Technologies and Processes for the Advancement of Materials

Thermal processing

ISSUE FOCUS ///

PROCESS CONTROL / PYROMETRY

OPTIMIZING PROCESS OPERATIONS

COMPANY PROFILE ///

Lucifer Furnaces

MARCH 2021
thermalprocessing.com


BEAVERMATIC
BEAVERMATIC
DANGER
HIGH VOLTAGE
DANGER
Premier Furnace Specialists




FROM BEAVERMATIC STANDARD DESIGNS TO CUSTOM SOLUTIONS

Premier Furnace Specialists, Inc.

BeaverMatic

23850 Freeway Park Drive
Farmington Hills, MI 48335

PREMIER FURNACE SPECIALISTS, INC. IS YOUR TRUSTED SOURCE FOR YOUR THERMAL PROCESSING EQUIPMENT.

CONTENTS ///

COVER PHOTO: SHUTTERSTOCK (2) / ILLUSTRATION BY RICK FRENNEA

WISCONSIN OVEN

Horizontal Quench System

A Cost Effective Option for Your Solution Treatment Process

The Horizontal Quench System utilizes an electrically operated pusher/extractor mechanism providing a quench time as low as 7 seconds, which combined with a load capacity of up to 6,000 lbs, makes it ideal for a wide range of applications.

Benefits:

- 5 standard sizes
- Custom sizes available
- Gas fired or electrically heated
- Cost effective alternative to a drop bottom furnace
- Ideal for castings, extrusions, forgings, and other aluminum
- Automated controls available for easier operation
- AMS2750E compliance available
- Fully factory assembled and tested prior to shipment to reduce installation and start-up time

Standard Features:

- High capacity recirculation system
- Quench tank water agitation pump with distribution manifold
- Combination airflow through oven chamber
- Standard temperature uniformity of +/- 15° F, tighter tolerances available upon request
- Air operated vertical lift oven door & quench platform

2675 Main Street • PO Box 873 • East Troy, WI 53120 USA
www.wisoven.com • sales@wisoven.com • 262-642-3938

Wisconsin Oven is a brand of
Thermal Product Solutions, LLC

DEPARTMENTS ///

MARCH 2021 VOLUME 10 / NUMBER 3

Thermal Processing is published monthly by Media Solutions, Inc., 266D Yeager Parkway Pelham, AL 35124. Phone (205) 380-1573 Fax (205) 380-1580 International subscription rates: $105.00 per year. Postage Paid at Pelham AL and at additional mailing offices. Printed in the USA. POSTMASTER: Send address changes to *Thermal Processing* magazine, P.O. Box 1210 Pelham AL 35124. Return undeliverable Canadian addresses to P.O. Box 503 RPO West Beaver Creek Richmond Hill, ON L4B4R6.


LINDBERG/MPH

Thermal Processing welcomes IFHTSE

One goal of *Thermal Processing* is to be able to give our readers the best and brightest the heat-treat industry has to offer — whether that's an exclusive look at a new product or a technical deep dive into the complex processes that make heat treating possible.

With the latter in mind, *Thermal Processing* is pleased to announce our membership with the International Federation for Heat Treatment and Surface Engineering (IFHTSE). In addition to our membership, *Thermal Processing* will also be IFHTSE's media partner.

For those unfamiliar with IFHTSE's history, the organization is a not-for-profit body founded in Switzerland in 1971 made up of scientific/technological societies and associations, universities, research institutes, and companies, whose primary interest is heat treatment and surface engineering.

IFHTSE uses its platform to promote international collaboration and communication on heat treatment and surface engineering through the sharing of knowledge. This knowledge is communicated via conferences and international congresses held around the world.

Beginning with our March issue, *Thermal Processing* will also be spotlighting IFHTSE's accomplishments and plans in a two-page spread published every month. This exclusive feature will be devoted to IFHTSE's latest information, events, and more.

This also means that *Thermal Processing* will be able to share technical articles and other important information as our partnership grows in the coming months.

So, check out IFHTSE's latest, and keep a lookout for more from this prestigious organization. I believe I speak for all of *Thermal Processing's* staff when I say we are honored to be a part of IFHTSE and look forward to a bright future with it.

MEDIA PORTAL

I also want to remind our readers that *Thermal Processing's* Media Portal on our website is in full swing and ready to direct you to all the latest social media from heat-treaters from all across the map. It's a one-stop shop for social media (including Facebook, Twitter, and YouTube videos), webinars, podcasts, blogs, and more. Head to our website and give it a go, and let me know what you think.

MARCH ISSUE

Last, but not least, please enjoy all the amazing information in our March issue as we share several articles on process control and pyrometry, as well as the insightful and educational information offered by our talented columnists.

Thanks for reading!

KENNETH CARTER, EDITOR
editor@thermalprocessing.com
(800) 366-2185 x204

CALL FOR ARTICLES Have a technical paper or other work with an educational angle? Let Thermal Processing publish it. Contact the editor, Kenneth Carter, at *editor@thermalprocessing.com* for how you can share your expertise with our readers.

Media solutions

PUBLISHED BY MEDIA SOLUTIONS, INC.
P. O. BOX 1987 • PELHAM, AL 35124
(800) 366-2185 • (205) 380-1580 FAX

David C. Cooper
PRESIDENT
Teresa Cooper
OPERATIONS

IHEA INDUSTRIAL HEATING EQUIPMENT ASSOCIATION
IFHTSE

Investment will expand size capability for UltraGlow® Induction Hardening. (Courtesy: AHT)

AHT purchases two new induction machines

Advanced Heat Treat Corp. (AHT), a recognized leader in heat-treat services and metallurgical solutions, has purchased two additional induction units. The induction equipment, which is being custom built, is expected to be operational this spring.

The custom build will increase the heat treater's induction hardening size capability, allowing them to handle parts up to 600 pounds in weight, 14 inches in diameter, and 51 inches in length.

AHT has offered UltraGlow® Induction Hardening in Waterloo, Iowa, since 1993 and has a wide array of coils on hand to accommodate various part geometries. AHT also runs three shifts for around-the-clock coverage.

AHT President Mikel Woods said, "We are excited to add more state-of-the art equipment. The new technology will ultimately allow us to be more efficient, resulting in even better turnaround times for our customers."

AHT purchased two new induction units in 2019, as well.

"As our company's mission statement says, we are committed to exceeding our customers' expectations with UltraGlowing results," Woods said.

Aside from UltraGlow Induction Hardening, AHT also offers carburizing, through hardening, annealing, stress relieve, carbonitriding, and other case hardening heat treatments at its Burton Avenue location. AHT also has a location in Waterloo which is focused on nitriding and nitrocarburizing.

MORE INFO www.ahtcorp.com

Solar Atmospheres SC awarded GE Aviation approval

Solar Atmospheres' Greenville, South Carolina, facility was awarded GE Aviation approval. With this approval, now all Solar Atmospheres facilities are an option for customers with GE Aviation requirements for vacuum heat treating and brazing services.

Steve Prout, president of Solar Atmospheres' Greenville facility, said, "We are proud to once again provide our customers in the southeastern U.S. with another regional option for aerospace vacuum thermal processes, saving them time and money while continuing to deliver the high level of quality required."

With the ability to support vacuum thermal processing needs ranging from development cycles to 50,000-pound loads at temperatures of up to 2,400°F, Solar Atmospheres provides AS9100 and Nadcap quality accredited heat treatments, providing customers with the confidence their product is being processed as specified.

MORE INFO www.solaratm.com

Solar Atmospheres' Greenville, South Carolina, facility was awarded GE Aviation approval. (Courtesy: Solar Atmospheres)

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

Ipsen USA serves 250 customers in January amid pandemic

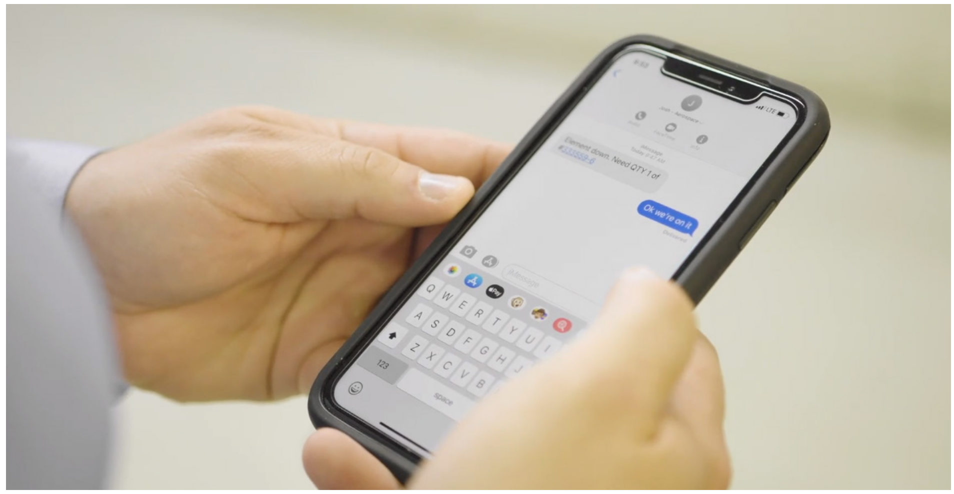
Ipsen's North American customer service team continues to conduct necessary in-person and remote appointments amid pandemic-related restrictions.

In January, Ipsen logged more than 150 field service visits, which included vacuum furnace installations, start-ups, relocations, hot zone replacements, annual preventative maintenance check-ins, temperature uniformity surveys, leak checks, and other various troubleshooting and repair activities. The other 100 service calls, conducted by Ipsen's technical support and sales teams, happened using remote tools such as desktop sharing and video conferencing. This is an uptick from January 2020 and from previous months.

Ipsen remains committed to making sure its customers achieve maximum uptime — especially those who supply essential products to medical technology, energy, aerospace, and agribusiness to deliver vital goods and services — around the globe.

As vaccines are administered and the economy rebounds, Ipsen's field teams continue to follow all necessary safety restrictions and protocols. Contact an Ipsen representative to discuss options.

MORE INFO www.ipsenusa.com



Ipsen USA worked with customers in the field and virtually during January. (Courtesy: Ipsen USA)

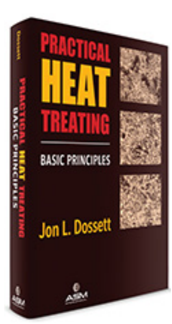
Thermcraft celebrates 50th anniversary

Thermcraft began in January of 1971 in a small warehouse space in downtown Winston-Salem, North Carolina. From that small startup operation, Thermcraft has progressively grown into a leading international manufacturer of thermal-processing equipment, offering industrial and laboratory furnaces, ovens, high-temperature heating elements, insulation, and replacement parts. Thermcraft now occupies a 70,000-square-foot manufacturing and office space located just a few miles from downtown Winston-Salem, where it all began. The first priority at Thermcraft has always been customer service, and the company looks forward to serving the thermal processing industry for another 50 years.

MORE INFO www.thermcraftinc.com

New book provides a primer of basic heat-treat principles

Practical Heat Treating: Basic Principles, by Jon L. Dossett, describes the basic principles of heat-treating technology in clear, concise, and practical terms for students, emerging professionals, production personnel, and manufacturing or design engineers. It is an excellent resource and introductory guide on the practical "whys and therefore" of heat treatment — including the tips and useful look-up information of a perennial reference book. With in-depth and comprehensive coverage, this book details many practical implications of heat treatment in terms of material and process selection and structure and property development, with insights on doing it right or more reliably.



Derived from the author's decades of experience and familiarity with many of the publications and educational and programming products of ASM International, each chapter is amply illustrated with charts and supported by current or classic references for background or further reading. This thorough and practical coverage on the basic principles of heat treating would be a useful addition to the bookshelf of anyone with an interest in heat treating.

Chapters detail the basic metallurgy of heat treatment and microstructural effects of heat-treat processes on the major types of steels and nonferrous alloys. Extensive coverage is given to the reliable, effective, and cost-conscious heat treatment of carbon and low-alloy steels. Tool steels and stainless steels are also covered, along with a chapter that outlines the basic principles in heat treating aluminum alloys, titanium alloys, nickel alloys, magnesium alloys, and others.

MORE INFO www.asminternational.org

Gasbarre opens technical center in Michigan

Gasbarre Thermal Processing Systems is pleased to announce the opening of a 7,700-square-foot technical center in Livonia, Michigan. With locations in Pennsylvania, Rhode Island, and Michigan, the addition of the technical center completes another step in the process Gasbarre announced a little over a year ago to position themselves to better support its customers and advance its product offering.

The Livonia technical center will house

sales, engineering, and service personnel, achieving a core initiative of Gasbarre to have qualified personnel to support the large customer base in the Midwest region. Gasbarre is currently in the process of installing both atmosphere and vacuum processing equipment in the technical center to support product development, customer trials, and demonstrations.

Industrial Furnace Systems President Ben Gasbarre said, "The opening of the technical center not only maintains our presence in the Midwest, but also allows us to have a convenient location for customers and vendors to meet with our experienced team. The furnace equipment being installed will give us the flexibility to process material in both atmosphere and vacuum environments. The technical center is a key addition for us to continue to position ourselves as a leader in the thermal processing market and provide solutions to our growing customer base."

MORE INFO www.gasbarre.com

Retech experiences a banner year in spite of pandemic

2020 was a strong year for Retech and the Seco/Warwick vacuum metallurgy segment.

Despite the ongoing global crisis, Retech, a leading supplier of vacuum induction melting (VIM), plasma (PAM), electron beam melting furnace (EB), and VAR furnaces, has completed orders for the largest companies in the aviation and energy industries.

2020 was a very challenging year, due to the many economic and social constraints, hence the implementation of the remote furnace factory acceptance testing (FAT) and a number of modifications to the team's work organization. However, thanks to these changes, a strong commitment to work through the many challenges, and a dedication to meet or exceed our customer's expectations, Retech will count this year a successful one.

Early last year, Retech began preparations to relocate the manufacturing and R&D furnaces from Ukiah, California, to Buffalo, New York. After many delays as a result of the pandemic, Retech is working on installing all of its equipment in Buffalo. The new location means more than 4,500 square meters of manufacturing space, creating the potential to add up to 80 new jobs, as well as opportunities for growth and innovation. This new space will provide a showplace for Retech's operation in North America. Additionally, western New York is both home to, and close to, a number of strong engineering and technology schools, creating the opportunity to further strengthen the Retech team.

The change of location will allow Retech to continue developing and working on further innovative solutions, providing growth potential. The new location also reduces the distance between the American members of the Seco/Warwick Group. Locating all the companies in one general region guarantees better cooperation, and provides the opportunity to recognize the Group's overall potential.

"This modern, new facility potentially provides the cornerstone in leading this effort," said Earl Good, the executive director of Retech Systems.

During the course of 2020, Retech was able to successfully deliver and start-up a broad range of equipment including the following furnace types: VIM, VAR, consumable caster, and PAM. The two qualities that stand out the most with the team's effort during the pandemic, are that Retech was able to deliver all of these furnaces on, or ahead of, schedule and was able to satisfy the customers' expectations.

An additional noteworthy achievement from 2020 is that a Retech Consumable Caster (CC 1,000kg) furnace delivered to one of the world's top research institutions in the UK successfully produced the world's largest titanium casting, weighing 1,000 kilograms.

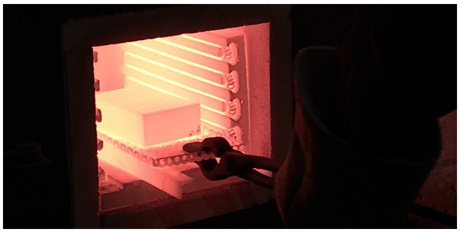
Another interesting project that began in 2020 is an 8.4 MWatt furnace with as many as five burners. It will be the crown jewel in the melting facility of one of the world's biggest titanium producers.

Retech is a global supplier of vacuum metallurgy solutions. (Courtesy: Seco/Warwick)

Retech's team provided solutions to customers around the world in 2020. This included customers in North America, Europe, Asia, and the Middle East.

Last year, Seco/Warwick and Retech implemented a comprehensive remote factory acceptance test (FAT) program. The first fully remote tests were performed for customers in China, Mexico, and South Korea. They were carried out without the involvement of the customers' engineers being on-site in Poland. The tests were successful, and the adopted procedures guarantee the reliability and completeness of data. Remote FAT tests (of which as many as nine were performed in 2020) have therefore become prevalent, and an acceptable standard for many of its customers.

MORE INFO www.secowarwick.com



Lucifer furnaces and ovens have been shipped to Air Force bases throughout the United States. (Courtesy: Lucifer Furnaces)

Lucifer Furnaces delivers 18 furnaces to U.S. Air Force

Lucifer Furnaces has completed a yearlong contract to deliver 18 AMS2750 compliant furnaces and ovens to the U.S. government.

Models supplied include 5000 Series heavy duty single chamber furnaces, 8000 Series dual chamber furnace/oven combos, 4000 Series recirculating convection ovens and DU4 Series dual ovens. All models are designed and built to comply with AMS2750 Class 2 (±10°F) and Class 5 (±25°F) specifications with instrumentation package D which includes digital paperless recorder/controllers, high limit safety systems and SCR power supplies.

TUS and SAT access ports are built in for ongoing system accuracy tests and temperature uniformity survey compliance.

