, 10 kHz Ajax/Tocco, 48" Scanner
- 150 kW, 3/10 kHz Ajax/Tocco, 48" Scanner

WALK-IN OVENS

- 72"W x 72"H x 120"L, CEC, 1000°F, Gas Fired
- 48"W x 72"H x 48"L, Precision Quincy, 1000°F, Gas, Solvent
- 55"W x 60"H x 30"L, 350°F, Electric, Precision Quincy
- 48"W x 72"H x 48"L, 1250°F, Gas Fired, TPS - 4 Available
- 72"W x 78"H x 117"L, Despatch, 500°F, Electric, Solvent Rated
- 48"W x 72"H x 84"L, Grieve, 850°F, Electric, Atmosphere
- 48"W x 72"H x 48"L, Grieve, 500°F, Electric, Double Ended
- 48"W x 48"H x 72"L, Grieve, 650°F, Electric
- 48'W x 72"H x 60"L, Grieve, 500°F, Gas
- 36"W x 60"H x 48'L, Grieve, 350°F, Electric
- 36"W x 72"H x 48"L, Gruenberg, 300°F, Electric
- 30"W x 76"H x 48"L, Precision Quincy, 1000°F, Electric
- 72"W x 75"H x 120"L, Grieve, 450°F, Electric
- 68"W x 72"H x 72"H, Gruenberg, 500°F, Electric

CABINET OVENS

- 36"W x 48"H x 24"L, Electric, 600°F, Blue M, Class "A"
- 25"W x 20"H x 20"L, Electric, 650°F, Inert Gas, Blue M
- 48"W x 36"H x 24"L, Electric, 500°F, Inert Gas, Blue-M
- 25"W x 20"H x 20"L, Blue M, 1300°F, Electric
- 20"W x 20"H x 18"L, Blue M, 1100°F, Electric, Atmosphere
- 36"W x 36"H x 36"L, Grieve, 500°F, Electric, Double Chamber
- 36"W x 36"H x 36"L, Grieve, 850°F, Electric, Double Chamber

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PIT TEMPERS/NITRIDERS

- 28" Dia x 48"Deep, L & N, 1200°F, Electric, NITIRIDER
- 28" Dia x 28"Deep, Lindberg, 1250°F, Gas
- 38" Dia x 48"Deep, Wisconsin, 1250°F, Electric, 2 Avail.
- 38" Dia x 48"Deep, Lindberg, 1250°F, Electric, 3 Avail.

SHOT BLAST

- 36" x 48" Goff Spinner Hanger w/Dust Collector
- 12 Cube, Wheelabrator Rubber Belt w/Loader

WASHERS CONVEYOR & BATCH

- 24"W x 10"H, SS Belt Washer, Electric, Wash & Blow-Off
- 12"W x 12"H, SS Belt Washer, Electric, W/R and Blow-Off
- 36"W x 36"H x 48"L, AFC, Dunk & Spray Batch Washer, Gas Fired
- 30"W x 20"H x 48"L, Surface Combustion Spray Only, Gas Fired
- 32"Dia x 18"H, ADF, Pass Thru Batch Washer, Electric
- 36"W x 18"H, SS Belt Washer, Gas, W/R/Blow-Off
- 24"W x 18"H, SS Belt Washer, Electric, W/R/Blow-Off

MISCELLANEOUS

- 48"W x 36"H 48"L, Despatch Quick Quench Drop Bottom, Electric 1000°F
- 36 x 48 AFC Charge Car, Double Ended, 2 Available
- Several 36 x 48 scissors lift tables and stationery tables

CALL OR E-MAIL YOUR REQUIREMENTS

Jeffrey D. Hynes, 248.343.1421 or sales@fobinc.com. For a complete inventory listing with photos visit www.fobinc.com

Precision Manufacturing Insurance Services

Heat Treat Today's MTI MEMBER PROFILE

Over the last few months, the Metal Treating Institute requested comments from members on how their current business insurance programs have been progressing with property, liability, errors-omissions, commercial auto, and workers compensation. What we learned is this is a huge pain point for most heat treaters of any size.