The Lucifer furnaces and ovens have been shipped to Air Force bases throughout the United States and will be used to support airplane and helicopter repair and maintenance, processing a wide range of materials from aluminum to tool steels.

MORE INFO www.luciferfurnaces.com

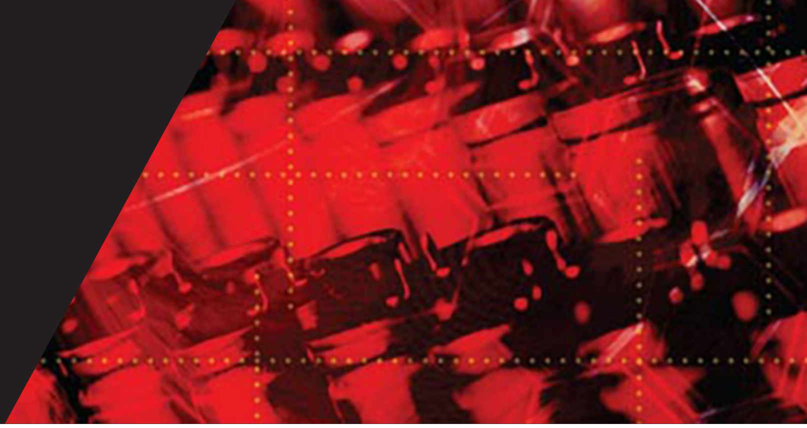
ZRCI has ceramic fiber reinforced alumina cylinders

ZIRCAR Refractory Composites, Inc, (ZRCI) Florida, New York, introduced refractory sheet type RS-101 cylinders, ceramic fiber-reinforced structural alumina products with useful properties to 1,260°C (2,300°F).

These cylinders retain strength and utility to levels far exceeding maximum use temperatures of reinforced plastics and asbestos-cement replacements, such as calcium silicate. RS-101 not only makes an excellent replacement for rigid asbestos-containing products, but also may be employed to even higher temperatures. RS-101 is 100 percent inorganic, non-flammable, and contains no asbestos. It undergoes no outgassing on heating, is not brittle, and may be cut and machined with standard tooling.

RS-101 is available in standard and custom-size cylinders. RS-101 cylinders are ideal as replacement cylinders for many induction heating, forging, and melting applications.

MORE INFO www.zrci.com



Zoltán Koloszváry appointed honorary president of IFHTSE

For the first time in 30 years, IFHTSE has appointed an honorary president. Honorary presidents have rendered outstanding and continuous service to the Federation over many years, not necessarily as president. They have given the Federation its shape and standing in their time and have enlarged its scope, initiated new activities, or renewed and reinforced its structure and been the face of the Federation for the public. Upon recommendation of the Executive Committee and approval of the Governing Council, IFHTSE confers to Dr. Zoltán Koloszváry this honor for "his outstanding leadership to IFHTSE and his dedicated, successful, and long-term service as its president and treasurer."

Zoltán Koloszváry

Dr. Kolozsváry has provided outstanding leadership for several decades, beginning in the 1970s. His multilingual abilities (he will happily communicate in his native Hungarian and Romanian as well as in English and German) have always ensured a good level of understanding at many meetings.

His efforts to maintain IFHTSE as an organization of international relevance in the critical fields of heat treatment and surface engineering have been constant and much valued. For example, after the changes in the USSR/Russia, he was central to the restoration of active Russian contributions to IFHTSE, and membership of the Russian Heat Treating Society to IFHTSE.

Dr. Kolozsváry participated in his first international conference held in Switzerland 1968. He attended many meetings and conferences of the International Federation for Heat Treatment (IFHT) from the beginning of the Federation (1971), and he has represented Romania in the Federation since 1986. In 1973, he was invited to Liverpool University as a visiting researcher by Professor Tom Bell. A three-decade scientific collaboration was started with Prof. Bell on nine international projects in the field of surface science and heat treatment.

He became vice president of IFHTSE in 1995 (at the congress held in Teheran, Iran), and president in 1998 at the congress in Florence, Italy. During his period as president of the IFHTSE, he worked to strengthen the collaboration between the Federation and partners in Asia and North America. He became treasurer of the Federation in 2001, a position he held until 2016. He became a Fellow of IFHTSE in 2007.

Dr. Kolozsváry was born in 1937 in Târgu Mureş, Romania. He graduated with honors from the Technical University of Bucharest in 1959. He started to work in the machine factory "Encsel Mór" (Târgu Mureş) as trainee and soon became the head of the heat-treatment workshop. In 1963, he was commissioned to build a nitriding furnace and technology for large parts used for knitting machines. This development has ultimately determined his professional and scientific career where he focused on the effect of nitriding technology (salt bath and atmosphere treatments) on the wear of steel parts. He defended his doctoral dissertation in 1970. The year after, he was nominated to establish a Romanian Research Institute for Heat Treatments and Surface Engineering. His patents on gas nitriding have been used by several companies related to the German vehicle industry, and his company Plasmatherm is well noted for plasma nitriding for many different applications. He became the scientific director of the institute Metalotehnica in 1976. He has published more than 200 scientific and technological papers in eight languages, several chapters in *Metal Handbooks, ASM Handbooks,* and the *Handbook of Residual Stress and Deformation.*

Previous honorary presidents of IFHTSE include:

» Dr. H. U. Meyer, director of Climax Molybdenum, served as the chairman of the Founding Committee and as president until 1974. He became honorary president in 1986.

» Urs Wyss served as secretary of IFHT (later IFHTSE) until 1988. He became honorary president in 1991. In 2006, he was awarded the IFHTSE Medal.

MEMBERS IN THE NEWS

Rob Goldstein, executive director of Product Development and Strategic Planning, Fluxtrol, was recently awarded an ASM International Fellow for his contributions in the field of induction applications. He was also identified as one of the "Monty's 30 Most Influential People in The North American Heat Treating Industry 2021."

Fluxtrol has been a member of IFHTSE since 2019.

IFHTSE 2021 EVENTS

APRIL 26–28
European Conference on Heat Treatment and 2nd QDE – International Conference on Quenching and Distortion Engineering
Online event | Germany | www.echt-qde-2021.de

SEPTEMBER 5–9
6th International Conference on Steels in Cars and Trucks
Milan, Italy | www.sct2020.com

SEPTEMBER 8–10
4th Mediterranean Conference on HTSE
Istanbul, Turkey | mchtse2020.com

SEPTEMBER 13–16
International Materials Applications & Technologies
St. Louis, MO, USA | www.asminternational.org/web/imat

SEPTEMBER 29–OCTOBER 1
14th HTS International Exhibition and Conference
Mumbai, India | www.htsindiaexpo.com

OCTOBER 26–28
HK 2021
HK is the largest materials technology industry meeting in Europe
Cologne, Germany | www.hk-awt.de

APRIL 2022
12th Tooling Conference
Sweden

SEPTEMBER 2022
27th IFHTSE Congress / European Conference on Heat Treatment
Austria

For details on IFHTSE events, go to www.ifhtse.org/events

IFHTSE

IFHTSE LEADERSHIP

EXECUTIVE COMMITTEE

Eva Troell | President
RISE IVF Research Institutes of Sweden | Sweden

Dr. Scott MacKenzie | Past President
Houghton International Inc. | USA

Prof. Masahiro Okumiya | Vice President
Toyota Technological Institute | Japan

Dr. Stefan Hock | Secretary General
IFHTSE Italy

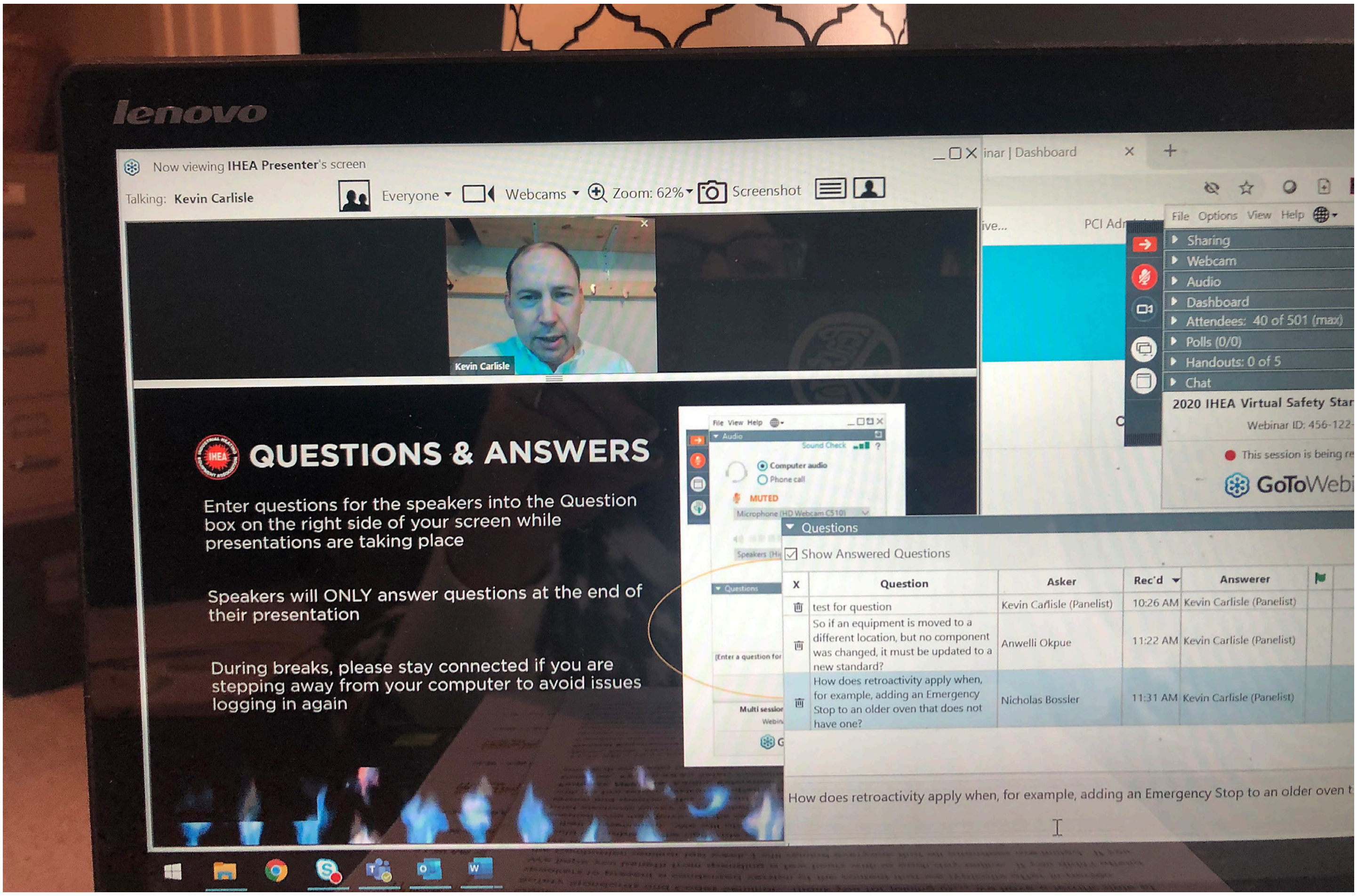
Dr. Imre Felde | Treasurer
Óbuda University | Hungary

OTHER MEMBERS

Prof. Rafael Colas | Universidad Autónoma de Nueva Leon | Mexico
Dr. Patrick Jacquot | Bodycote Belgium, France, Italy | France
Prof. Massimo Pellizzari | University of Trento | Italy
Prof. Larisa Petrova | MADI University | Russia
Prof. Reinhold Schneider | Univ. of Appl. Sciences Upper Austria | Austria
Prof. Marcel Somers | Technical University of Denmark | Denmark
Prof. Kewei Xu | Xi'an University | China

ONLINE www.ifhtse.org | **EMAIL** info@ifhtse.org

IHEA offers 2021 Virtual Spring Safety Standards & Codes Seminar

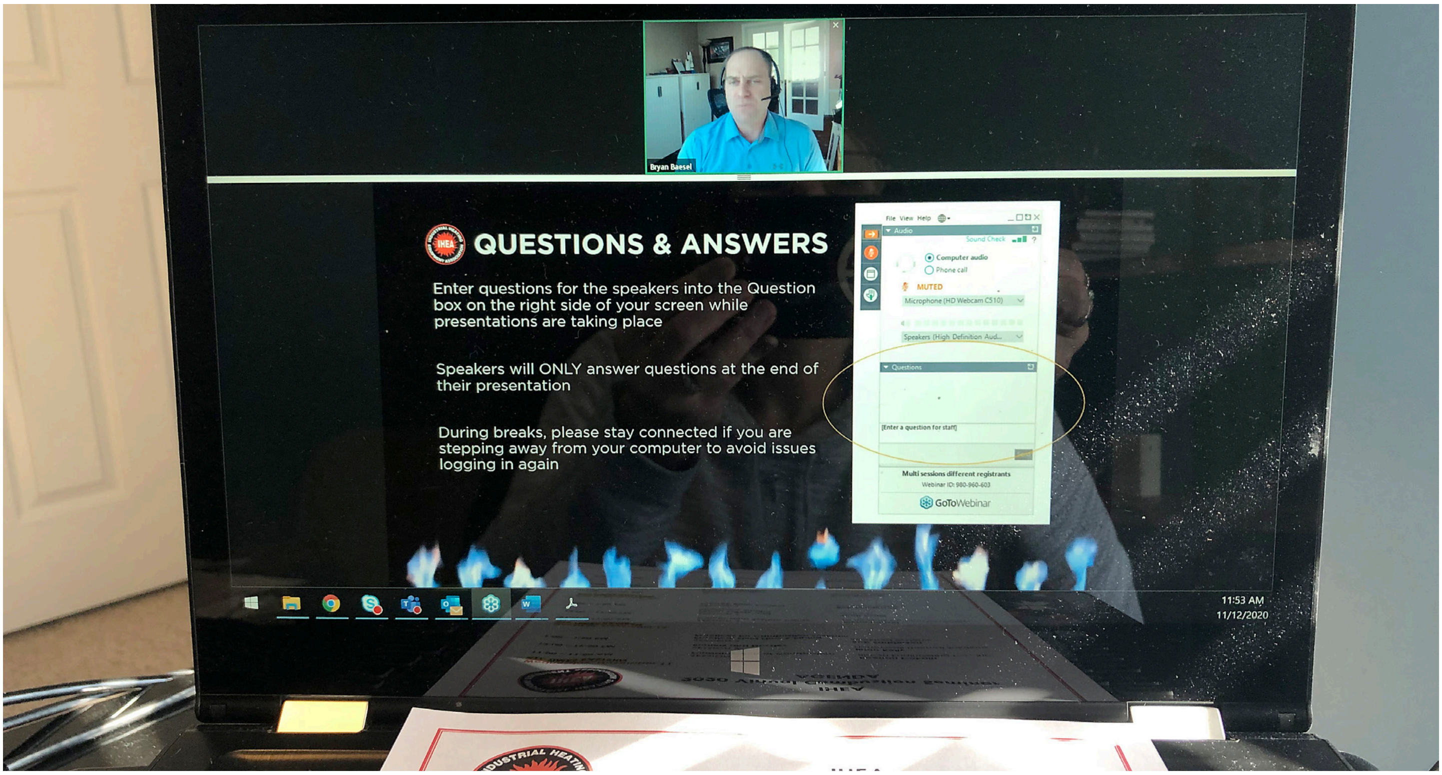


The Virtual Safety Standards and Codes Seminar covers critical safety information for those involved with a wide range of industrial thermprocess applications.

After the success of a series of virtual seminars last fall, the Industrial Heating Equipment Association (IHEA) has scheduled a virtual Safety Standards & Codes Seminar for April 14-16. The seminar provides a comprehensive review of the 2019 edition of NFPA 86 Standard for ovens and furnaces. The agenda for IHEA's virtual Safety Seminar contains vital topics that have been adapted to an online version so attendees can still get the information they need, whether they are working from home or in the office.

IHEA's Safety Standards & Codes Seminar is designed for individuals involved in the design, manufacture, service, or operation of ovens, furnaces, kilns, dryers, thermal oxidizers, and a wide range of industrial applications. Understanding the proper use of national standards governing the compliant design and operation of ovens and furnaces is essential for everyone involved with this type of equipment.

"While we are hoping to hold our seminars in person during the fall of 2021, there is ongoing demand for virtual training now, so a decision was made to offer our popular Safety Standards & Codes Seminar again this spring," said IHEA Executive Vice President Anne Goyer.



The three-day virtual seminar will include the following sessions presented by industry professionals who are experts in safety:

» **Overview of NFPA 86 Standards for Ovens & Furnaces Including Administration, References & Definitions.** Kevin Carlisle, Karl Dungs.

» **General Requirements, Location and Construction.** Glen Mortensen, Zurich Services Corp.

» **Furnace Heating Systems Including Class B Furnace Considerations.** Bryan Baesel, Honeywell Combustion Safety.

» **Safety Equipment & Application Including Safety Shutoff Valves.** Aaron Zoeller, SCC Inc.

» **Safety Equipment & Application Including Programmable Logic Controller Systems.** Bryan Baesel, Honeywell Combustion Safety.

» **Class A Ovens & Furnaces and Thermal Oxidizers.** Jason Safarz, Karl Dungs.