Many are experiencing cancellation of coverage, refusal to be offered a quote, or large rate increases. The insurance industry is really backing away from writing policies for heat treating companies.

photo source: www.pmiservices.com

To help heat treaters deal with this huge challenge, the board of trustees of MTI is excited to announce that they have partnered with Precision Manufacturing Insurance Services out of California as the official insurance agency partner for business insurance coverages. They have already written several MTI members' policies and provided quality coverage with significant savings averaging 35% to 50%.

Precision Manufacturing Insurance Services (PMIS) provides heat treating companies with comprehensive competitive insurance and risk management solutions. They are dedicated to protecting the future of this vital industry. They offer their knowledge, experience, and service to many types of metalworks that put people to work, contribute significantly to the U.S. national GDP, and deliver quality products worldwide.

They know there is nothing cookie-cutter about what a heat treating company does when altering the physical properties of material. That work is precise and custom. With PMIS, your company will get the same type of focused approach with your insurance and risk management plan. Recognized nationwide for their specialization in working with metalworking manufacturers, they'll provide you with tailored solutions based on your unique risks. Their professional staff is available to support your industry and business.

When prospective clients ask why they should partner with PMIS for their insurance and risk management needs, the answer is simple: They are metalworking manufacturing insurance specialists. This is who they are and the only thing they do. They are not a generalist broker who happens to write a few manufacturing accounts. PMIS has written over 1,000 policies for metalworkers — all attributed to their expertise, experience, and longstanding relationships with insurance markets. This enables them to deliver affordable solutions to MTI members that protect property, assets, employees, and reputation, while reducing risk and costs. The following are the types of coverages PMIS can create for you:

- Custom Manufacturing Insurance
- General Liability Insurance
- Property Insurance
- Workers' Compensation
- Manufacturers' Errors and Omissions
- Equipment Breakdown
- Commercial Auto

To see more details on Precision Manufacturing Insurance Services and the MTI Insurance Program, including a link to request speaking to a PMIS team member about getting a free quote for your company, visit HeatTreat.net and click on the Business Insurance link under the Benefits tab at the top.

PMIS Precision Manufacturing Insurance Services

"We Protect the Future of Manufacturers!"

If you have any questions, contact Tom Morrison at tom@heattreat.net.

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Used Heat Treating Furnaces and Ovens

BELT FURNACES/OVENS

18" x 4' x 2"	Grieve	Elec 500˚F
32" x 24' x 12"	OSI Slat Belt	Gas 450˚F
36" x 20'	Cast Belt-Surface	Gas 1750˚F
48" x 20' x 48"	Thermation	Gas 500˚F
60" x 40' x 14"	Wellman Roller Hearth (Atmos)	Elec 1650˚F
2000 #/HR	AFC Pusher Hardening (Atmos)	Gas 1750˚F

MISCELLANEOUS

- Combustion Air Blowers (All sizes)
- 24" x 36" Lindberg Charge Car (Manual)
- 36" x 48" Surface Scissor Lift (2)
- 36" Diam. Viking Rotary Table Washer Elec
- Garden City Alloy “Plug” Fans (2) - 1350˚F
- 30" x 48" x 36" Surface Washer Gas
- 30" x 48" x 30" Surface Washer (2) Gas
- (2) Bell & Gossett “Shell & Tube” Heat Exchangers
- 30" x 30" x 30" Subzero -105 to 375˚F Elec.
- 30" x 48" Lindberg Charge Car
- 30" x 48" x 30" Surface D&S Washer Gas
- AFC Pusher Line (Atmos.) Gas 1750˚F
- 36" x 48" AFC Scissor Lift(6) Elec
- 36" x 48" Charge Car(DE) AFC - Elec (2)
- 36" Wide Table- Rotary Hearth (Atmos.) Elec 1850˚F
- 36" x 48" x 36" AFC D&S Washer Gas
- 36" x 48" GoFF Shot Blaster Elec
- 36" x 48" Holcroft Charge Car (DE)
- 24" Wide Table Surface Rotary Hearth Gas 1750˚F
- SBS Air/Oil Collers (8)