» **Safety Equipment & Application with Safety Controls & Devices.** Michael San Antonio, Fireye.

» **Special Atmospheres for Class C Ovens & Furnaces and Quench & Molten Salt Bath.** Anthony Cherol, Surface Combustion.

» **Commissioning, Operations, Maintenance, Inspection & Testing.** Aaron Zoeller, SCC Inc.

What former Safety seminar attendees are saying:

» "The seminar was excellent. It was very informative."

» "Good speakers, good distinction between OEM and end user responsibility."

The registration fee for the three-day virtual event is $295 for IHEA members and $350 for non-members and includes a printed copy of the NFPA 86 Standard for Ovens and Furnaces and a certificate of completion awarding PDHs.

Group Discount Available: Register two or more people from the same company at the same time and save money. The first registrant pays the regular registration fee, and each additional attendee receives a $50 discount.

For additional details and to register, go to www.ihea.org/event/SafetySpring21.

IHEA 2021 CALENDAR OF EVENTS

JANUARY 25–MARCH 7

Fundamentals of Industrial Process Heating

6-week online course beginning January 25, 2021

This course is designed to give the student a fundamental understanding of the mechanisms of heat transfer within an industrial furnace and the associated losses and the operation of a heating source either as fuel combustion or electricity. All concepts are derived mathematically with limited use of "rules of thumb."

APRIL 14–16

Virtual Safety Standards and Codes Seminar

3-day online course

This seminar covers critical safety information for those involved with a wide range of industrial thermprocess applications. Attendees will receive a printed copy of the current NFPA 86 Standard for Ovens and Furnaces. Registrations that are received after April 2 may not get the printed NFPA 86 book prior to the seminar.

For details on IHEA events, go to www.ihea.org/events

INDUSTRIAL HEATING EQUIPMENT ASSOCIATION

P.O. Box 679 | Independence, KY 41051

859-356-1575 | www.ihea.org

JERRY WEINSTEIN, PH.D.
MATERIALS SCIENCE ENGINEER /// CERAMATERIALS

This lightweight and versatile material offers easy handling, high temperature tolerance, and cost-saving options.

An overview of refractory ceramic fibers

This article will review refractory ceramic fibers (RCFs), which are amorphous, inorganic, man-made aluminosilicate fibers. RCFs belong to a class of materials termed man-made vitreous fibers, which includes glass wool, rock (stone) wool, slag wool, mineral wool, and special-purpose glass fibers.

The products made from RCF wools are most important for thermal-processing installations and industrial furnace construction and insulation. The RCF products are lightweight and easy to handle, with high temperature capabilities, good thermal shock and chemical resistance, and low thermal conductivity and heat loss. They are generally used in commercial applications requiring lightweight insulation that is capable of withstanding high temperatures, such as furnace and kiln insulation, fire protection, and automotive exhaust systems.

RCF products are used in high-temperature applications in many industries including metals processing, heat treating, glass and ceramics, chemical and petrochemical, automotive, aerospace, power generation, and even domestic appliances.

The maximum service temperature of different RCFs varies in different atmospheres. Complete replacement of dense refractories with an RCF product form provides the most savings in this regard. Using RCF as backup insulation or as a hot-face veneer over an existing refractory lining, however, affords significant energy savings as well.

VARIOUS TYPES OF RCFS

Refractory ceramic fibers are synthetic fibers produced by the melting and blowing or spinning of calcined kaolin clay or a combination of alumina (Al_2O_3), silicon dioxide (SiO_2), or other oxides, usually in a 50:50 weight ratio. The most common grade RCF fiber provided by most USA-based fabricators and suppliers is the "high purity" grade having a temperature rating of around 1,260°C max or 1,180°C continuous use.

There is a higher temperature grade RCF containing about 15 percent ZrO_2 with improved temperature rating of about 1,427°C max or about 1,343°C continuous use for the most common zirconia grades. Pricing for this grade is a bit higher than the standard high purity grade.

A biosoluble RCF grade is called AES wool (alkaline earth silicate), consisting of amorphous fibers produced by melting a combination of CaO, MgO, and SiO_2. AES fiber products having a temperature rating of around 1,260°C max or 1,150°C continuous use, not quite as high as the standard high purity RCF. The calcium and magnesium oxide content are easier for the body and lungs to dissolve, so called biosoluble.

Ceramic fiber blanket from CeraMaterials available in varying dimensions, densities, grades, and temperature ratings. (Courtesy: ©CeraMaterials)

Products made of AES exhibit lower chemical resistance and are more prone to recrystallization, thereby limiting their potential application in thermal-process engineering. The main application for these AES materials is in the domestic appliance industry and in industrial processes for temperatures to a maximum of 1,100°C, although rated for 1,150°C continuous.

Polycrystalline wools (PCWs) are a higher temperature RCF,

HIGH TEMPERATURE INSULATION WOOL (HTIW)

HTIW Grades		Chemical Composition	Acid / Alkaline	Max Temp.	Continuous Use Temp.	Typical Service Temp.	Melting Point	Mean Fiber Length	Thermal Shock Sensitivity	Bulk Density
	AES Wool	CaO 27 - 32 % MgO 2 - 6 % SIO_2 61 - 68 %	- / +	1260°C 2300°F	1150°C 2102°F	< 1000°C < 1832°F	≈ 1300°C ≈ 2372°F	1 - 4.5 µm	+	64-128 kg/m³ 4 - 8 lb/ft³
RCF	Aluminum Silicate Wool	Al_2O_2 47 - 49% SIO_2 50 - 52%	+ / -	1260°C 2300°F	1180°C 2156°F	< 1150°C < 2102°F	≈ 1760°C ≈ 3200°F	1 - 4.5 µm	++	64-160 kg/m³ 4 - 10 lb/ft³
		Al_2O_2 35 - 40% SIO_2 38 - 50% ZrO_2 15 - 17%	+ / -	1427°C 2600°F	1343°C 2450°F	< 1300°C < 2372°F	≈ 1760°C ≈ 3200°F	1 - 4.5 µm	++	96-160 kg/m³ 6 - 10 lb/ft³
PCW	Polycrystalline Wool	Al_2O_2 72 - 80% SIO_2 20 - 28%	+/+	1649°C 3000°F	1600°C 2912°F	< 1600°C < 2912°F	≈ 1871°C ≈ 3400°F	1 - 4.5 µm	++	96-160 kg/m³ 6 - 10 lb/ft³
		Al_2O_2 95 - 97% SIO_2 3 - 5%	+/+	1800°C 3272°F	1650°C 3002°F	< 1650°C < 3002°F	≈ 2000°C ≈ 3600°F	1 - 4.5 µm	++	96-160 kg/m³ 6 - 10 lb/ft³

Table 1: The physical and chemical properties of various high temperature insulation wools. (Courtesy: CeraMaterials)

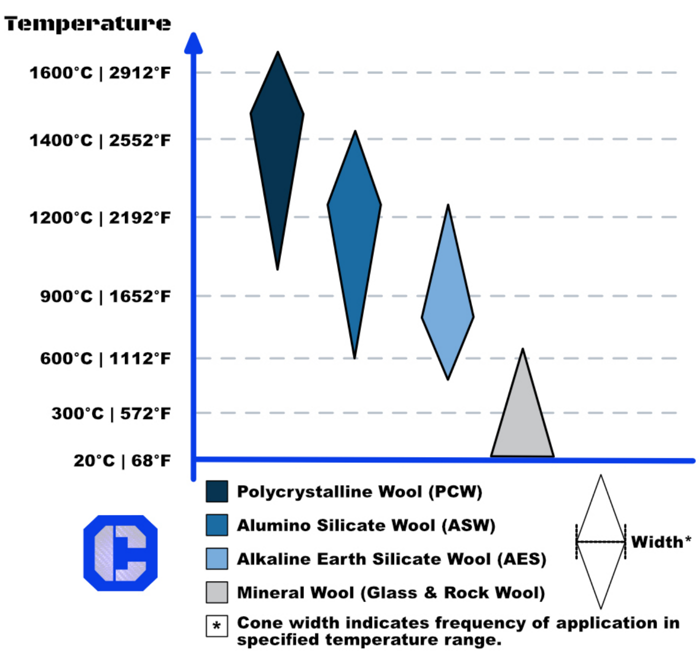


Figure 1: Frequency of use and common temperature ranges for the application of HTIW products. (Courtesy: www.htiwcoalition.org)

consisting of fibers with an Al_2O_3 content above 63 wt. percent and a SiO_2 content under 37 wt. percent. Most suppliers produce the PCWs fiber by aqueous spinning solutions in the sol-gel method. The sol-gel-derived green fibers formed initially as a precursor are then crystallized by means of heat treatment and then handled much like standard RCF and AES fibers. Polycrystalline fiber wools have a max temperature rating of around 1,800°C max and 1,650°C continuous use. (Table 1)

Note that the actual maximum continuous use temperatures for RCF fibers are generally at least 150-200°C (safety allowance) below the max use or classification temperature. This is because, in contrast to the determination of the classification temperature in ideal, neutral-firing conditions with a relatively short exposure (24 hours), the products used in the field are not only exposed to high temperatures but to additional chemical and physical stresses that often deviate far from ideal conditions and therefore limit the application temperature. (Figure 1)

The bulk RCF wool previously described can be used directly for some applications, but are more commonly converted into other physical forms, including blankets, modules, paper, board, vacuum-formed parts, textiles, foam and putties, or pastes, adhesives and coatings. Conversion to various physical forms takes place at locations where RCF fibers are produced, as well as at facilities operated by converters (producers of intermediate goods) or end users. (Figure 2)

CERAMIC BLANKETS

RCF blankets are manufactured by a felting process from a water-based slurry of the RCF fibers with needling from both sides to help interlock the fibers and felt layers, dried in continuous ovens, which results in high-porosity binder-free porous blankets with flexibility and good handling strength. Blankets are produced in varying dimensions, thicknesses, densities, and temperature ratings based on the RCF fiber used. For the standard RCF and AEW fibers, blankets are offered in four, six, and eight pound (per cubic foot) densities, widths of 12, 24, and 48 inches, and thicknesses from 1/8 to two inches. Alternate sizes and shapes are often special orders with capabilities up to 60 inches wide.

RCF blanket Wet Wool is a unique product that takes the standard RCF binder-free blanket and pre-wets it with water-based inorganic bonding agents and then packages it in a clear polyethylene bag to retain the wet binder during shipping and storage. The manufacturing process results in flexible insulation that can be formed to complex shapes in place and air dries to form a hard, rigid structure. Additionally, the material can be cured by immediate exposure to temperature in application. Material has a dry density of 12-18 lbs/ft^3.

Foil-backed or wrapped RCF blanket is also commercially popular, with the foil improving abrasion and moisture resistance, and reducing loose fiber loss. The foiled blanket is often used in appliances, automotive applications, chimney repair, and gasket seal applications.

MODULES

RCF modules are created from folded and compressed blanket, banded to standard block shapes and sizes, with metallic attachment mechanisms folded into the shape. These modules are then used as building blocks to line furnaces and kilns. The assemblies of the modules are designed to create a no-gap environment upon unbinding, where the modules spring apart laterally, sealing gaps and holding in place. Ceramic fiber module systems provide an energy-efficient solution that can aid in alleviating the need for controlled start-up after installation. Common uses include annealing and tempering furnaces, combustion chambers, oxidizers, burn-off ovens, hydrocarbon reformers, kilns, incinerators, ducts and flues, and more.

Figure 2: An overview of products made from high temperature insulation wools (HTIW). (Courtesy: CeraMaterials)

CERAMIC PAPER

Ceramic fiber paper is manufactured through a fiber washing process which produces a non-woven matrix blend of the fibers, water-based organic binders (~10 percent), and additives to form randomly oriented fiber continuous mat that is flexible and uniform. This process controls the content of unfiberized glass to a minimal level within the paper. Ceramic paper is typically available in RCF and PCW grades in rolls that are 24 and 48 inches wide, with customized sizes up to 60 inches wide. Note that the high binder content results in smoke during initial heat up, resulting in a very weak powdery product after firing.

Binderless paper is available at a premium price which provides a smoke-free option and is manufactured without the organic binder system.

VACUUM FORMED PRODUCTS

RCF porous rigid boards are manufactured through a vacuum casting process using a slurry made of RCF fibers with inorganic and organic binders, formed to near thickness, dried in an oven, and sanded to final thickness. Standard casting thickness can be up to six inches, but thicker than four inches is often made by stacking board assemblies. Boards are fabricated in low and higher densities to standard sizes, but also available up to 60 inches diameter. Low density boards are slightly better insulators, but they are not as durable and strong as high density.

Customized shapes can be fabricated with made-to-order vacuum molds or by assemblies of smaller parts and layers bonded with RCF cement. The rigid RCF molding mix is machinable and can be manufactured in a wide range of shapes and sizes to meet customer needs, including bolt-together pipes, manifolds, elbows, transitions, and custom fittings, as well as burner blocks, peep-sight windows, and sleeves for any unique furnace system design. It also is possible to embed heating elements in the hot face of the insulation and attachment mechanisms into the body and back of the boards.

MOLDABLE MIXES AND ADHESIVES

There are various RCF ceramic moldable mixes consisting of RCF fibers dispersed in a slightly sticky refractory binder system to permit vibratory or hand-packed casting. The putty-like consistency allows easy application by caulking, troweling, hand-forming, and pressure molding. Once cast in place, the moldable mix dries and hardens with minimal shrinkage yielding high porosity, rigidity, high strength, and machinability.

Fiberboard glue is a colloidal silica- and alumina-based RCF mix best used for joining two pieces of ceramic fiber board together or patching small areas. The glue is manufactured by dispersing ceramic fibers in a liquid-based refractory binder system. The resulting viscous consistency allows the glue to be easily applied to refractory ceramic fiber surfaces by troweling or hand forming. Once fully dried, the glue can be sanded or cut using traditional finishing methods due to the product's excellent mechanical strength. Additional coats can be applied or used as a coating on fiberboard shapes, available to match all RCF temperature ranges.

TEXTILES AND ROPE

Textile products are manufactured from RCF and PCW fiber with the same temperature ratings. For improved manufacturing and handling, most textile products do contain approximately 15 percent

Ceramic fiber blanket with and without foil backing. (Courtesy: ©CeraMaterials)

organic carriers, which will smoke during burn out. Textile products can also contain reinforcement insert materials of Inconel wire or continuous fiberglass filament to increase handling strength during installation and to enhance fiber durability. Inconel reinforcement has a temperature rating of 2,000°F (1,093°C) and fiberglass reinforcement has a temperature rating of 1,200°F (649°C), so while the fiber can handle higher temperatures, the reinforcement may give out sooner.

RCF cloth, tape, and sleeving are very strong and flexible fabrics as formed. Insert materials of Inconel wire and fiberglass filaments are incorporated into the yarn to increase the tensile strength of the fabrics both before and after exposure to heat. Typical applications include gaskets, seals, pipe wrapping, furnace, and welding curtains. A variety of sizes, diameters, and rolls are available off the shelf.

Round and square RCF braid are manufactured by over-braiding around a core of ceramic fiber to achieve maximum resistance to mechanical abuse. In addition to its superior strength, round and square braids also exhibit minimal unraveling when cut.

Three-ply twisted ceramic fiber rope is manufactured by forming strands of thick RCF yarn, which are then twisted into a three-ply rope.

Both the braid and ropes are readily available in diameters from 1/8 to 2 inches and are used as gaskets and seals in furnaces and reinforcements for larger RFC forms.

Tadpole gaskets are custom manufactured to customer specifications from sewn blends of RCF fabric, blanket, rope and tape. Available in many designs such as single or double bulbs or single or double tails, these gaskets provide an excellent solution for high-temperature sealing applications such as door, flange, and air-handling valve gaskets.

Ceramic fiber products have lightweight, good heat insulation performance and thermal stability, good chemical stability, easy processing, and convenient construction. Its defect is that it is not abrasion and impact resistance, which cannot resist high speed air flow scouring, and the erosion of slag. There are various ceramic coating materials and rigidizer (colloidal silica and alumina) available to reduce the thermal shrinkage and increase the mechanical strength of the RCF parts.

CONCLUSION

Refractory ceramic fibers are used in commercial applications requiring lightweight insulation that is capable of withstanding high temperatures, such as furnace and kiln insulation, fire protection, and automotive exhaust systems. The RCF fibers are formed into lightweight and easy-to-handle high-temperature insulation products with excellent thermal shock, chemical resistance, low thermal conductivity, and heat loss and low weight.

These products include bulk fiber, blankets, modules, paper, board, vacuum formed parts, textiles, foam, putties, adhesives, and coatings. The RCF products are used in high-temperature applications in many industries including metals processing, heat treating, glass and ceramics, chemical and petrochemical, automotive, aerospace, power generation, and even domestic appliances.

Complete replacement of dense refractories with an RCF product provides cost savings in fuel needs and efficiency. Even using RCF as backup insulation or as a hot-face veneer over an existing refractory lining results in significant energy savings as well.

ABOUT THE AUTHOR

CeraMaterials' Materials Science Engineer Jerry Weinstein has a Ph.D. in ceramic engineering from Rutgers University with more than 30 years' experience, 46 U.S. patents, and numerous publications and presentations. He has extensive experience working and consulting in fields such as advanced ceramics, graphite composites, heat treating, armor, aerospace, turbine engines, electronics, nano-composites, erosion/corrosion and whitewares. Jerry also consults outside projects through CeraGraphiSolutions.

HOT SEAT ///

D. SCOTT MACKENZIE, PH.D., FASM
SENIOR RESEARCH SCIENTIST–METALLURGY /// QUAKER HOUGHTON INC.

Discussing the concepts of artificial aging and some of the basic recipes for artificially aging aluminum.

Heat treatment of aluminum VI – Artificial aging

In the previous column, we described the fundamentals of natural aging. In natural aging, the solid solution obtained after quenching starts to form precipitates immediately at room temperature. This process is termed natural aging, and the hardening during natural aging is attributed almost entirely to the homogenous precipitation of solute-rich GP zones and the clustering of vacancies.

While precipitation occurs naturally at room temperature, in a supersaturated solid solution after quenching the effects of precipitation on mechanical properties can be greatly accelerated, and improved, by aging at an elevated temperature after quenching. This is performed at a temperature typically in the range of about 200° to 400°F (95°-205°C). Aging at an elevated temperature is referred to as precipitation heat treating or as artificial aging. The typical change in hardness for artificial aging of aluminum is shown in Figure 1.

Precipitation hardening is the mechanism where the hardness, yield strength, and ultimate strength dramatically increases with time at a constant temperature (the aging temperature) after rapidly cooling from a much higher temperature (solution heat treat temperature). This rapid cooling or quenching results in a supersaturated solid solution and provides the driving force for precipitation. This phenomenon was first discovered by Wilm [1], who found that the hardness of aluminum alloys with minute quantities of copper, magnesium, silicon, and iron increased with time, after quenching from a temperature just below the melting temperature.

During artificial aging, the supersaturated solid solution created by quenching from the solution heat-treating temperature begins to decompose. Initially, there is a clustering of solute atoms near vacancies. Once sufficient atoms have diffused to these initial vacancy clusters, coherent precipitates form. Because the clusters of solute atoms have a mismatch to the aluminum matrix, a strain field surrounds the solute clusters. As more solute diffuses to the clusters, eventually the matrix can no longer accommodate the matrix mismatch. A semi-coherent precipitate forms. Finally, after the semi-coherent precipitate grows to a large enough size, the matrix can no longer support the crystallographic mismatch, and the equilibrium precipitate forms.

Heating the quenched material in the range of 95°-205°C accelerates precipitation in heat-treatable alloys. This acceleration is not completely due to changes in reaction rate. As was shown in Figure 1, structural changes occur that are dependent on time and temperature. In general, the increase in yield strength that occurs during artificial aging increases faster than the ultimate tensile strength. This means that the alloys lose ductility and toughness. T6 properties are higher than T4 properties, but ductility is reduced. Over-aging decreases the tensile strength and increases the resistance to stress corrosion cracking. It also enhances the resistance to fatigue crack growth. It also imparts dimensional stability of the part.

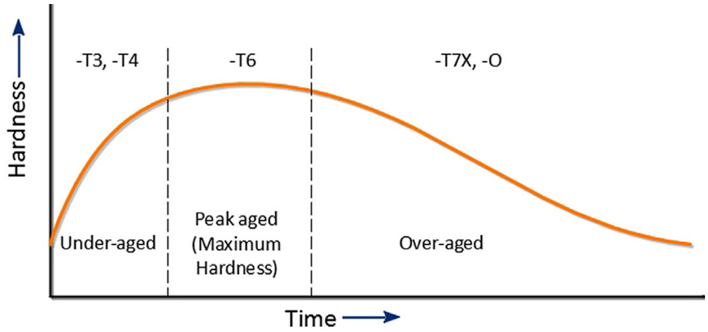


Figure 1: Typical artificial aging curve for aluminum.

In artificial aging, the degree of precipitation and morphology of the precipitate is controlled by aging time and temperature. Within limits, approximately equivalent effects can be obtained by shorter periods of time at higher temperatures or longer times at lower temperatures. A series of different transition precipitates can occur when aging is done at elevated temperatures.

Commercial aging practices represent compromises to provide the desired mechanical and corrosion properties. The recommended soaking times assume that furnace characteristics and loading are such that the load is heated reasonably rapidly to temperature. Over-aging can result if the rate of approach to the soaking temperature is unusually slow, because of heavy compact loading, overloading the furnace, or use of a furnace with inadequate heating capacity. Typical artificial

Alloy	Starting Temper	Final Temper	1st Step			2nd Step		
			Temp °F	°C	Time Hours	Temp °F	°C	Time Hours
2XXX	AQ, W	T4	Room		N/A			
2024	T4	T6	375	190	9			
2024	T4	T8	375	190	12			
6061	T4	T6	350	170	12			
6063	T4	T8	350	170	8			
7075	AQ, W	T6	250	121	24			
7075	AQ, W	T73	250	121	5	350	177	8
7075	AQ, W	T76	250	121	5	350	177	6
7050	AQ, W	T73	250	121	7	350	177	12

Table 1: Typical artificial aging practice for selected aluminum alloys [2].

aging times for different alloys are shown in Table 1.

Consideration must be given to temperature control and furnace response to avoid over-aging or under-aging. During the soaking period, the furnace should be capable of maintaining the metal temperature within ±5°C (±10°F) of the recommended temperature. With suitable placement of thermocouples within the load, the soaking time should be counted from the time the lowest temperature in the load reaches within 5°C of the temperature specified. The recommended soaking times assume that furnace characteristics and loading are such that the load is heated reasonably rapidly to temperature. Overaging can result if the rate of approach to the soaking temperature is unusually slow, because of heavy, compact loading, overloading the furnace, or use of a furnace with inadequate heating capacity. If load thermocouples are not employed and soaking time is estimated from a total furnace time, under-aging can result.

During artificial aging, mechanical properties will improve. The yield strength will increase, as will the ultimate tensile. The yield strength will increase faster than the ultimate tensile strength. Because of this, the ductility decreases as the aging sequence progresses. Once as the peak aged condition is reached, then the yield and ultimate strength will decrease, but the ductility will increase.

Other factors, however, may greatly favor the use of an overaged temper. In certain applications, for example, strength factors are outweighed as criteria for temper selection by the resistance to SCC, which improves markedly with aging for some alloys, or by the greater dimensional stability for elevated temperature service that is provided by aging.

Some paint/bake operations are in the temperature range commonly used for aging aluminum. Consequently, autobody sheet can be formed in the T4 condition, where formability is high, and then aged to higher strengths during the paint/bake cycle. Alloy 6010 was developed to maximize the response to aging in the temperature range commonly used for paint baking.

The stresses developed during quenching from solution heat treatment are reduced during artificial aging. The amount of stress relief is dependent on the artificial aging time and temperature. Peak aged tempers (T6) see a 10-35 percent reduction in stress, while over aged tempers (T7X) provide for substantial residual stress reduction [3].

CONCLUSIONS

In this short column, we have introduced the concepts of artificial aging, and illustrated some of the basic recipes for artificially aging aluminum. In the next column, we will illustrate some of the different equipment types for heat treating aluminum.

Should there be any questions or comments regarding this column, please contact myself or the editor.

REFERENCES

[1] A. Wilm, Metallurgie, vol. 8, p. 225, 1911.

[2] SAE International, "Heat Treatment of Wrought Aluminum Alloy Parts," SAE International, Warrendale, 2015.

[3] K. R. Van Horn, "Residual Stresses Introduced During Metal Fabrication," Trans. ASM, vol. 47, pp. 38-76, 1955.

ABOUT THE AUTHOR

D. Scott MacKenzie, Ph.D., FASM, is senior research scientist-metallurgy at Quaker Houghton Inc. For more information, go to https://home.quakerhoughton.com/

TONY TENAGLIER
HEAT TREAT PROCESS ENGINEER ///
HITCHINER MANUFACTURING

Each day is game day in the field of thermal processing, and every player has a key role.

Heat treating from the operator's perspective

Often, a customer visit involves a walk through the facility. Comments are made about how clean it is or how well organized a process is put together, but probably the most important compliment is the heat-treat operator's ability to express the knowledge of the process. To hear — in between the technical jargon — the support needed and given by the rest of the team at the facility displaying the confidence in the actions of what, how, and why they perform their job.

Similar to a sports team, the heat-treat team is comprised of different functions and roles that must all work together and support one another in achieving the goal of heat treating successfully to customer requirements. Fans file in to see the sports game and cheer and support the players on the field. They comment on how nice the stadium is or how well organized the processes of finding their seat and bathroom are. But what the fans really cheer for is the success of the players on the field.

In sports, it is the players on the field who ultimately make the plays that win the game, but the support on the sideline leading up to the game, during the game, and even after the game is what is crucial in making the program and team an overall success. Similarly, the heat-treat operator is on the playing field to properly run the cycle and meet the customer's requirements with the support of maintenance, human resources, engineering, management, and quality.

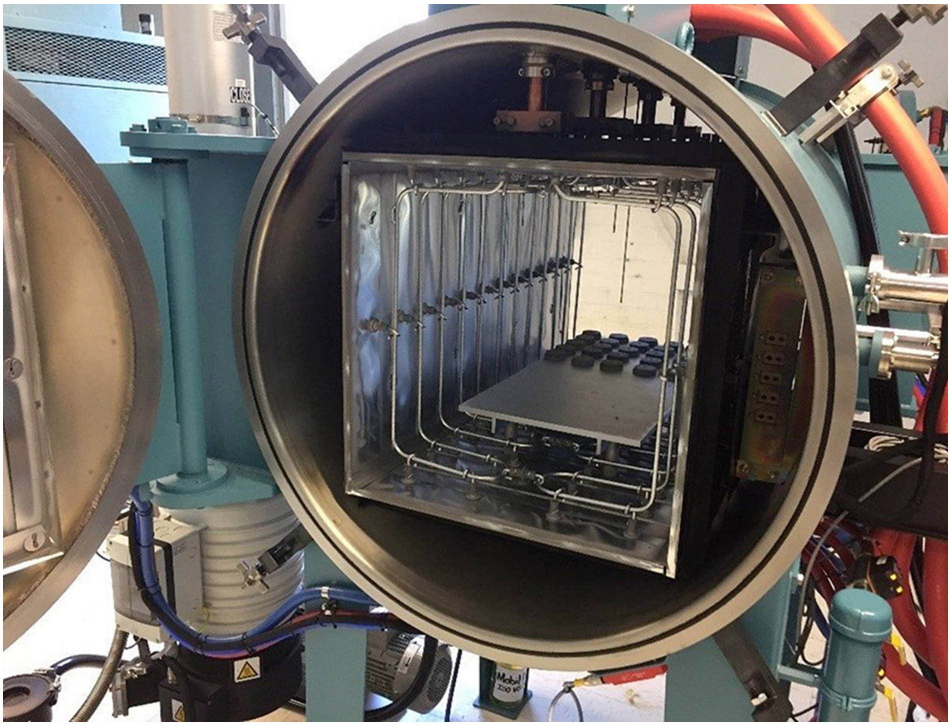
PRE-GAME (PRIOR TO SHIFT)

A typical Monday for vacuum furnace heat treating often begins with performing the leak rate test, a check that determines the integrity of the seals and the chamber for no possible air contamination during a cycle. The operator then begins to make sure the furnace is in working order by performing the daily checklist, a combination of basic maintenance items such as ohm resistance checks on the elements, replacement of possible hot zone parts, and an overall walk around of the furnace inspecting for leaks and other items that might stand out. When needed, the operator gets support from the maintenance team with a simple QR code work order entry to minimize the downtime.

Once the furnace is in working order, the operator makes sure the stickers are up to date, that all pyrometry requirements from the TUS (temperature uniformity survey), CAL (instrument calibration), and SAT (system accuracy test) are all up to date. If not, a simple request via email notifies the heat-treat engineer and quality personnel of the furnace calibration.

In sports, athletes need various forms of training. Maybe it's mental training for confidence in the game or physical training to be stronger and faster. The heat-treat operator also needs training, mental training for audit preparation and physical training on how to operate any forklift equipment or how to properly run the heat-treat furnace.

In building the team, human resource personnel search the industry's network for top talent. Once on board, training programs such as ARP1962 Training and Approval of Heat Treating Personnel are recommended and suggest both classroom and practical training. Exams are administered to check competency but also simulate questions that might be asked during an audit. Preparation is key to winning the championship game, and so is the preparation and



Each day, the goal is to improve upon the operator's success whether you are in maintenance, process engineering, quality, or management. The culture of success requires continual maintenance before, during, and after the heat-treat shift.

training that makes an audit successful.

DURING THE GAME (DURING SHIFT)

The stage is set; It's game time. Lights come on in the furnace area and the furnace power turns on, ready to go. Parts are ready to be heat treated. The operator has a beginning-of-shift huddle for the play actions for the day with the manager instructing the goals ahead for the shift. How many parts are there to heat treat? How many cycles need to be run? Once they are on the clock, the operator gets to work setting up various loads and running multiple furnaces simultaneously.

Like juggling multiple different plays that could be run, the operator must juggle the priorities of the day. A furnace may be running smoothly and then suddenly lose power. Last minute jobs that have become greater priority must be shuffled into the schedule. Even continual quality check-ins throughout the shift are important. For example, replacement of thermocouple wire lots dictates a possible alternate SAT requirement, or dew point verification testing may also be required. The original play call may need to be changed.

POST GAME (END OF CYCLE/SHIFT)

Once the clock hits the end of the shift, the game for that day is done. The reports get generated for the production and quality personnel of the day's work and are reviewed by the management "upstairs." Deeming the work adequate and conforming, human resources rewards the operator with a paycheck or sometimes even special awards for service to the company that is above and beyond what is required.

Process engineers then come in and analyze the plays and try to optimize for the next day. Opportunities lost in scrap or wasted time can be improved upon to help the operator be more successful. Maybe new techniques or more training is required. To keep the company successful, upper management measures the success based on AS9100 requirements of defining company goals and key process indicators (KPIs). A win at the end of the business day is determined by whether the entire team is trending toward the goal.

THE MONDAY QUARTERBACK

Business and production are a never-ending cycle as each day is a game day. Sports teams have their dynasties where special players with great talent bring victory with triumph over defeats. In a company's culture and organization, it is important to remember that each of the team members — the heat-treat operators, the personnel on the floor working with the process, and those in upper management — is equally important. Think of the professional sport programs that fire the head coach before the players!

Each day, the goal is to improve upon the operator's success whether you are in maintenance, process engineering, quality, or management. The game to be won is not a short-term goal in just KPIs reviewed quarterly, but rather the lifetime of the company. The culture of success requires continual maintenance before, during, and after the heat-treat shift. Continual effort must always be made to improve the operator's ability to successfully heat treat.

ABOUT THE AUTHOR

Tony Tenaglier is the heat treat process engineer at Hitchiner Manufacturing. He earned both a B.S. in material science engineering and an M.A. in psychology. You can contact Tenaglier at tony_tenaglier@hitchiner.com.

OPTIMIZING PROCESS OPERATIONS

A combustion chamber section with a dedicated recirculation fan, gas train, and integrated electrical controls for quick response time to ensure target temperatures and uniformity. (Courtesy: Epcon Industrial Systems)

From metal preparation, coating application, and curing, to emissions compliance and safety measures, a custom-engineered controls system is an essential feature for any metal coil coating line.

By TASHA JAMALUDDIN

An integrated control system is the most effective way to enhance any complex industrial manufacturing process. A well-designed control system not only ensures greater safety and hazard prevention, but it also allows for precise monitoring for strict operating parameters. While recommended for all industrial process equipment, for some applications, such as metal coil coating, a sophisticated controls system is a critical element for successful production. Process speeds, temperature ranges, airflows, and pressure, as well as air pollution control mechanism, all need to be closely monitored and adjusted for the progressive stages of production.

In the modern manufacturing industry, coil coating represents an essential step in metal production, ensuring a long-life span of the metal parts. Before applying coating material onto the rolled metal strips, cleaning and chemical pretreatment are undertaken to prepare the coating session of metal, where the metals are dipped into a liquid chemical solution. After the coating applications, curing represents the crucial part of the process, where the coatings form physical and chemical bonds with the metal, resulting in a solid uniform layer that prevents corrosion.

CURING PROCESS

The curing process of organic coatings commonly takes place in two conveyor ovens: a prime and finish oven. The metal parts are typically transferred via a conveyor belt through the oven, where the precise temperature and pressure conditions take place. The passage of the metal parts through each oven takes between 15 and 60 seconds, depending on the coating type. The oven's operating temperatures are predetermined based on the coating's chemical structure and features. During the curing process, under higher temperatures, chemical reactions produce molecules that evaporate from the coating film. These molecules are highly toxic volatile organic compounds (VOCs) that must be eliminated in accordance with regulatory compliance before the exhaust air emissions enter the atmosphere. The destruction of VOCs, under the influence of extremely high temperatures in a thermal oxidizer, is one of the most efficient techniques for VOC removal and the most widely used air pollution control measure for industrial applications.