OVENS/BOX TEMPERING

8" x 18" x 8"	Lucifer	Elec 1250˚F
12" x 16" x 18"	Lindberg (3)	Elec 1250˚F
14" x 14" x 14"	Blue-M	Elec 1050˚F
14" x 14" x 14"	Blue-M	Elec 650˚F
14" x 14" x 14"	Gruenberg (solvent)	Elec 450˚F
19" x 19" x 19"	Despatch	Elec 850˚F
20" x 18" x 20"	Blue-M	Elec 400˚F
20" x 18" x 20"	Despatch	Elec 650˚F
20" x 18" x 20"	Blue-M	Elec 650˚F
20" x 18" x 20"	Blue-M (2)	Elec 800˚F
20" x 20" x 20"	Grieve	Elec 1000˚F
22" x 42" x 22"	TM (Vacuum)	Elec 750˚F
24" x 24" x 36"	New England	Elec 800˚F
24" x 24" x 48"	Blue-M	Elec 600˚F
24" x 36" x 24"	Demtec (N2)	Elec 500˚F
24" x 36" x 24"	Grieve	Elec 1000˚F
25" x 20" x 20"	Blue-M	Elec 650˚F
24" x 36" x 48"	Gruenberg	Elec 500˚F
25" x 20" x 20"	Blue-M (Inert)	Elec 1100˚F
26" x 26" x 38"	Grieve (2)	Elec 850˚F
30" x 30" x 60"	Gruenberg	Elec 450˚F
30" x 30" x 48"	Process Heat	Elec 650˚F
30" x 38" x 48"	Gruenberg (Inert) (2)	Elec 450˚F

OVENS/BOX TEMPERING (CONT.)

30" x 48" x 24"	Selas	Elec 1450˚F
30" x 48" x 30"	Surface (2)	Gas 1400˚F
30" x 48" x 30"	Surface (2)	Elec 1400˚F
30" x 48" x 24"	Ipsen	Gas 1250˚F
30" x 48" x 30"	Lindberg (2)	Elec 1400˚F
30" x 48" x 76"	P-Quincy	Elec 1000˚F
36" x 36" x 36"	Blue M Environment Chamber	(-18˚C to +93˚C)
36" x 36" x 60"	P-Quincy	Gas 500°F
36" x 42" x 72"	Gruenberg	Elec 450˚F
36" x 48" x 30"	Lindberg	Elec 1250˚F
36" x 48" x 30"	AFC (2)	Gas 1250˚F
36" x 48" x 36"	TPS (Environmental)	Elec -40˚C to +200˚C
36" x 60" x 36"	CEC (2)	Elec 650˚F
36" x 108" x 36"	Wisconsin	Elec 1250˚F
37" x 25" x 37"	Despatch	Elec 500˚F
37" x 25" x 37"	Despatch	Elec 1000˚F
38" x 20" x 26"	Grieve	Elec 500˚F
40" x 52" x 63"	Despatch	Elec 650˚F
48" x 48" x 20"	Lindberg (Hyd. Press)	Elec 1250˚F
48" x 48" x 72"	Blue-M	Elec 600˚F
48" x 34" x 52"	Heat Mach. (2)	Elec 350˚F
48" x 48" x 72"	P-Quincy	Gas 1000°F
48" x 48" x 48"	L+L (Atmos)	Elec 1200˚F
48" x 48"x 60"	Blue-M	Elec 400˚F
48" x 48" x 72"	Grieve	Gas 650°F
40" x 52" x 63"	Despatch	Gas 650°F
48" x 48" x 72"	P-Quincy	Gas 450˚F
60" x 60" x 60"	P-Quincy	Gas 500˚F
60" x 96" x 72"	P-Quincy	Elec 450˚F
72" x 72" x 60"	JPW “Top Loader”	Elec 1250˚F
60" x 84" x 84"	P-Quincy (Car)	Gas 750°F
72" x 120" x 72"	Grieve	Gas 1050°F
72" x 120" x 72"	Despatch	Gas 500°F
84" x 60" x 66"	Wisconsin	Elec 350˚F
72" x 120" x 72"	P-Quincy	Gas 1000˚F
96" x 192" x 96"	Despatch	Gas 650˚F
96" x 360" x 48"	Sauder Car Bottom	Elec 1400˚F