There are many challenges to overcome in metal coating production, as the continuous process needs to meet large throughput demands while allowing multiple slow-curing phases. A pre-painted metal manufacturer approached Epcon to replace its 20-plus-year-old coil coating line with a faster and more efficient system that reduced the curing bottleneck in its process. Our engineering team redesigned the system to a multi-zone continuous conveyor oven design with target peak metal temperatures between 475°F and 500°F and variable operating speeds from 60 to 250 FPMs. The overall scope of the final design included a three-zone prime oven, a four-zone finish oven, integrated thermal oxidizer air pollution control and heat recovery system with primary and secondary heat exchanger, complete air handling ductwork, an advanced PLC (programmable logic controller) system with quality and performance monitoring sensors, and a user-friendly HMI interface.

Each component of the system was designed for optimal efficiency and performance for its individual tasks as well as its role in the overall system. The advanced PLC controls monitor operating parameters, such as temperatures and pressures, throughout the system to achieve targeted zone control set-points and monitor peak metal temperatures to guarantee the process is meeting performance goals. Pre-programmed set-points are saved as for each material type and size to simplify system operation. The control system, from concept through panel build, programming, and custom HMI screen development, is completed in-house at Epcon's UL Certified shop, so we are able to quickly make adjustments for optimal performance.

CONTINUOUS PROCESS CONDITIONS

In order to enable continuous process conditions with appropriate line speed, the conveyor ovens needed to exceed 60 feet in length. Besides high-energy demands, the issue with excessive oven length presents difficulties in maintaining a uniform temperature, in this case ±3°F, across all sections with a single heating source.

Another challenge is that the curing oven temperature requirements are low in comparison to the high temperatures required for the air pollution control equipment, creating a tremendous temperature gap between the oven exhaust air and the thermal oxidizer's target temperature of 1,500°F. Continuously raising the process flow from the oven exhaust by more than 1,000°F for the VOC combustion chamber requires an exorbitant amount of operating fuel.

To address the issues of temperature uniformity and high-energy usage across the long curing lines, Epcon's engineers designed an integrated unit with the custom coil coating ovens and exhaust gas treatment, essentially combining the thermal process and air pollution control equipment into a single system, interconnected by heat exchangers and multivariable process controls.

REMOVING VOLATILE ORGANIC COMPOUNDS

The conveyor ovens feature internally mounted exhaust plenums connected to a single thermal oxidizer. After leaving the oven, the exhaust air, laden with VOCs, first enters the primary heat exchanger, where it absorbs the heat from the "clean" oxidized air, exiting the thermal oxidizer. The proprietary large diameter tube and shell heat exchangers is a key feature of the Epcon's Recuperative Thermal Oxidizer integrated into the system. With specially designed baffles that enable turbulent fluid flow and enhance the heat transfer coefficient, raising the air temperature to 950°F-1,000°F. Thanks to

An on-site factory acceptance test to calibrate and fine tune the pre-programmed operating parameters and control settings. (Courtesy: Epcon Industrial Systems)

the primary heat exchanger, the temperature difference between the combustion chamber inlet and the target temperature is narrowed, causing a significant reduction in operating costs. Any additional heat required is provided by natural gas burners to reach the target temperature in the combustion chamber.

After passage through the primary heat exchanger, the treated "clean" air passes through a secondary heat exchanger, where it warms the coater room exhaust air. Once the ambient coater room exhaust air is preheated to an approximate temperature of 650°F-680°F, it is supplied back to each oven via ducts connected to plenums in each section. These plenums extend throughout the length of the oven, allowing for precise tuning of the oven balance, ensuring a uniform and consistent coating cure.

The ovens are divided into sections separated by automatic doors. The closing and opening of the automated doors enable metal parts to pass between sections with minimal air mixing and heat transfer. Each section of the oven is equipped with a burner and recirculation fans with airflow as a critical design feature as it can influence heat and mass transfer between sections. The unique air handling configuration found in Epcon's patented designs provides higher velocity strip impingement, resulting in increased coefficient of heat transfer allowing the oven to be operated at lower zone temperature set points while still achieving targeted peak metal temperature. Lower zone temperatures translate to reduced energy costs as well as longer life expectancy of the system due to reduced thermal loads. Equally as important, this improved zone efficiency facilitates increased strip speeds, proven to be as much as 20 percent higher within a given oven size, allowing the new line to exceed the customer's goal of increased throughput in the production space available. Therefore, the oven uniformity and performance standards are met while significantly increasing processing speeds and saving on operating fuel as well.

MAIN DESIGN PARAMETERS

The peak metal temperature and lower explosion limit (LEL) are the oven's main design parameters and critical variables that must be monitored. The LEL represents the minimum concentration of the volatile organic compounds that will ignite at specific process temperatures. Although VOC oxidization takes place in the thermal oxidizer's combustion chamber, they are initially generating in the oven, so VOC levels must be monitored and controlled from the origination point until final oxidation. The LEL sensor detects the VOCs' concentration, and the actuators adjust the openings of various dampers. The exhaust air dampers are programmed in coordination with the hot inlet air dampers, enabling continuous air flow and maintaining a constant pressure within the system. As the LEL and the temperature setpoint values must be achieved and controlled throughout the entire system, strategically placed and highly sensitive thermocouples constantly monitor the systems temperature from the oven, heat exchangers, and oxidizer. Based on transmitted values, control valves automatically regulate the flow

A continuous metal coil coating oven assembly in final production prior to testing and shipping. (Courtesy: Epcon Industrial Systems)

A custom electrical control panel with user friendly plc, computer connection, and emergency shut off for operating ease. (Courtesy: Epcon Industrial Systems)

of the air and natural gas, with a 20:1 turndown ratio, enabling quick responses when the difference between the setpoint and actual operating temperatures is out of range. The predefined excess air ratio is also maintained at all times to enable complete natural gas combustion, despite fluctuations in the total process volume.

Each burner is equipped with a burner management system. This microprocessor-based system, with built-in purge and pilot timers, is responsible for controlling all combustion-related aspects of the system. The proportion, integral, and derivative gain are precisely determined, so the system's steady state is achieved in the shortest period with the natural gas combustion, adjusted to meet the setpoint's temperature range with minimal fuel usage.

Additional features are also integrated into the system controls to efficiently ensure temperature uniformity. For example, custom designed nozzles induce the atomization of air, with specifically engineered ranges to optimize distribution, enabling uniform heat transfer. In addition, recirculation fan locations are determined for optimal heat transfer from the upper section where the burners are mounted to a lower section where the product passes. Each of these elements is independently controlled and adjusted automatically to ensure precise operating parameters are constantly maintained.

REGULATING AIR POLLUTION EQUIPMENT

As an integrated system, the controls also need to simultaneously monitor and regulate the air pollution equipment. The thermal oxidizer's essential duty is to reach a setpoint temperature above 1,400°F and to ensure optimal residence time sufficient for complete VOC combustion. The residence time in the combustion chamber is a critical feature within the operating controls. The exhaust air volume flow is regulated by damper openings and fan, adjusted by a variable frequency driver, to keep the residence time in the oxidizer constantly above 1 second. As the exhaust air coming from the oven is preheated in the primary heat exchanger, increasing its temperature to 950°F-1,000°F. The remaining heat demand is supplied by a burner strategically placed from the exhaust airflow to ensure uniform temperature distribution in the oxidizer's chambers. The natural gas supply and combustion is regulated by a negative feedback control loop, similar to the one used in the oven controls.

Another key factor in performance is in the dimensions and sizing of the thermal oxidizer to accommodate the process flow volumes. Since the exhaust air comes simultaneously from both primary and secondary heat exchangers, the thermal oxidizers' dimensions must be large enough to meet process requirements. The oxidizer's cross-section area dimensions are designed to fulfill the air's turbulent flow, which contributes to uniform temperature distribution throughout the combustion chamber, while maintaining the minimum residence time. Additionally, the strategic burner design in relation to airflow dynamics enables highly efficient heat transfer, resulting in complete VOCs oxidation even in layers located far from the burner.

AIR MANAGEMENT STRATEGY

Properly managing the air flow throughout the process affects compliance as well as both cure and energy-consumption performance. Employing a cascading air management strategy, drawing air from the coater rooms through the oven and oxidizer systems, minimizes

The installation of a recuperative thermal oxidizer with an internal shell and tube heat exchanger for air pollution control and thermal recycling. (Courtesy: Epcon Industrial Systems)

fresh air make-up reducing overall system energy consumption.

As with any industrial manufacturing process, operating safety and hazard prevention are the ultimate concern. Many organic coatings, such as epoxies and polyurethanes, are highly flammable substances that may cause an explosion even under mild temperatures. The VOCs' local combustion is an exothermal process that causes further temperature rise, chain reactions, and rapid solvent evaporation where more VOCs are produced, potentially causing an explosion. Therefore, the PLC (programmable logic controller) is programmed to shut off the whole system if the oven temperature reaches the upper-temperature limit.

Additionally, the pressure in natural gas pipes is constantly monitored and controlled. A higher gas pressure leads to the excessive instantaneous flow of natural gas and uncontrolled combustion that may cause higher local temperature; while low gas pressure occurrence may result in incomplete combustion, and formation of an extremely flammable byproduct, carbon monoxide (CO). Therefore, both the upper and lower pressure boundary values are defined and closely monitored, triggering a total system shut down to prevent flashbacks and explosions.

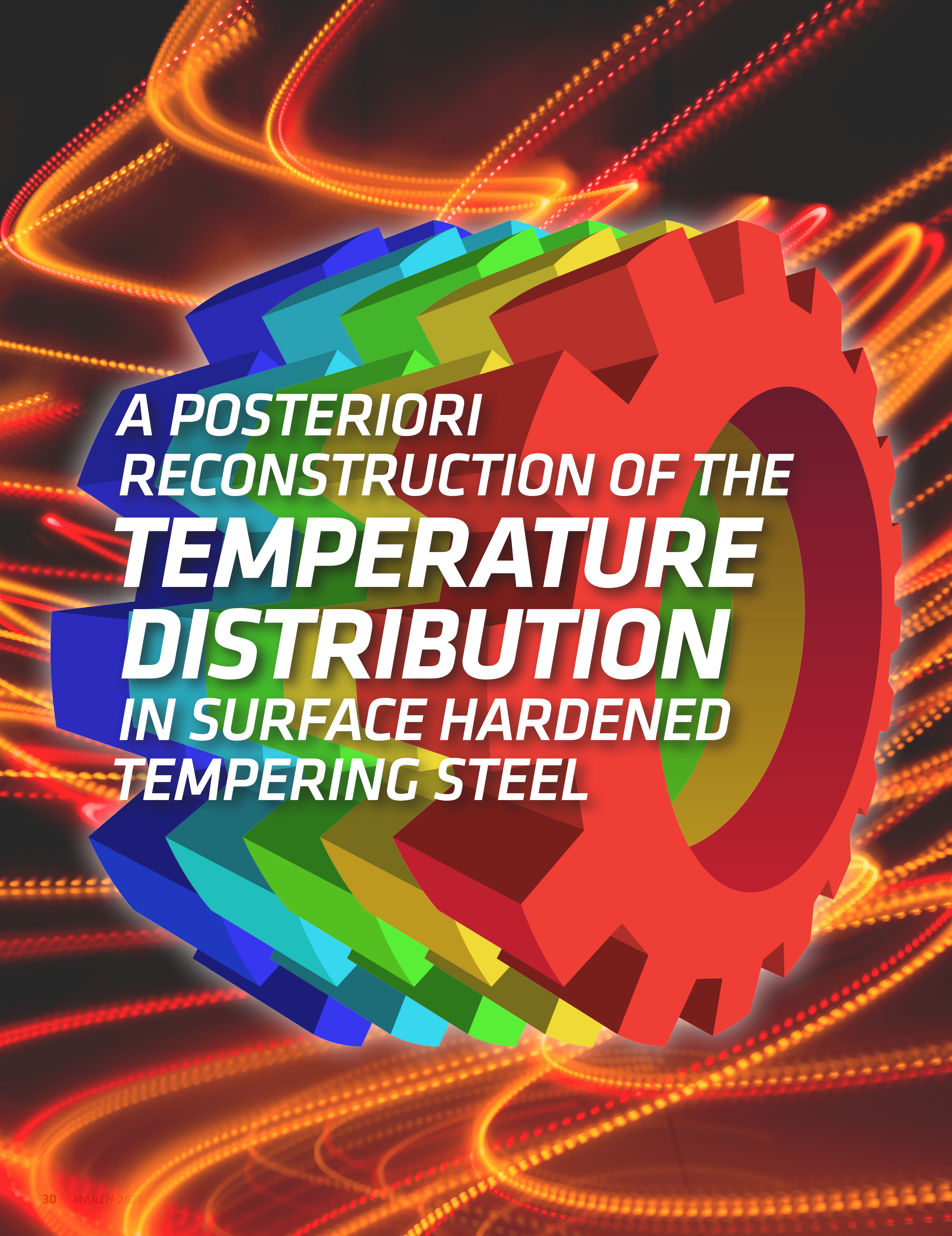
CUSTOM-ENGINEERED CONTROLS SYSTEM

From metal preparation, coating application, and curing, to emissions compliance and safety measures, a custom-engineered controls system is an essential feature for any metal coil coating line. This "oven/oxidizer combination" design is based on Epcon's patented systems proven across multiple installations at coil coating facilities around the globe. The thermal recycling and custom engineered systems that manage the airflow throughout the process translate to reduced energy costs, while enhancing emission compliance and performance. Before shipment of the equipment to customers, Epcon's team conducts a full controls test, adjusting specialized tuning based on required setpoint temperatures and a particular range of process variables and inlet values. In addition, once installed, our in-field commissioning teams work with the system in operation to ensure all targets are precisely met. Together, the design of the air management system, PLC, remote sensors, and custom programming results in an integrated solution that delivers easy-to-manage and integrated system controls. Every thermal process application across industries has unique challenges and specific operating parameters. The best way to ensure the successful and safe operations of thermal processing equipment is to invest in a quality controls system.

ABOUT THE AUTHOR

Tasha Jamaluddin is managing director of Epcon Industrial Systems. Jamaluddin is a graduate of Harvard Business School and holds a Master's Degree from New York University. As managing director of Epcon Industrial Systems since 2013, Jamaluddin oversees internal operations and represents the company at industry associations and events. She is currently serving as a Board Member of the HBS Club and is a longstanding member of the Environmental Technology Trade Advisory Committee (ETTAC) to the U.S. Department of Commerce. For more information: 936-273-3300 or www.epconlp.com.


YOU'VE GOT THE PRODUCTS.
YOU'VE GOT THE SERVICES.
NOW, LET US SHARE YOUR STORY.
Thermal Processing wants to make sure the best possible audience knows your company. Through our print, online, and social media presence, our experienced staff can get your message to an industry that wants to know what you can do.
Thermal processing
To learn more, contact national sales director Dave Gomez at dave@thermalprocessing.com or call 800.366.2185 ext. 207



A POSTERIORI RECONSTRUCTION OF THE TEMPERATURE DISTRIBUTION IN SURFACE HARDENED TEMPERING STEEL

Under certain conditions, the temperature history at given points on or slightly below the surface of a surface-hardened part can be reconstructed based on microstructural features found by a post-mortem microscopy study.

By DANIEL G. MEVEC, PETER RANINGER, PETRI PREVEDEL, and VINCE JÁSZFI

Process control in surface hardening depends greatly on the repeatability of the results. Induction heating facilities stand out in this aspect but challenges arise when it comes to the verification of the expected temperatures. In-situ temperature measurement of a workpiece may be made impossible due to it moving through an enclosed, automated induction facility that lacks built-in sensors. This paper uses transition patterns in the microstructure of the hardened region to reconstruct isothermal contour lines of the temperature field during austenitization. It does so based on a continuous cooling transformation phase diagram and a time-temperature-austenitization diagram of the considered steel. The presented method serves as a practical approach to validate simulations of the inductive austenitizing process and supports simulations of the heat treatment of the work piece. Once these simulations have been iterated upon and validated thoroughly, they may then yield a reconstruction of the entire temperature field during the heat treatment process.

C	Mn	Si	P
0.36% to 0.40%	1.30% to 1.45%	0.50% to 0.65%	≤0.025%
S	**Cr**	**N**	**Cu**
0.050% to 0.065	0.10% to 0.20%	0.013% to 0.017%	0.25%
Mo	**Al**	**Ni**	**V**
≤0.050%	0.010% to 0.030%	≤0.15%	0.08% to 0.12%

Table 1: Chemical composition as specified by the bearing manufacturer; all data points are given in weight percent.

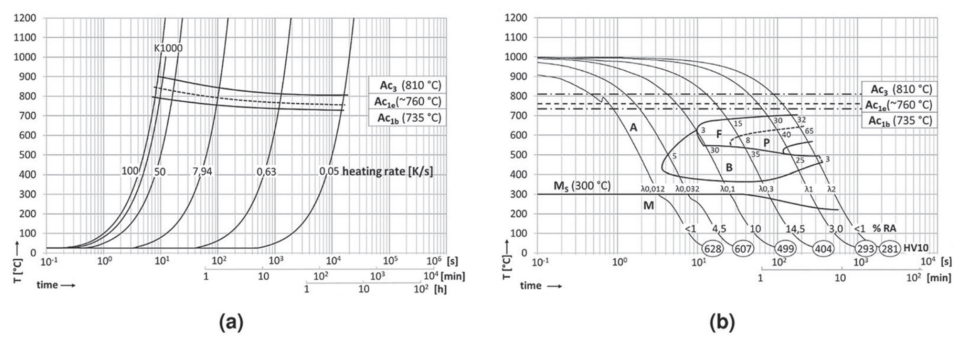


Figure 1: The phase transformation behavior of the sample steel. (a) Displays the time-temperature-austenitization diagram. Note the shifted transformation temperatures Ac_1 and Ac_3 at high heating rates, as well as the split of Ac_1 into a beginning and an end temperature (Ac_{1b} and Ac_{1e}). The heating rate associated with the inductive surface hardening process is marked as K1000 and has a value of 81.67 Ks^{-1}. (b) Shows the continuous-cooling-transformation diagram evaluated for an austenitization temperature of 1,000°C with 10s hold time. A – Austenite, F – Ferrite, P – Pearlite, B – Bainite, M – Martensite, MS – Martensite start, RA –retained austenite, HV10 – Vickers hardness HV10, λ – time in seconds from 800°C to 500°C divided by 100, 3; 5; 8; … – percentages of final microstructure.

Induction heating techniques have proven a boon to surface hardening, based on their short process times, precise energy input, and resulting low energy usage [1]. The repeatability inherent in electronically controlled induction circuits further lends itself to a high degree of automation within a production chain. Process design for induction hardening, however, is non-trivial as the short heating times allow for little diffusion, giving the microstructure of the base material some influence on the properties of the hardened surface [2]. More difficulties are encountered when defining a new geometry or introducing a workpiece with varying electromagnetic (EM) properties.

In the past, extensive trial and error used up valuable machine time to find new process parameters. Nowadays, simulation techniques such as the Finite Element Method (FEM) take on much of the burden by predicting the distribution of heat generation during the heat treatment and inform design decisions before the first test run is scheduled [3-5]. In general, several simplifications and assumptions are always made when simulating a problem (not least of which are estimates of unknowns, such as surface emissivity or heat-transfer coefficients), and any simulation needs to be verified in order to produce meaningful data [6,7].

The most direct way to verify process simulations is to compare the resulting temperature field with data obtained from experiments [7-9]. Temperature data in particular is relatively easy to obtain [10] — as opposed to the magnetic field distribution within steel parts — and is not contingent on further material models, as the phase or stress distributions are. The concrete difficulty of obtaining the temperature data for a given process can vary wildly from one facility to another. Many modern industrial heat-treatment facilities are sealed off from any outside interference, simultaneously increasing the controllability of the process and decreasing the risk of injury due to interaction with moving, conducting, and/or hot parts [11]. These safety and control features come at the expense of accessibility, hindering measurements if no instrumentation has been included during the construction of the facility or the design of the process control software.

Ideally, the heat-treatment process is monitored, so that temperature at a certain heating stage or the time dependent temperature of each workpiece is logged, stored, and transferable for quality control and simulations. Often, however, this is not the case. On top of that, if the heat-treatment process also involves moving workpieces or induction coils, they may obscure line of sight for ad-hoc pyrometer measurements and make instrumentation of samples impossible.

The method described in this article deals with such a case, where there was virtually no temperature data available. This was due to the induction facility being highly automated (and therefore enclosed), but not instrumented. While material data could be gained from treated and untreated workpieces, there was no information available on the heat-treatment curve the bearing underwent during the process, and recording one was infeasible.

The only data point was an estimate of 1,050°C, obtained through glimpsing into the induction oven from the intake conveyor and seeing a bright yellow shine through the rotating heating assembly. Needless to say, that one temperature value of such questionable origin could hardly be used to verify the rather complex multiphysics simulation that would have to be implemented further in the future.

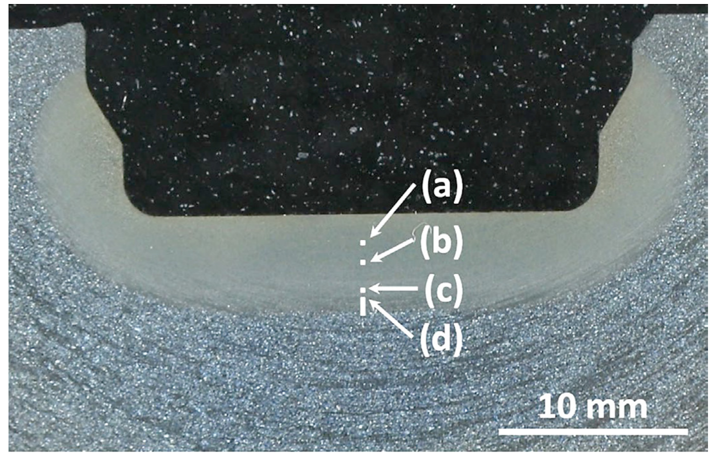


Figure 2: Overview image of the examined microstructure. The marked areas denote the positions at which the micrographs of Figure 3 were taken. All of the images from Figure 4 are located at position (d).

While there was no way of measuring the temperature in-situ, the temperature history of the hardened workpiece still left its traces in its microstructure. This paper aims at describing a method of combining metallurgical data from phase diagrams usually available to the heat-treatment facility with a micrograph analysis of a surface hardened sample in order to deduce several depths of different transition temperatures within the material. Consequently, a general numerical temperature distribution fitted to these temperature-depth pairs can be used to verify the estimated surface temperature.

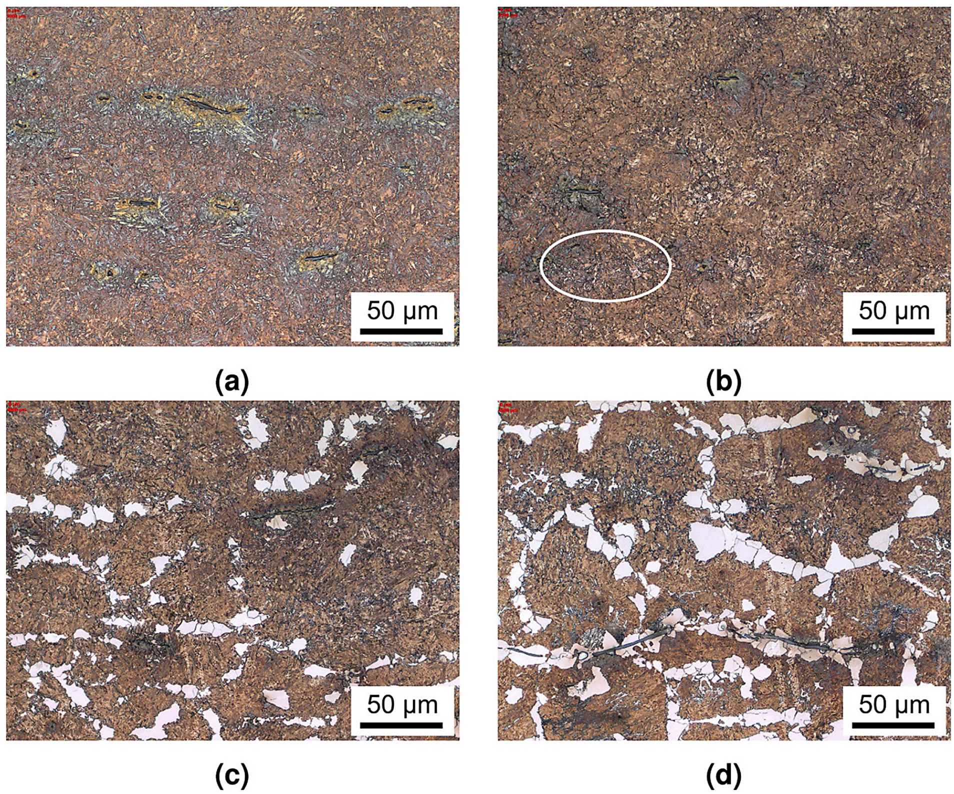


Figure 3: Micrographs of the hardened zone. (a) Taken at 1,000 μm depth: pure martensite with some manganese sulphides. (b) Taken at 2,500 μm shows the first occurrence of ferrite (circled) indicating that the material does not entirely reach Ac_3 any more due to local differences in chemistry (segregations). In (c) at a depth of 4,000μm, the original ferritic areas only partly transformed into the austenitic phase, remaining in their original structure of the base metal. In (d), the first traces of pearlite are found at 4,400μm, where some of the microstructure did not transform into austenite, indicating that the end temperature for Ac_1 transformation was not reached at this depth.

EXPERIMENTAL CHARACTERIZATION

Phase diagram

The steel in this study was a modified C38 tempering steel forged into shape and subsequently inductively surface hardened. Its chemical composition is specified by the manufacturer to be according to the ranges listed in Table 1. Its base microstructure was pearlitic-ferritic with a grain size of approximately 30 μm and contained randomly distributed MnS inclusions. These did not affect the hardening process and are irrelevant to the following investigation. The hardening was performed to heat treat a minimum depth of 3mm from the surface. Samples for dilatometry were cut from untreated zones of the component shafts, measuring 10mm in length and 4mm in diameter and tested using a Bähr DIL805A quenching dilatometer. The phase transformation temperatures were determined at a heating rate (HR) of 3 $Kmin^{-1}$, noting a distinct split of Ac_1 into a starting temperature Ac_{1b} and an end temperature Ac_{1e}. All of these temperatures increase with heating rate, so that the heat treatment in practice, with a heating rate of 81.67 Ks^{-1}, experiences Ac_{1b} at 790°C, Ac_{1e} at 840°C and Ac_3 at 895°C. Differing cooling rates were examined at this heating rate up to an austenitization temperature of 1,000°C, with 10 seconds of holding time to allow for appropriate austenitization of the samples. The material exhibits a distinct bainite nose between λ0.02 and λ0.1. Figure 1 shows the time-temperature-austenitization (TTA) and continuous-cooling-transformation (CCT) diagrams generated from these experiments.

Micrographs

The heat-treated part consists of a bearing journal surface surrounded by flanges. The shaft was cut through the bearing's axis, and one journal surface was trimmed to fit into the bedding. The sample was ground and polished with a 1 μm diamond suspension as the finishing step, and subsequently etched using a 3% nitric acid

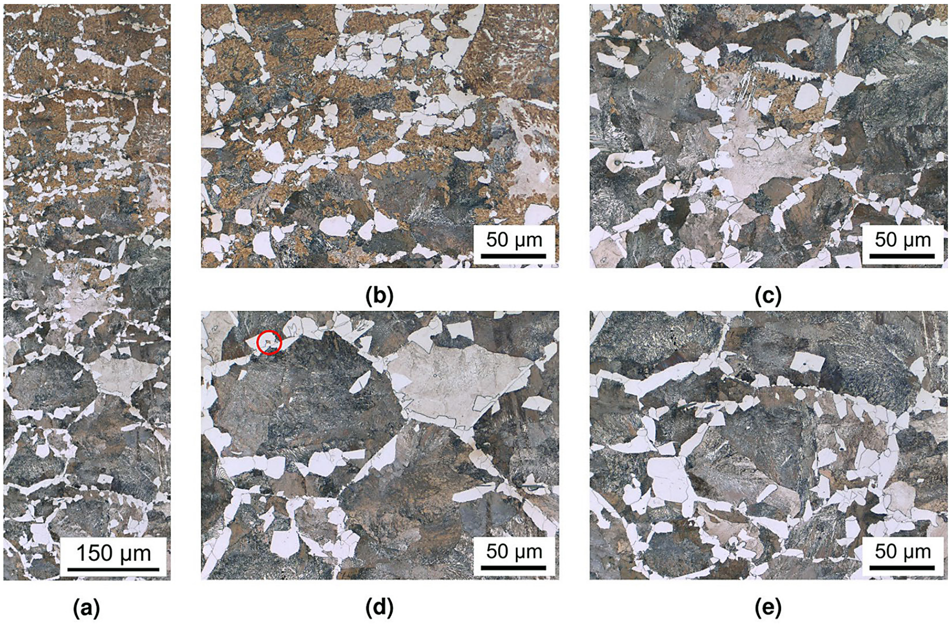


Figure 4: Micrographs of the transition zone: (a) shows the entire composite image detailing the changing microstructure in a depth of 4,400μm to 5,300μm from the surface. The first 200μm are presented in Figure 3d, with a noticeable overlap of ~20μm with (b), at 4,700μm depth, where untransformed pearlite becomes more pronounced. The amount of martensite is considerably decreasing toward (c) with its last traces circled in (d), at 5,000μm depth; the vast majority of the microstructure being the original ferritic-pearlitic structure signifies that Ac1b was barely reached. At 5,200μm, shown in (e), the microstructure consists entirely of pearlite and ferrite, being consistent with the unaustenitised base metal.

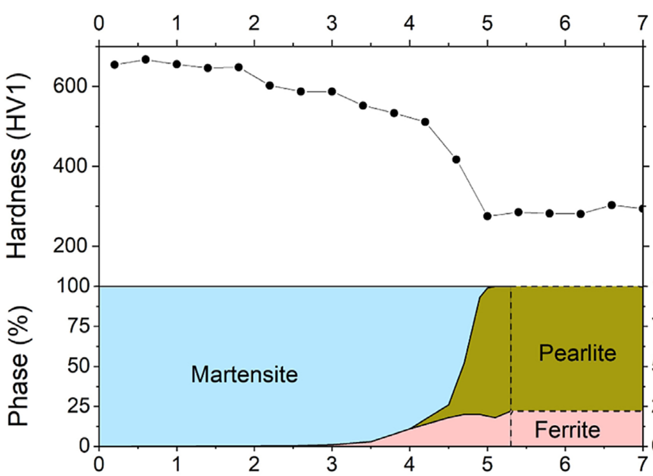


Figure 5: Hardness distribution at the bearing journal centerline showing a plateau of 650 HV1 down to a depth of 2mm followed by an approximately linear decline to 520 HV1 at 4.2 mm, and a steep drop to a stable hardness of 280 HV1 from 5mm downward, indicating the original microstructure of the base material. The accompanying phase fractions are shown underneath the hardness, with the microstructure beyond 5.3mm assumed to be of constant composition.

solution, with the prepared sample shown in Figure 2 as an overview.

This and all following micrographs were taken by using a Zeiss Axio Imager M2m optical light microscope with an AxioCam MRc5 installed. The diameter of the bearing is 50mm while the hardened zone of the material extends to about 5 mm depth at the journal centerline. The surface is austenitized within 12 s and quenched to room temperature within another 10 s, roughly following the λ0.012 line in Figure 1a. The expected microstructure within the hardened zone is therefore purely martensitic. Figure 2 describes the positions of the following micrographs, with Figure 2a through 2c and the upper part of 2d being represented in Figure 3, and the entirety of 2d shown in Figure 4.

Hardness gradient

A line of Vickers hardness measurements was taken along the same centerline as the micrographs, using a Qness Q10A+ Vickers hardness tester. A measuring load of 1 kgf (HV1) was set to allow for close placement of indentations. Figure 5 shows the hardness as a function of depth projected over a phase fraction analysis that was performed on the micrographs shown in Figures 3 and 4. The hardness gradient is an amalgamation of not only the phase transition, but other influences such as grain size and phase structure. While discerning the exact influences of each effect would go beyond the scope of this report, the hardness is representative of the continuously varying microstructure in the hardened zone. This variation is due to the transformation from ferrite-pearlite to austenite (and later, during quenching, to martensite) by the heat input of the temperature field during the performed inductive surface hardening. Thus, the plateau at the end of the hardness gradient corroborates the depth of the Ac1b temperature determined through micrograph analysis.

RECONSTRUCTION OF THE TEMPERATURE FIELD

The silhouette of the thermal gradient that the material experienced during heat treatment can be guessed from the overview in Figure 2. However, the detailed analysis in Figures 3 and 4 reveals the transition zones at which the material crossed the transition temperatures depending on the fast austenitizing and short holding time depicted in Figure 1a. The transformation temperatures Ac_3, Ac_{1e} and Ac_{1b} are determined at the depths of 2,500 μm, 4,400 μm and 5,000 μm, respectively. The performed hardness measurement corroborates these depths fairly well with average hardness of 650HV1 at the surface coinciding with the predicted 628HV10 of the quenched martensite described in Figure 1b until a depth of about 2,000 μm. While they were attained with a differing load on the Vickers indenter, the resulting hardness values can be assumed to be comparable, as the indentation size effect only starts taking effect at the micro scale (100 gf indentation load) [12]. The subsequent hardness drop can be attributed to the incomplete dissolution of ferrite, which has not completely transformed into the austenitic phase during the heating process, as seen in Figures 3b-d and 5. An even steeper drop toward the base hardness begins below 4,200 μm and corresponds to further increasing amounts of ferrite and the beginning appearance of pearlite (see Figures 4b,c and 5), indicating the temperature during austenitization only slightly exceeding Ac_{1b} and thus starting the pearlite to austenite transformation but not completing it.

The precise depths can be incorporated into the overview image to show an approximation of the transformation zones present during the heat treatment, as depicted in Figure 6.

The temperature at the surface may still be of interest, since it is the control parameter of choice in most automated induction facilities. Analytical solutions describing the temperature distribution of induction heated cylindrical parts exist [13] but ignore the cooling of the surface.

A simplified, axisymmetric cylindrical model of the bearing was calculated by FEM simulation with load parameters approximating those of the industrial heat treatment, with detailed parameters given in Table 2 and Figure 7. The model uses fixed time increments of 250 ms to leapfrog between a linear harmonic solution to the electromagnetic problem and a heat transfer solution that uses heat sources obtained from the previous EM calculation, which provides the temperature distribution for the next EM step. This interaction is regulated by a python script controlling the ABAQUS software used to calculate the results.