ATMOSPHERE GENERATORS

500CFH	Ammonia Dissoc. Drever	Elec
500CFH	Endothermic Lindberg	Gas
750CFH	Endothermic Ipsen	Gas
800CFH	Endothermic Surface	Gas
1,000CFH	Exothermic Gas Atmos.	Gas
1,500CFH	Endothermic Lindberg (Air)	Gas
3,000CFH	AFC - (2) Air Cooled	Gas
3,000CFH	Endothermic Lindberg (4) - Air	Gas
3,600CFH	Endothermic Surface	Gas (2)
6,000CFH	Exothermic Modern Equipment	Gas
6,000CFH	Gas Atmos. Nitrogen Generator	Gas

BOX FURNACES

12" x 24" x 10"	Lindberg (Atmos.)	Elec 2000˚F
12" x 24" x 10"	Lindberg (Atmos.)	Elec 2500˚F
12" x 24" x 12"	Hevi Duty (2)	Elec 1950˚F
17" x 14.5" x 12"	L&L (New)	Elec 2350˚F
18" x 36" x 18"	Lindberg (Retort)	Elec 2050˚F
18" x 36" x 18"	Lindberg (Atmos)	Elec 2500˚F
18" x 36" x 18"	Lindberg (Fan)	Elec 1850˚F
20" x 48" x 12"	Hoskins	Elec 2000˚F
30" x 48" x 30"	Surface (RTB)	Elec 1750˚F
36" x 48" x 30"	Surface (RTB- Atmos)	Gas 1850˚F
36" x 84" x 24"	Lindberg	Gas 2000˚F
48" x 96" x 48"	L&L	Gas 2200˚F
60" x 216" x 48"	IFSI (Car Bottom)	Gas 2400˚F
72" x 120" x 60"	CEC(2002)	Gas 1750˚F
96" x 360" x 48"	Sauder Car Bottom	Elec 1400˚F
126" x 420" x 72"	Drever “Lift-Off” (2) (Atmos.)	Gas 1450˚F

PIT FURNACES

14" Dia x 60"D	Procedyne Fluid Bed	Elec 1850˚F
22" Dia x 26"D	L + N (2)	Elec 1200˚F
22" Dia x 36"D	L + N	Elec 1400˚F
28" Dia x 48"D	L + N Nitrider	Elec 1200˚F
38" Dia x 48"D	Wisc Oven (2)	Elec 1250˚F
38" Dia x 48"D	Lindberg (3)	Elec 1250˚F
72" Dia x 72"D	Flynn + Dreffein (2) (Atmos.)	Elec 1400˚F
43" Dia x 36"D	Lindberg	Elec 1250˚F

VACUUM FURNACES

12" x 20" x 12"	Abar	Elec 2400˚F
24" x 36" x 18"	Hayes (Oil Quench)	Elec 2400˚F
48" x 48" x 24"	Surface (2-Bar)	Elec 2400˚F

INTEGRAL QUENCH FURNACES

24" x 48" x 18"	Ipsen T-8 (2 Zone)	Gas 1850˚F
30" x 48" x 20"	Surface (2)	Gas 1750˚F
30" x 48" x 24"	Surface	Gas 1750˚F
30" x 48" x 30"	Ipsen T-9	Gas 1750˚F
30" x 48" x 30"	Surface “Top Cool”	Elect 1750˚F
30" x 48" x 30"	Surface	Elect 1750˚F
36" x 48" x 36"	Surface	Gas 1750˚F
36" x 48" x 36"	Surface	Elec 1750˚F
36" x 48" x 36"	AFC	Gas 1850˚F

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