The 5° slice of rod had a radius of r^{rod} = 5 mm and length of l^{rod} = 150 mm. A complex claw-shaped inductor of proprietary geometry encompassed ≈150° of the bearing, which rotated constantly at a distance of 0.5 mm during the hardening process.

Since the simplified model was only an axisymmetric slice of the whole circumference, the inductor was represented as a coil of rectangular cross section (w^{coil} = 6 mm wide by h^{coil} = 5 mm tall) with two turns d^{coil} = 5.4 mm apart, distanced 0.5 mm from the bearing surface. The model air space had a radius of r^{air} = 250 mm. Homogeneous Dirichlet boundary conditions were defined at all surfaces; these confined the magnetic field to the simulated geometry by acting as magnetic insulation. This was well suited since the field was assumed to be axisymmetric and to not extend past the dimensions of the defined cylinder of air. The mesh within the rod was generated from hexagons with a set width of e_0^{rod} = 2.5 mm. The skin depth was 349 μm and divided into 15 elements geometrically scaled from e_0^{skin} = 2 μm at the surface to e_1^{skin} = 83 μm. The air mesh was generated procedurally to scale from 1.5mm at the coil surface to e_∞^{air} = 15mm at the model boundary, while the coils were modeled one element thick with a wall thickness of 1mm. The load was a sine wave current with an amplitude of I = 1,850 A and a frequency of f = 10.5 kHz. This amperage was based on a measurement on the induction coil but increased slightly to result in a solution close to the assumed maximum surface temperature of 1,050°C. The heat-transfer model used only the mesh of the rod and applied a convective film boundary condition of h_{air} = 20 $Wm^{-2}K$ and ambient radiation condition assuming the surface emissivity to be ε = 0.7. The initial temperature distribution was set to be a uniform room temperature 25°C, and the rod was heated for t_{heat} = 12 s.

The resulting distribution shows the temperature envelope, i.e. the maximum reached throughout the process, along the path shown in Figure 7b. While the surface temperature was dialed in to the assumed 1,050°C, its envelope was found to be too high for the observed internal transformation depths. Assuming a linear scaling of the entire distribution, it was fitted to the measured depth of phase transitions and their associated temperatures, minimizing the sum of squared residuals. This resulted in an estimated surface temperature of 985°C (see Figure 8).

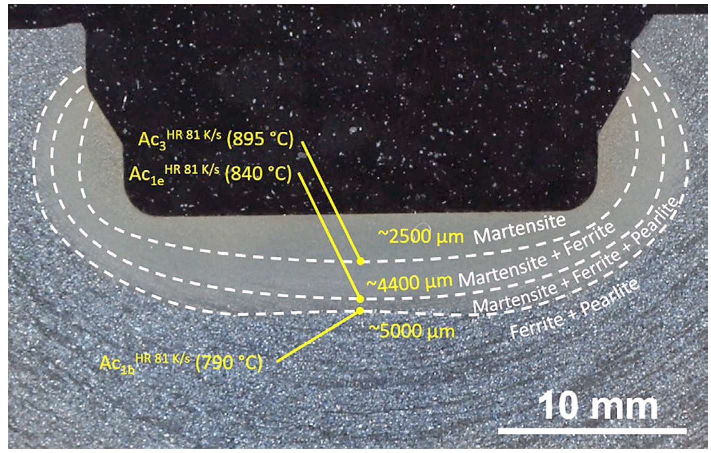


Figure 6: Hardened bearing surface with the three established transition depths at the bearing center, along with estimated lines of phase transitions and regions of differing microstructures.

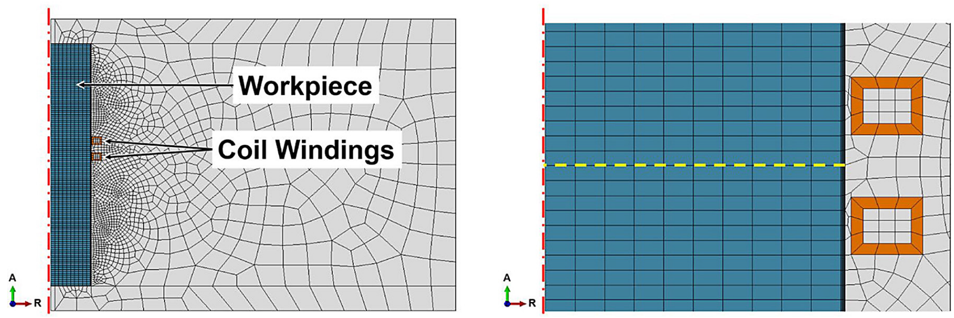


Figure 7: The mesh of the FEM simulation, with the rotational symmetry axis indicated by the red dash-dotted line on the left. The length of the rod above and below the induction coils was chosen to match the mass of the flanges to the sides of the bearing journal, so that it approximates the heat sink of the surrounding material. The yellow dashed line in (b) shows the path of the temperature analysis.

r^{rod}	t^{skin}	ri^{coil}	w^{coil}	h^{coil}	d^{coil}	r^{air}
25 mm	349 μm	25.5 mm	6 mm	5 mm	5.4 mm	250 mm
e_0^{rod}	e_0^{skin}	e_1^{skin}	e_∞^{air}	f	I	t_{heat}
2.5 mm	2 μm	83 μm	15 mm	10.5 kHz	1850 A	12 s

Table 2: Simulation parameters for verification.

DISCUSSION

As stated in the introduction, the presented method represents an approach for obtaining temperature data of a surface hardening heat-treatment process where there is no in-situ measurement possible or available. The thorough investigation of the microstructure in the surface-hardened region supplies rather precise ranges of the transition from one microstructural region to another. It is important to note the transitions are not sharp but rather transitional areas due to local differences in chemistry because of production related segregations and possible variations in the temperature distribution imposed by the inductive heat generation. However, the evaluated transition depths in combination with a TTA-recording for the process conditions supply the transition temperatures for the considered heat treatment quite precisely on a macro scale.

The actual transition temperatures in the bearing journal may be somewhat higher, since the TTA-information is drawn from tiny samples with a diameter of 4mm that experience homogeneous heating in the dilatometer compared to the 50mm diameter of the bearing, where a certain degree of overheating is necessary since its core acts as a heat sink during the heating process.

While the transition lines shown in Figure 6 are based entirely on the evaluation of the microstructure of the central line of the bearing and a qualitative assessment of the overview image, it is of course possible, though work intensive, to generate an arbitrarily

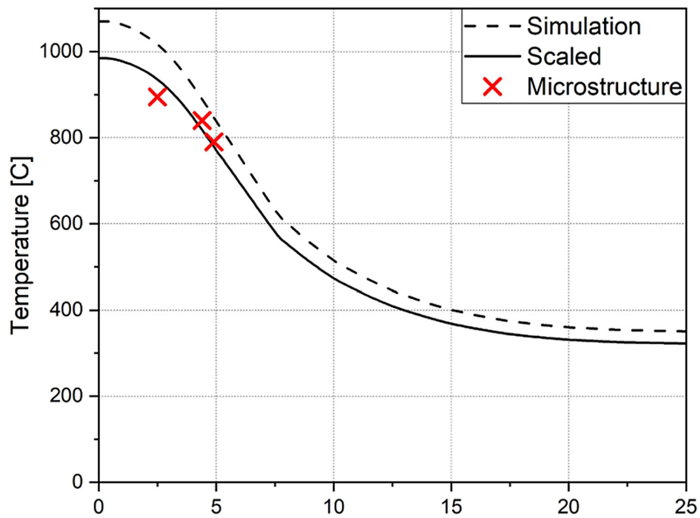


Figure 8: Maximum temperatures reached at each depth as calculated by FEM simulation. The dashed line shows the original calculation reaching a surface temperature of 1,071°C, whereas the solid line has been scaled to minimize the squared differences to the determined transition points in the microstructure. Here the surface temperature reaches 985°C.

fine grid on the etched area, detailing the exact shape of the zones. For verifying a simulation of the heat-treatment process, however, a handful of temperatures at different known points is usually sufficient.

The FEM simulation used to extrapolate the surface temperature serves as an example for the verification process: It is a preliminary study using a simplified geometry with estimated process parameters and a linear electromagnetic material model. While the surface temperature fitted in Figure 8 is close to the expected 1,050°C, the simulation is still in need of calibration and with depth, temperature drops faster than expected. The phase transition regions determined in the microstructure indicate a slower drop of the temperature, which the electromagnetic model needs to be adjusted to account for.

Further steps in the modeling procedure now include updating the model geometry, parameters, and material model to closer match the physical bearing and result in a better fit with the temperature distribution observed in Figure 6.

CONCLUSIONS

The following conclusions can be drawn from this work:

» The temperature history at given points on or slightly below the surface of a surface-hardened part can be reconstructed based on microstructural features found by a post-mortem microscopy study provided that a time-temperature austenitization diagram of the material, which has been recorded for process relevant cooling rates, is available.

» FEM simulations of the thermal problem can be validated by comparing the calculated temperature field with those reconstructed temperatures. Unknown simulation parameters such as surface-to-air heat transfer coefficients can inversely be determined by an iterative approach.

REFERENCES

[1] Rudnev, V., Loveless, D., Cook, R. & Black, M. Handbook of induction heating, 1st edn (CRC Press, New York, NY, USA, 2017).

[2] Eggbauer, A. et al. In situ analysis of the effect of high heating rates and initial microstructure on the formation and homogeneity of austenite. Journal of materials science 54, 9197–9212 (2019).

[3] Boadi, A., Tsuchida, Y., Todaka, T. & Enokizono, M. Designing of suitable construction of high-frequency induction heating coil by using finite-element method. IEEE Transactions on Magnetics 41, 4048–4050 (2005).

[4] Sun, J., Li, S., Qiu, C. & Peng, Y. Numerical and experimental investigation of induction heating process of heavy cylinder. Applied Thermal Engineering 134, 341–352 (2018).

[5] Istardi, D. & Triwinarko, A. Induction heating process design using comsol multiphysics software. Telkomnika 9, 327–334 (2011).

[6] Mevec, D., Raninger, P., Prevedel, P., Jászfi, V. & Antretter, T. Getting to know your own induction furnace: Basic principles to guarantee meaningful simulations. HTM Journal of Heat Treatment and Materials 74, 267–276 (2019).

[7] Vieweg, A. et al. Experimental and numerical analysis of the inductive tempering of a qt-steel. HTM Journal of Heat Treatment and Materials 72, 199–204 (2017).

[8] Di Luozzo, N., Fontana, M. & Arcondo, B. Modelling of induction heating of carbon steel tubes: Mathematical analysis, numerical simulation and validation. Journal of Alloys and Compounds 536, 564–568 (2012).

[9] Sadeghipour, K., Dopkin, J. & Li, K. A computer aided finite element/experimental analysis of induction heating process of steel. Computers in Industry 28, 195–205 (1996).

[10] Kranjc, M., Zupanic, A., Miklavcic, D. & Jarn, T. Numerical analysis and thermographic investigation of indction heating. International Journal of Heat and Mass Transfer 53, 3585–3591 (2010).

[11] Nacke, B. & Baake, E. (eds.) Induction Heating: Heating | Hardening | Annealing | Brazing | Welding (Vulkan Verlag, 2016).

[12] Broitman, E. Indentation hardness measurements at macro-, micro-, and nanoscale: a critical overview. Tribology Letters 65, 23 (2017).

[13] Carslaw, H. S. & Jaeger, J. C. Conduction of heat in solids, 2nd edn (Oxford: Clarendon Press, 1959).

ACKNOWLEDGEMENTS

This topic originally featured at the ECHT 2019 – European Conference on Heat Treatment – Bardolino (Italy), 5–7 June 2019. The authors gratefully acknowledge the financial support under the scope of the COMET program within the K2 Center "Integrated Computational Material, Process and Product Engineering (IC-MPPE)" (Project No 859480). This program is supported by the Austrian Federal Ministries for Transport, Innovation and Technology (BMVIT) and for Digital and Economic Affairs (BMDW), represented by the Austrian research funding association (FFG), and the federal states of Styria, Upper Austria and Tyrol.

AUTHOR CONTRIBUTIONS

Writing — Original Draft and Presentation: D.G.M.; Writing — Review and Editing: D.G.M., P.R., and P.P.; Conceptualization: D.G.M., P.R., P.P., and V.J.; Investigation: P.P. lead, V.J. supporting; Resources: P.P.; Methodology: D.G.M., P.R., and P.P.; Supervision, Project Administration, and Funding Acquisition: P.R.

COMPETING INTERESTS

The authors declare no competing interests.

ABOUT THE AUTHOR

Daniel G. Mevec, Peter Raninger, Petri Prevedel, and Vince Jászfi are with the Materials Center Leoben Forschung GmbH, Leoben, 8700, Austria.

CASE STUDY

NEW TEMPERATURE CONTROL SYSTEM

DELIVERS PRECISION, EFFICIENCY, AND FLEXIBILITY

With process controls well over 10 years old, Clifford-Jacobs turned to Conrad Kacsik to improve its temperature process control system.

By **CHRISTOPHER S. MILLER**

Clifford-Jacobs is a nearly century-old producer of die forgings. When the company needed to improve its process controls on its heat-treating furnaces, it turned to Conrad Kacsik.

Clifford-Jacobs serves a number of industries, including construction, mining, forestry, aerospace, energy, and rail. With process controls well over 10 years old, the company was eager to improve its temperature process control system, particularly because the incumbent system was producing inconsistent work.

THE CHALLENGE

Clifford-Jacobs was not getting consistent, repeatable results from its furnaces. The company also wanted more efficient and automated processes with data acquisition and electronic operating capability. Bud Kinney, vice president of Innovation and Technology at IMT Corporation, the parent of Clifford-Jacobs, sought out the best firm to solve the problems and take Clifford-Jacobs to the next level.

"We looked at a number of controls companies throughout the Midwest and interviewed them to learn about their experience with system controls and data acquisition," Kinney said. "We knew we wanted an integrated system, so we started looking at companies that did that as a matter of course. Most companies are limited to traditional controls, but Conrad Kacsik has a lot of experience doing the exact type of job we needed."

INCREASING DEMANDS

Clifford-Jacobs makes forged parts for a variety of clients. Although forging does not generally require as much precision as other types of processes, customers are becoming increasingly demanding, according to Kinney.

"We believe that sooner, rather than later, things like Nadcap will come into forging, and our customers are very interested in us being able to demonstrate that our processes are always in control, even forge heating," he said. "This project helps ensure that we meet those needs. We couldn't track things like set-point input values before. That's another element we wanted to manage."

THE SYSTEM

Conrad Kacsik built a full process temperature control system that includes SCADA software from SpecView. It was able to retrofit the system on Clifford-Jacobs' existing 16 furnaces, saving considerable expense and time. The temperature process control system uses Watlow F4T controllers paired with SpecView SCADA software, which allows for programming jobs/recipes, remote operation, secure (password protected) operation of furnaces, and accurate automatic temperature recording. Conrad Kacsik also added alert lights that allow operators to quickly see the status of each furnace from the shop floor.

BENEFITS OF TEMPERATURE CONTROL SYSTEM INTEGRATION

Clifford-Jacobs is already enjoying many benefits from the new temperature control system. These include:

» **Increased accuracy:** The new system runs each recipe exactly, and records the results. The company can also control which employees can adjust temperature settings, preventing operators from rushing jobs with a higher temperature or inadvertently setting the furnace incorrectly.

The Conrad Kacsik Engineering Team responsible for the design and installation of the system. (Courtesy: Conrad Kacsik)

» **Higher efficiency:** With preprogramming, each furnace is always at the exact temperature it needs to be for the given task. An automatic preheat setting also safely prepares the furnace for the workday — eliminating downtime or the need to send an employee in early to start the furnaces.

» **More speed:** Clifford-Jacobs can pre-program any recipe it needs, allowing for highly accurate and fast running of complex processes.

» **More convenience:** Clifford-Jacobs can operate its furnaces from anywhere with an internet connection or via an iPad used by an approved employee.

"We believe that sooner, rather than later, things like Nadcap will come into forging, and our customers are very interested in us being able to demonstrate that our processes are always in control, even forge heating."

The Specview operator control terminal with an ethernet connection to the plant network. (Courtesy: Conrad Kacsik)

» **Precision for the future:** The new system can be part of a Nadcap-approved process should the need arise. The SpecView software and advanced controllers automatically record each job and retain all data for verification.

THE RESULTS

"We used to have to use all kinds of resources to provide oversight on temperature control," Kinney said. "This has given us a heating strategy. We write the recipes we want and just select from those. In addition to that, we know exactly what every furnace is doing at all times."

The company is pleased with the increased efficiency as well. It only heats product when it is ready to run production, and the furnace only uses the exact energy needed for each recipe. The company is also saving on staffing, as it used to have to schedule people to ensure the furnace was at the right temperature.

"With this system, we can develop recipes for each part we make, which is both convenient and precise," Kinney said. "It's doing exactly what we expected it to do."

ABOUT THE AUTHOR

Christopher S. Miller is chief executive officer of Conrad Kacsik Instrument Systems Inc.

The Watlow F4T Temperature and Process Controller with ethernet connectivity. (Courtesy: Conrad Kacsik)

A BRIGHT, HOT FUTURE

Lucifer Furnaces' LI Series. The upper chamber (hardening) is designed with lightweight ceramic fiber insulation for energy saving low power input and maximum heating efficiency for operation to 2,200°F. This furnace shipped to a large automotive corporation. (Courtesy: Lucifer Furnaces)

Lucifer Furnaces has been a leading manufacturer of industrial heat-treating furnaces and ovens for more than 65 years.

By KENNETH CARTER, Thermal Processing editor

If you're in search of a breakdown of what a company does, look no further than Lucifer Furnace's name, because it essentially boils down to three words: Furnaces. Are. Hot.

The words behind the name may sound simple, but the minds behind Lucifer Furnaces take seriously their jobs of building and offering a wide range of furnace models guaranteed to get hot … and stay hot.

"We manufacture a wide range of small- to medium-size furnaces — from front-loading, top loading, bottom load, and continuous furnaces to furnaces that operate with protective atmospheres, high-temperature models, convection ovens, just a real wide range of products," said Larry Jones, president of Lucifer Furnaces. "We have very extensive lines of standard models. But then, of course, we customize to meet specifications that a customer may have. That's been our niche: to offer that real wide range of product lines, and that was the goal early on as the company developed — to be able to offer that wide mix of products, to expand the product line, and to expand our customer base."

VARIED PRODUCT LINE

Lucifer Furnaces' product line of industrial heat-treating furnaces, industrial recirculating ovens, and quench tanks are suitable for a variety of applications including hardening, drawing, annealing, brazing, sintering, and stress relief in both air and atmosphere.

All Lucifer Furnaces are ruggedly constructed using the highest quality materials to deliver superior performance and dependability, according to Jones. Products feature compact design, easy installation, energy-efficient operation, and easy-to-replace heating elements. Most replacement parts are stocked for quick shipment to minimize customer downtime.

A few of Lucifer Furnaces' more popular products include the dual chamber "Space-Saver" furnace combining a hardening chamber above a tempering oven in one complete space-saving unit, and the economical Red Devil Series, which meets the needs of occasional heat treaters wanting to bring their heat treating in-house.

CUSTOMIZATION CAPABILITIES

Even with its extensive product line, the ability to customize is an important tool in Lucifer Furnaces' toolbox, because, more often than not, a job may involve some kind of unique feature a customer may need, according to Jones.

"We have standard model-chamber sizes or temperature ranges, but even then, a customer may need a simple change to a type of control system, heat-up rates, zoning, or door arrangements, for example," he said. "We could have two of the same model sitting next to each other, and yet, each one could be for different customers that would be configured completely differently — anything from the style of the door to the controls on it to maybe a temperature uniformity or a heat-up rate or a cool-down rate requirement. This all comes back to a customer's specifications, their heat-treating requirements, and their process."

That process is part of what keeps the jobs at Lucifer Furnaces interesting, according to Jones.

Lucifer Furnaces' Red Devil Dual Chamber furnace meets the needs of occasional heat treaters. The RD series is a top choice for trade schools. (Courtesy: Lucifer Furnaces)

"That's part of the challenge that we face here, you might say," he said. "But it's also part of the fun. It keeps us hopping and it makes our operation very interesting."

DIVERSE MIX OF COMPANIES

Facing those challenges has kept Lucifer Furnaces dealing with a diverse mix of companies that includes automotive, aerospace, the U.S. government, ceramics, glass, schools, and more, according to Jones. The company's high performing thermal processing equip-

Left: Lucifer Furnaces’ 7000 Series Box Furnace heats to 2,300°F. This furnace was built for a small Stamping company. (Courtesy: Lucifer Furnaces)

Below: Lucifer Furnaces’ Elevator Furnaces are ideal for large loads and production type requirements. (Courtesy: Lucifer Furnaces)

ment has been shipped worldwide to be used in the metalworking, ceramic and glass manufacturing industries by small tool rooms to large corporations, educational institutions, research laboratories, and government agencies.

“We try to reach out and have a broad market, and it’s quite nice,” he said. “We get orders from your largest companies in the world to your small little mom-and-pop shops. We have really tried to focus on a diverse product with a diverse market.”

REPEAT CUSTOMERS

Lucifer Furnaces’ ability to adapt and diversify means that the company’s customers’ keep coming back, according to Jones.

“One of our biggest successes is that we have enjoyed repeated customers, and that comes back to our products,” he said. “We build a product based on very conservative designs, which has led to a quality product and longevity. That says a lot as to why we’ve been in business for so long and enjoy a very solid reputation in the industry.”

OVER SIX DECADES OF SERVICE

Lucifer Furnaces has been in business for more than 65 years and has been a small, family-owned company from the start.

During that time, Lucifer Furnaces has focused on building quality small- to medium-size heat treating furnaces, and ovens.

“Everyone puts in a lot of work to make it happen here,” Jones said. “We are a small company. We’re only 20 to 25 people. Always have been. And it’s been a challenge, but it’s been very rewarding.”

Being a small company has its advantages, according to Jones, especially when getting products to customers.

"I think we're very responsive; we can adapt quickly and make a decision on the spot," he said. "These are not earth-shattering decisions, but we can consider the options and then say: Let's go one way or another. That has been internally a trademark in house where we go: What do we want to do? We can't sit around and debate. We've got to make a decision."

READY FOR CUSTOMER CHALLENGES

And when Lucifer Furnaces is approached with a challenge from one of its customers, Jones said he and his team jump into action to assess the customer's needs.

"We will try to ask a lot of questions, listen to their concerns, and, at the same time, look back at what we have done in the past," he said. "What have we built? Have we had similar applications? And in fact, sometimes we have to decide if this is an application we want to take on. The bottom line is we want to be able to offer a product that's going to meet their requirements and have a happy customer. And this all comes back to having hopefully a repeat customer."

Part of guaranteeing that repeat business rests in Lucifer Furnaces' ability to react, and react quickly, according to Jones.

"I think it helps that we're responsive, and we will try to answer someone, whether it's an inquiry or their application, we will respond quickly and give them an answer — if we know it, we will do it," he said.

BOOMING BUSINESS

And judging from the amount of business Lucifer Furnaces maintains, that is a strategy that seems to be a good one. Jones emphasized that even heading into the pandemic last year, the company was carrying a large furnace backlog.

"We're generally very busy, and it seems like Lucifer Furnaces has been getting more and more so," Jones said. "We have a strong demand for our product, and I think it's going to continue for us as a company. Of the heat-treating furnaces and other furnaces that we make, I've always felt that they are really one of the main backbones of manufacturing. And as long as you've got metal products, you're going to need a furnace, and that's what we do."

And Jones is proud to point out that every furnace is built completely in house.

"Everything we build, we do it here," he said. "Everything is done under the roof here. We've pushed a lot of furnaces out the door, and we bring in all the raw goods. We cut it, bend it, weld it, insulate it, paint it, wire it, test it, and it's out the door. Everyone's involved."

MORE INFO luciferfurnaces.com

Lucifer Furnaces' TL furnace allows dual entry for ease of replacing heating elements. This furnace was built for a medical equipment manufacturer. Top Loading furnaces are ideal for heavy workloads which require crane/hoist-assisted loading from above the furnace. (Courtesy: Lucifer Furnaces)

MARKETPLACE ///

Manufacturing excellence through quality, integration, materials, maintenance, education, and speed.

Contact **Thermal Processing** at 800-366-2185 to feature your business in the Marketplace.

REBUILDING YOUR FURNACE?
Make it better than new!
HEAVY CARBON CO. ENDOCARB

- Produce payloads up to 30% faster using the patented Endocarb System.
- No down time for soot burn out using method 4 – only possible with this system.
- Simply add the Endocarb system during the rebuild to further extend your carburizing performance and reduce operations costs.

WORKS WITH ANY FURNACE BRAND

Contact HeavyCarbon@Frontiernet.net
View on heavycarbon.com

Used Heat Treating Furnaces and Ovens

Since 1936
THE W. H. Kay COMPANY
Cleveland, Ohio

Web: whkay.com
Email: sales@whkay.com
Phone: 440-519-3800

Over 200 ovens and furnaces in stock

CAN-ENG
WWW.CAN-ENG.COM

To explore how CAN-ENG's custom systems can help with your individual needs, visit us online www.can-eng.com or email furnaces@can-eng.com.

CAN-ENG FURNACES ENGINEERING SOLUTIONS TO LAST

CUSTOM SYSTEMS FOR CUSTOM PRODUCTS

CAN-ENG Furnaces International Limited specializes in the design of unique, high-volume batch and continuous industrial furnace systems for today's and tomorrow's demanding applications.

Propelling industry toward tomorrow's opportunities, whether for Automotive, Aerospace, Steel, Military, or Oil and Gas applications, CAN-ENG has the experience and expertise to enable your success.

P.O. Box 235, Niagara Falls, New York 14302-0235 | T. 905.356.1327 | F. 905.356.181 MTI

YOUR THERMAL HEATING EXPERT

Charles A. Hones, Inc. is a recognized industry leader with over 100 years of expertise in thermal, heating and combustion engineering. We specialize in the production and restoration of melting furnaces, heat treating products, and industrial gas burners.

315-623-2124 315-623-2206
info@charlesahones.com
www.charlesahones.com

L&L Special
FURNACE CO, INC

Precision Pyrolysis & Debinding Furnaces for Ceramic Matrix Composites & Additive Manufacturing

If you have high-value loads to process, look no further than L&L Special Furnace. Our furnaces are the most reliable on the market – at any price! Each one is Special!

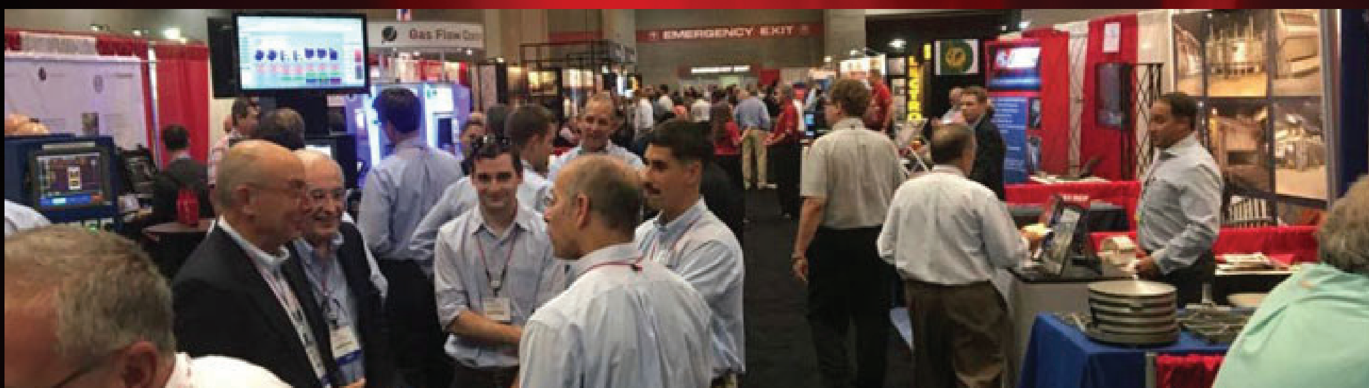
- **Precision**
- **Uniformity**
- **Value**

XLC2448 set up for Pyrolysis with Multizone Heating Banks, Inert Atmosphere, and Rapid Cooling

20 Kent Road Aston, PA 19014
Phone: 877.846.7628
www.llfurnace.com

L&L CAN MEET THE STRICTEST PROVISIONS OF AMS2750E FOR AEROSPACE APPLICATIONS

HEAT TREAT EVENTS 2021



AeroMat 2021 › May 24–26 | Virtual

ITSC 2021 › May 24–26 | Virtual

AMPM2021 › June 20–23 | Orlando, FL

PowderMet2021 › June 20–23 | Orlando, FL

Tungsten2021 › June 20–23 | Orlando, FL

AISTech2021 › June 29–July 1 | Nashville, TN

Ceramics Expo USA › August 30–September 1 | Cleveland, OH

IMAT 2021 › September 13–16 | St. Louis, MO

Heat Treat 2021 › September 14–16 | St. Louis, MO

Motion+Power Technology › September 14–16 | St. Louis, MO

Thermal processing

Look for bonus distribution of *Thermal Processing* at many of these shows. And we look forward to seeing you at select events this year.

ADVERTISER INDEX ///

COMPANY NAME	PAGE NO.

ANDREW BASSETT /// PRESIDENT /// AEROSPACE TESTING & PYROMETRY, INC.

"(Aerospace Compliance Software) eliminates human errors of our certification process; it's a self-checking system."

You recently launched your Aerospace Compliance Software. How does it work?

Aerospace Compliance Software is a brainchild of ours. The software eliminates human errors of our certification process. It's a self-checking system. It's based on various aerospace pyrometry specifications as well as customized for those customers that may not need to meet the aerospace requirements but also their own requirements.

When we do pyrometry services for customers out in the field — either calibrations or uniformity surveys or system accuracy testing — all our paperwork is manually done. Obviously, when you have human intervention with it, mistakes can happen. We have done a lot on our certification process currently that are preventing most mistakes, but at the end of the day, mistakes can still occur. When you have these aerospace audits such as Nadcap or an aerospace prime like Boeing coming in, they may not know exactly the service that you're providing for the customer, but they'll see you forgot to "cross the T" or "dot the I."

What makes your software unique to what's been available?

The one big unique thing is that we're going to capture not only AMS 2750 revision F requirements, but we're also going to capture other pyrometry specifications. There are some limitations on other things in the market right now that only do AMS 2750. But, for instance, a supplier or customer may not need to follow 2750, but they have to follow GE specifications. They have their own pyrometry requirements. Our system will be able to, just by a checkbox, say, "OK, I need to meet this standard," and it'll automatically pull in the accept-reject criteria for that particular aerospace standard. I think from that standpoint, we'll be a lot further ahead of the game because there are other aerospace pyrometry requirements out there that we can follow.

The software can validate the accuracy for AMS-2750F, GE P10TF1, PWA MCLF40, and CQI-9 specifications, to name a few. What is important about those particular specs?

GE is probably one of the bigger pyrometry specifications out there; 10 years ago, they wrote their own pyrometry requirements that don't follow AMS 2750 at all. So there would be other aerospace specs, like Pratt and Whitney, the PWA MCLF 40. Basically it says you adopt everything in 2750 except for a few other items. Boeing has actually three different pyrometry specifications, depending on what Boeing sandbox you're playing in.

We're going to make sure that the system covers anything that's out there from a standpoint of an aerospace product.

Can the software be customized for other requirements?

We don't just provide pyrometry services. We are involved with calibrations of temperature, humidity, vacuum sensors for autoclaves and pressure vessels, and vacuum system calibration for vacuum furnaces, which don't really dovetail into AMS 2750 or any other pyrometry spec. The customer then might drive some internal requirements for temperature humidity instrumentation, for instance. We might go into a clean room, and they have a temperature humidity gauge. It's not governed by any specifications. So, they'll set what their requirements are going to be, and we'll be able to say, "OK, you need to be ±3 percent humidity on your gauge and ±2° on your temperature aspect." We can customize that portion of it.

Has the software made the customization easier than the way it had been done previously?

Yeah. It's very user-friendly. The one thing that we're planning on doing is having these dashboards of our customers' equipment, and it'll always keep everything in line. When a customer does have an audit, their records are going to be right there at their fingertips. No more pulling up a piece of paper and handing it to the auditor for review. They're going to be able to sit at a computer and just say, "OK, here's the calibration reports for X amount of years, and here's your uniformity surveys." And it's all going to be tied into this customer's equipment.

What has been the industry reaction to the software?

We've gotten a positive buzz. We did do a soft rollout at the Furnaces North America trade show. We were hoping to have everything ready to roll, and then of course, with developing any kind of software, there are always little glitches along the way. We have rolled out our calibration module, which is ready to be released, and we've done some beta testing on it and used some live customers on it, and it's working out the way we need it to. Our TUS module is our next module coming out. We're aiming for the end of March on that one. And then shortly behind that will be our SAT module. We have many clients who know our intentions of the software, and they like the fact that it's a self-checking system, so that human element goes out of the equation. We're excited about the rollout along with a lot of our clients.

MORE INFO www.atp-cal.com

SolarVac® POLARIS
AUTOMATION & CONTROLS

SOLARVAC® POLARIS: A NEW GENERATION OF INNOVATIVE AUTOMATION AND CONTROLS

The SolarVac® Polaris automation and controls platform is constantly evolving to provide our vacuum furnace customers the best in functionality and features. Our well designed PLC-based control system with PC-based HMI provides a solid foundation of standard features like unlimited recipe storage, alarm management, data acquisition, and maintenance metric functionality. Through continuous improvement, our engineers are enhancing the value and versatility of the Polaris control platform by creating efficient recipe management, reducing operator involvement, and capturing critical process data to help you make the most informed process decisions. Ingenuity and simplicity remain the driving forces in the development of our automation systems.

CORE SYSTEM ARCHITECTURE

- Programmable Logic Controller: Allen-Bradley CompactLogix
- HMI Operator Interface: Wonderware InTouch, Windows 7, 21.5" HD Touch PC
- Graphic Video Recorder: Eurotherm Digital Display

SOLAR MANUFACTURING

267.384.5040
sales@solarmfg.com

solarmfg.com

Give us a call to learn more about our vacuum furnace ingenuity.